A planning and control framework for residents' activities

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MANAGEMENT SUMMARY

Problem statement and research objective: Medicine residency is a challenging graduate medical training in which residents (in Dutch: AIOS: 'Arts in Opleiding tot Specialist') are exposed to one of the medical specialties. During the residency program, residents are considered both learners and providers of medical services. Many university medical centers face a difficult challenge of designing feasible schedules for their residents, because the schedules need to satisfy both the educational requirements and the demand of providing patient care.

The challenge on scheduling residents can also be observed at the Radiology department of the University Medical Center Groningen (UMCG). At the Radiology department of the UMCG, approximately 25 residents are trained to become a specialist in the field of Radiology. Current schedules affect both performance of the residency program and effective employment of residents at the department. For instance, the residency program faces problems with guaranteeing the learning curve of internships, due to the tasks residents have to perform for the patient care services. Furthermore, the department faces problems with the high amount of evening, night and weekend shifts taken by residents, which also affects the quality of the residency program.

Similar performance issues are observed at many other hospitals and are widely acknowledged in literature (Gaba & Howard, 2002; Güler, Idi & Güler, 2013; Prins, Hoekstra-Weebers & Van de Wiel, 2007). Typically, the scheduling issues faced are traced back to the setup and operation of scheduling systems. Researchers typify these scheduling systems as complex, due to the many parties with their often conflicting interests and requirements. Not surprisingly, observations made by these researchers suggest the development of residents' schedules to be time consuming. Starting from their observations, researchers suggest the development of more efficient scheduling procedures. Unfortunately, little progress has been made on this so far. To deal with the issues faced in scheduling residents' activities, the following research objective is determined:

Develop a framework for the planning and control of residents' activities in order to enhance the effectiveness, efficiency and job satisfaction of the department, the residency program and the residents.

The developed framework is meant to serve as a reference architecture for designing systems for the planning and control of residents' activities. The setup of the framework acknowledges the need to address problem complexity by a hierarchical decomposition of the planning and control tasks. By identifying planning levels, planning activities and performance criteria, it is meant to guide the planning and control system design.

Research design: To reach the goal, various steps of the design methodology are used. In this design, the Radiology department of the UMCG is used as a research vehicle. The main objectives underlying the research design are underpinning the need for a planning and control framework, developing an initial framework and illustrating and evaluating the possible use of the framework. The research design consisted of the following four steps:

Step 1) Describe current system
Step 2) Analyze performance of current system and underpin need for framework
Step 3) Design of framework
Step 4) Illustrate and evaluate use of framework

To support the findings from the case study, also observations from site visits to other hospitals and departments are used.

Analysis: The performance of the planning and control of residents has been analyzed according to the performance indicators effectiveness, efficiency and job satisfaction. The performance analysis showed that especially effectiveness of the residency program has much room for improvement. For instance, the mean of the days spent at an internship is 3.48 days for a first-year resident, 2.84 days for a third-year resident and 2.54 days for a fifth-year resident. These means of the days spent at an internship are considered to be too low. In addition, 37.9% of the internships contain less than four consecutive weeks at one internship for all residents. This is not sufficient, since following less than four consecutive week's causes fragmentation of the internships and affects the learning curve of residents.

To identify the causes of the problems occurring at the Radiology department, a cause and effect analysis has been performed. In addition, the identified causes are rated by various stakeholders, to identify the most important causes at the Radiology department of the UMCG. The most important causes can be divided into four main categories. First, there is no explicit planning and control architecture. Second, there is no clear division of planning levels, horizons and tasks. Third, improvements on the planning and control of residents are stagnated due to problem complexity. This confirms the complexity of designing a schedule for residents, suggested by various researchers. Finally, there is a lack of integration between the schedules of the residency program and the patient care services.

The identified causes of this analysis suggest to structure and to develop guidelines for the planning and control of residents. Thus, the observed performance underpins the need to develop a framework for the planning and control of residents. A specific requirement for the framework that follows from this analysis is a clear division between the various parties. Currently, there is a lack of overview, which should be provided by the framework. Furthermore, the framework should provide steps and deadlines that should be made at a specific time. Thus, besides a clear division of the parties, also a planning horizon should be included.

Design of the framework: The planning and control framework for residents' activities is developed by using the four hierarchical levels proposed by Hans, Houdenhoven & Hulshof (2011). These four levels are structural, tactical, offline operational and online operational planning and control. The four levels of planning and control are each decomposed in activities specific for the planning and control of residents. The proposed framework consists of two streams of activities; a stream for the residency program and a stream for the patient care services. The decomposition in two streams clarifies both roles of the resident, i.e. the graduate student and the employee.

Illustration and evaluation of the framework: The proposed framework can be used to improve the performance of the planning and control system of the Radiology department of the UMCG. To improve the performance of the current system, various solution directions have been explored. These solution directions build on analyzing other departments of various hospitals, the opinions of stakeholders and available literature. The planning and control framework is used to organize the various possible solutions into three redesigns.

The three proposed redesigns have been evaluated by various stakeholders. To evaluate the proposed redesigns, a survey was created and distributed among the Radiology department. In total 26 members of the Radiology department have filled in the survey, from which 11 residents. The main conclusion from this evaluation is that all stakeholders agree on introducing a structure with defined agreements and deadlines. This includes deadlines for the delivery of wishes and requests of internships, but also deadlines for days off, such as holidays. The most important element of the redesigns is that there is introduced a structure with defined agreements and deadlines. Therefore,

the proposed framework presents a first step in improving the effectiveness, efficiency and job satisfaction of the schedule of residents at the Radiology department of the UMCG.

Discussion: The designed framework for residents´ activities is a first step in guiding the planning and control system design. The framework addresses the problem complexity and the division of planning levels, tasks and horizons. However, more research is needed to expand the designed framework. The proposed planning and control framework can be used by any other department to create awareness about the planning and control of residents and to start evaluating their own planning and control system of residents. The arising problems around residents will force almost any department to redesign their planning and control system. When coping with these problems, the proposed framework can be used to guide the redesign of the planning and control system.

Conclusion + recommendations: This study aimed to propose a framework for the planning and control of residents' activities, in order to enhance the effectiveness, efficiency and job satisfaction of the department, the residency program and the residents. To reach its goal, a case study is performed on the Radiology department of the UMCG. The case study is used to underpin the need for a planning and control framework, develop requirements for the framework and illustrate and evaluate the possible use of the framework. During the case study, a planning and control framework is developed. The developed framework is meant to serve as a reference architecture for designing systems for the planning and control residents' activities. The setup of the framework acknowledges the need to address problem complexity by a hierarchical decomposition of the planning and control tasks. By identifying planning levels, planning activities and performance criteria, it is meant to guide the planning and control system design.

Further research is required to expand the proposed planning and control framework. Currently, the framework only includes one managerial area of the framework of Hans et al. (2011), namely the resource planning. However, the framework could be expanded in the other three levels: medical planning, materials planning and financial planning. For instance, the financial part of training residents and their delivery of patient care services could be investigated in future research. It would be interesting to know the total costs of residents and the financial effects of the various possibilities of restructuring tasks of residents. Furthermore, future research could investigate the application of the proposed framework for other departments. Finally, the proposed framework could be further detailed in future research.

FOREWORD AND ACKNOWLEDGEMENTS

This master thesis is written for the achievement Master of Science in Industrial Engineering and Management. The thesis is about the design of a system for the planning and control of residents' activities. The planning and control of residents is an interesting topic, because the residents are considered both learners and providers of medical services. They have to meet requirements from both the residency program and the patient care services. The planning and control of residents is a topic which problems have widely been elaborated in literature; however no solutions are presented yet. During the six months of my research, I discovered that the planning and control of residents is a highly-faced problem in many departments and hospitals, both on national and international level. Therefore, I hope that the framework developed in this thesis will be a first step in creating solutions for the planning and control of residents.

I executed this research at the University Medical Center Groningen, a hospital that I have known very well since I was little. For my master thesis, I wanted to combine my interest for healthcare with my knowledge gained during my study of Industrial Engineering and Management. I am very glad that I got the chance to conduct this research at the UMCG.

My supervisors for the master thesis have been Durk-Jouke van der Zee, Tjibbe Hoogstins and Jan Pruim. I would like to thank my supervisors for their guidance and support during my research. I would also like to thank my second assessor, Stuart Zhu. Furthermore, I would like to thank all the members of the department of Radiology; the residents, the staff and the educators. I felt very welcome during my research project and everyone was always open to make an appointment or answer my questions. From the Radiology department, I would like to specifically thank Manon Grave. Although she was not my formal supervisor in this project, she helped me with many problems I faced.

My final thanks go out to my family and friends, who are always a great support.

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Wendy Olsder

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LIST OF ABBREVIATIONS

AMC Amsterdam	Academic Medical Center Amsterdam
ATLS	Advanced Trauma Life Support
CT	Computed Tomography
EPA	Entrustable Professional Activities
Erasmus MC	Erasmus Medical Center
GH	Gastroenterology and Hepatology
IC	Intensive Care
MIC	Medical Imaging Center
MMB	Medical Microbiology
MRI	Magnetic Resonance Imaging
MRP	Manufacturing Resource Planning
NSP	Nurse Scheduling problem
OMRP	Ortec Multi Resource Planning
OR	Operations Research
UMCG	University Medical Center Groningen
UMC Utrecht	University Medical Center Utrecht

1. INTRODUCTION

1.1 RESIDENCY PROGRAM

The University Medical Center Groningen (UMCG) has three core tasks: delivering patient care, providing education and conducting research. The focus of this research is on a combination of two of these core tasks: delivering patient care and providing education. In the UMCG, approximately 600 residents (in Dutch: AIOS: 'Arts in Opleiding tot Specialist') are trained to become a specialist. During their training, residents are working closely together with their supervisors. These supervisors give coaching and feedback to the residents, to develop themselves from just graduated medical doctor to being a specialist in a specific field.

The residency program of Radiology is one of the 27 residency programs that the UMCG offers. Radiology is the specialty of medicine that uses ionizing and nonionizing radiation for the diagnosis and treatment of diseases. Radiology uses imaging technologies, such as X-ray radiography, magnetic resonance imaging (MRI), nuclear medicine, ultrasound and computed tomography (CT) to see within the human body in order to diagnose disease and abnormalities. The residency program of the UMCG develops residents to become a specialist in using these imaging technologies and to become a specialist in the field of Radiology. The post-graduate residency training of Radiology in the Netherlands takes 5 years. During these years, residents will become a specialist in the field of Radiology. This phase of medical education requires direct participation by residents in the delivery of patient care services. The residents have a unique position, acting both as students who have to attend educational activities and as providers of care services. Each year there are three to four residents that start their specialization in Radiology at the UMCG.

1.2 RESEARCH FOCUS

At the Radiology department of the UMCG, many scheduling challenges are occurring. As the number of residents is getting lower over the recent years, the fulfillment of the patient care services is under increasing pressure. To fulfill the patient care services, the Radiology department schedules residents more often at a different task than their residency program dictates. On the other hand, the residency program tries to ensure the quality of the education by adequately scheduling the internships. Both the Radiology department and the program coordinator want to provide an effective residency program. However, in practice these two stakeholders seem to have conflicting requirements, which makes the scheduling of the residents a complex task.

In addition to the Radiology department of the UMCG, many university medical centers face a difficult challenge of designing schedules for their residents, because the schedule needs to satisfy conflicting requirements. The schedule needs to satisfy a set of educational requirements that ensure that the resident gathers sufficient experience in a range of disciplines. Furthermore, residents have to contribute to the delivery of care services and must be adequately scheduled in staff shifts. These, often conflicting, requirements make the scheduling of residents a complex task. Therefore, the focus of this research is on developing solutions for the scheduling challenges of residents.

1.3 Structure of thesis

This thesis is divided into three sections; the problem statement and research setup, the case-study and the research findings.

Section 1: Problem statement and research setup

Chapter 1 - Introduction	Gives an introduction of the residency program and the research focus.
Chapter 2 - Research design	Provides the problem background, the research objective, the conceptual model, the research questions and the research plan.
Chapter 3 - Planning and control of residents	Provides an overview of the related literature on planning and control of residents and presents an initial framework.

Section 2: Case study of the radiology residency program of the UMCG

Chapter 4 - System description	Describes the current planning and control of residents.
Chapter 5 - Analysis of current system	Presents the performance and causes and effects of the current system.
Chapter 6 - Framework design	Proposes a planning and control framework for residents' activities.
Chapter 7 - Illustration of framework use	Presents an illustration of the proposed framework by using it to improve the performance of the Radiology department.

Section 3: Research findings

Chapter 8 - Discussion	Discusses and generalizes the outcomes of the research.
Chapter 9 - Conclusion	Provides conclusions of the research and suggests possibilities for future research.

2. RESEARCH DESIGN

This chapter lays the foundation for this thesis by presenting the research design. It will start by introducing the problem and the relevant stakeholders. The problem background will be followed by stating the research objective. Furthermore, the system on which this study focuses will be explained in a conceptual model. Finally, the research questions and the research plan will be presented.

2.1 PROBLEM BACKGROUND

2.1.1 PROBLEM DESCRIPTION

Medicine residency is a challenging graduate medical training in which residents (in Dutch: AIOS: 'Arts in Opleiding tot Specialist') are exposed to one of the medical specialties. During the residency program, the residents are considered both learners and providers of medical services. They are involved in the delivery of patient care under the supervision of an experienced specialist and at the same time they are considered to be a student in training. Many university medical centers face a difficult challenge of designing schedules for their residents, because the schedules need to satisfy both the educational requirements and the demand of providing patient care (Anderson & Gamarnik, 2013). The design of the schedules of residents becomes even more challenging with the current reduction of number of residents, due to decreased funding for existing residency positions (Abrass, Ballweg & Gilshannon, 2001).

The schedule for the residents has to satisfy several requirements. First, the schedule has to satisfy a set of educational requirements that ensure that the resident has sufficient experience in a range of disciplines (Franz and Miller, 1993). Second, residents have to contribute to the provision of patient care services and must be adequately staffed in every rotation period. Finally, the schedule has to satisfy the requirements of the residents. For instance, long hours of intense clinical work need to be avoided because they may result in stress, fatigue and medical errors (Topaloglu & Ozkarahan, 2011).

These, often conflicting, requirements make the scheduling of residents a complex task. If the requirements of the patient care services and the requirements of the residency program are not appropriately balanced, generally the requirements of the patient care services dominate. This requires the program coordinator to negotiate with the department on behalf of its residents to come to a solution that better fits the programs' educational needs (Guo, Morrison & Jacobson, 2014). Today in many hospitals the program coordinator spends very long hours to manually prepare schedules by trial and error (Day, Napoli & Kuo, 2006). Despite this effort, the resulting schedule is still not meeting all the requirements of the various stakeholders (Topaloglu, 2006).

The issues on scheduling residents can also be observed at the Radiology department of the University Medical Center Groningen (UMCG). The residents of the Radiology department have to attend several internships to gain competences in a certain specialty of Radiology (e.g. Abdominal Radiology or Cardiothoracic Radiology). The program coordinator schedules these internships and tries to ensure that it fulfills the educational requirements as well as the requirements on contributing to the patient care services. However, the resulting schedule gives various problems that affect both the residency program and the department of Radiology. One of these main problems is guaranteeing the learning curve within the internships. Residents need to attend several internships to gain their competences in the field of Radiology. However, the prescribed number of weeks scheduled for an internship, differs from the weeks that are actually spent on the internships. This causes problems with the learning curve of the residents. Furthermore, they have problems with the high amount of evening, night and weekend shifts taken by residents. This high amount of evening, night and weekend shifts affects the quality of the residency program. Besides the effect on both the residency program and the department of Radiology, the scheduling problems are also resulting in a higher workload for residents.

These problems around the planning and control of residents are occurring at many other hospitals (Gaba & Howard, 2002; Prins, Hoekstra-Weebers & Van de Wiel, 2007). Despite the effort of the program coordinators, the resulting schedules of residents are still not sufficient. There is a lack of overview of the planning and control of residents, due to the many requirements the schedule has to satisfy. This lack of overview suggests to organize the planning and control of residents. It asks for a clear framework that could help improve the planning and control of residents' activities.

2.1.2 Relevant stakeholders

There are various stakeholders involved in the planning and control of residents. The stakeholders can be divided in three perspectives: the pro-education perspective, the pro-patient care perspective and the residents. This division is showed in Figure 1. The stakeholders and their main requirements are stated below. More information about the stakeholders can be found in the stakeholder analysis of Appendix A.

Figure 1: Three stakeholders' perspectives

Residents

The main subjects of this research are the residents. They are following a challenging medical training to become a specialist in a medical field.

- The residents want to follow the best residency program possible.
- The residents want both to contribute to the provision of patient care services and attend sufficient days at their internships.
- The residents want to balance the number of residents at an internship, to enhance the learning effect.
- The residents want a fair and maximum amount of evening, night and weekend shifts.

Educators

Other stakeholders of this research are the educators. There are both main educators and subsidiary educators.

- The educators want to deliver the best residency program possible.
- The educators want to balance the number of residents at an internship, to both enhance the learning effect and not exceed the educational capacity of the sub-specialties.
- The educators want to safeguard the learning performance of the internships.

Program coordinator

The residency program has a program coordinator that works closely together with the residents and the educators. The program coordinator has various tasks related to the residency program. The most important task for this research is that the program coordinator does the planning and control of the residency program.

- The program coordinator wants an overview of the requirements and interests of the various stakeholders.
- The program coordinator wants guidelines to tradeoff the various interests.
- The program coordinator wants to deliver the best residency program possible.

Staff

Besides the educators, the staff members are involved in the residency program. They are supervising the residents, but are also involved in the division of tasks of residents at the sub-specialties.

- The staff wants to balance the number of residents at an internship, to fulfill the educational capacity of the sub-specialties.
- The staff wants the residents to provide patient care services, such as evening, night and weekend shifts, to have more time to perform their own tasks.
- The staff wants clearness and transparency on what happens with the planning and control and why problems are arising.

Planning department

The planning department is the department that plans the patient care services. Thus, they are, among others, planning the staff for the provision of patient care services.

- The planning department wants enough residents and staff members to fulfill the provision of patient care services.
- The planning department wants clearness and transparency on what happens with the planning and control of the residency program and why problems are arising.

Managers

The managers are responsible for everything that is related to the non-medical aspects of the department.

- The managers want the planning and control to be more effective.
- The managers want advice on want they can improve in the current situation.

Chef's de Clinique's

The Chef de Clinique's are in charge of the medical part of the department. Thus, the staff and residents are led by the Chef de Clinique's.

- The Chef de Clinique's want the residents to provide patient care services, such as evening, night and weekend shifts, such that the staff has more time to perform their own tasks.
- The Chef de Clinique's want the planning of the residents to be optimized, with minimizing the effect on the staff members and the department.

Summary

There are seven stakeholders, which can be divided among three perspectives as shown in Figure 1. The educators and the program coordinator want to deliver the best residency program possible. At the other hand the staff, the planning department, the managers and the Chef's de Clinique are on the side of delivering patient care services. They want the residents to fulfill tasks for the delivery of patient care, which might decrease the effectiveness of the residency program. The final stakeholders are the residents, who are in the middle of these two perspectives.

2.2 RESEARCH OBJECTIVE

From the problem description it can be concluded that the planning and control system of many hospitals do not have the desired outcome. There is a lack of overview of the planning and control of residents, due to the many requirements the schedule has to satisfy. This lack of overview suggests to organize the planning and control of residents. Therefore, the following research objective is determined:

Develop a framework for the planning and control of residents' activities in order to enhance the effectiveness, efficiency and job satisfaction of the department, the residency program and the residents.

The framework will serve as a reference architecture for designing systems for the planning and control residents' activities. The setup of the framework will acknowledge the need to address problem complexity by a hierarchical decomposition of the planning and control tasks. By identifying planning levels, planning activities and performance criteria, the framework will guide the planning and control system design.

This research will focus on both the technical and social part of the planning and control of residents. The technical part of the research is the actual composition of the planning and the social part are the various requirements of the stakeholders. Innovative aspects of this research relate to the fact that residents are shared resources, i.e. their planning has to accommodate both patient care services, and their own training.

The scope of the research is narrowed to only the residency program and the fulfillment of the provision of patient care services by residents. This means that the planning and control of the staff members are left out of scope. Furthermore, the research will focus on the fulfillment of shifts for patient care services, not on the appointment with patients specifically.

This research will perform a case study on the Radiology department of the UMCG. Therefore, this study will provide three main deliverables to the Radiology department of the UMCG:

- A clear overview and an analysis of the current planning and control system, including the key parameters and the requirements of the stakeholders;
- A proposed redesign for the improvement of the planning and control system of the residency program of Radiology;
- An initial assessment of the effects of the proposed redesign.

Furthermore, it will be considered if the proposed redesign is also suitable for other residency programs.

2.3 Conceptual model

To provide a clear overview of the system, a conceptual model is constructed. The conceptual model is presented in Figure 2.

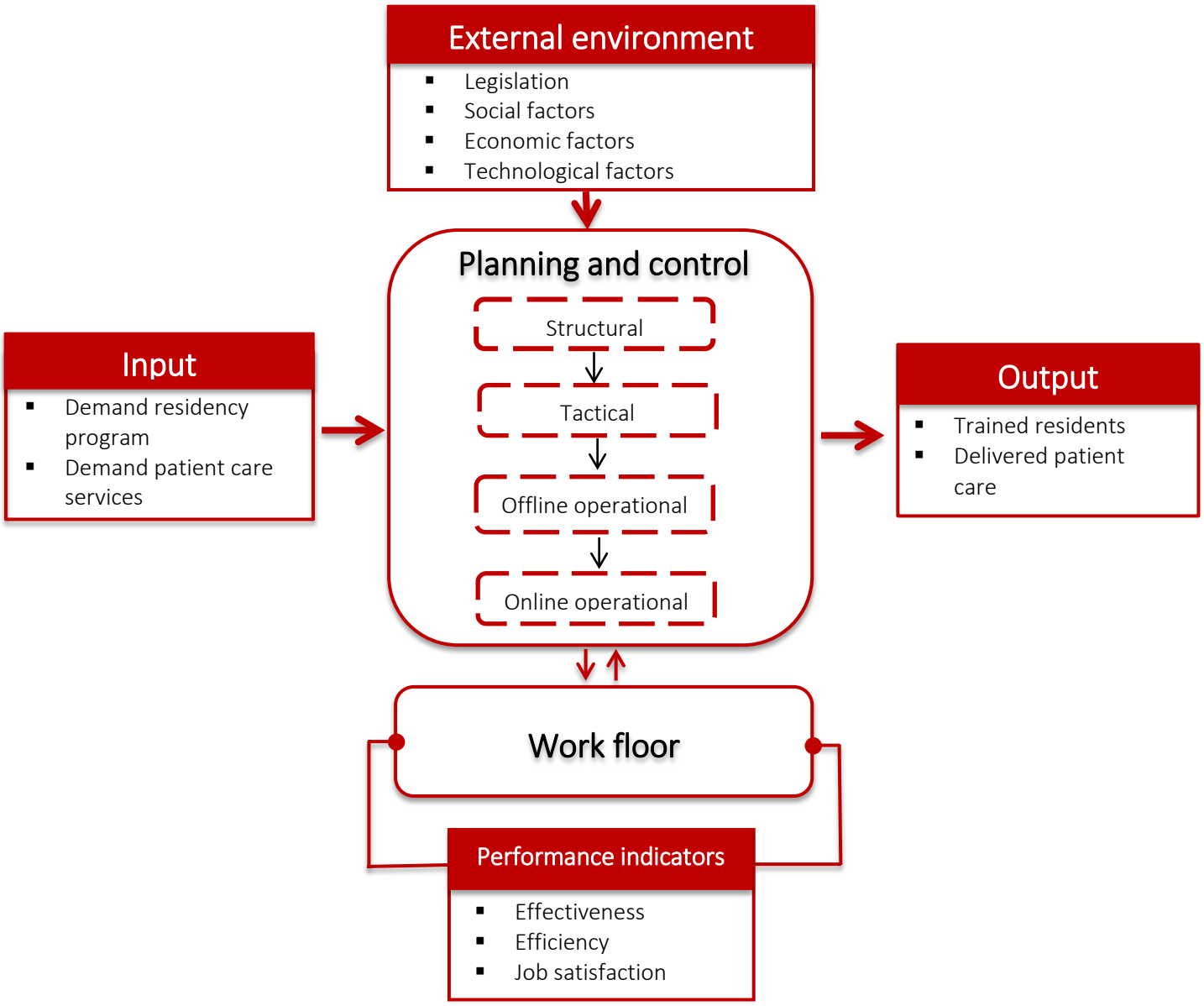


Figure 2: Conceptual model of planning and control residents

2.3.1 Input

The input of the system is defined as the parameters that affect the behavior of the system. In this system, the input is a stream of information. This information consists of the demand of the residency program and the demand of the patient care services. The demand of the residency program defines the number of residents that are allowed to follow the residency program. Furthermore, the demand of patient care services defines the volume of patient care tasks that need to be fulfilled by staff and residents.

2.3.2 System

The system that is defined here is the planning and control system of residents. This system performs the planning and control of both the residency program and the patient care services related to the residents. Thus, only the shifts that are done by residents are included and not the staff shift scheduling. The shifts done by residents can include for instance evening, night and weekend shifts or shifts at the ATLS. The system does not consider the allocation of patients to doctors, thus the appointment scheduling is left out of scope.

As shown in Figure 2, the planning and control influences the work floor, because the schedule will be executed on the work floor. In turn, if there are problems with the schedule on the work floor, the planning and control needs to be changed. The planning and control of residents consists of various activities and elements. The planning and control is structured using four levels, which will be further elaborated in chapter 3. The four levels are structural, tactical, offline operational and online operational planning and control.

2.3.3 External environment

The controls of the system are based on external factors that cannot be influenced and are controlling the planning and control system. The variables that are used to categorize the external factors are described by Johnson, Scholes & Whittington (2008) and are called "PESTEL". The "PESTEL" variables categorize external factors into six main types: political, economic, social, technological, environmental and legal. In this research, the environmental and political influences are left out of scope, because the influences are too low. Examples of external factors that will be considered are regulations from the national residency program, business regulations from hospitals, funding of residents, pregnancies etc. These external factors will be further elaborated in chapter 3.

2.3.3 Output

The output of the system consists of two parts: trained residents and delivered patient care. The planning and control of residents should provide trained residents, who have become a specialist in their medical field. Furthermore, the residents should fulfill tasks for the provision of patient care, which results in delivered patient care.

2.3.4 Performance indicators

The planning and control of residents can be measured in three dimensions (Maenhout & Vanhoucke, 2013). These three dimensions are effectiveness, efficiency and job satisfaction, as presented in the conceptual model defined in Figure 2. To measure these three performance indicators, proxy indicators will be used. The defined performance indicators are difficult to measure in hospital environments. Therefore, they are measured using proxy indicators. Each of the performance indicators and their proxy measures are further elaborated below.

Effectiveness

Effectiveness is defined by Carmichael (2012) as to which extent planned activities are realized and planned results are achieved. A process is effective if its outcomes match the stated goals. The effectiveness of the planning and control of residents is divided in three components:

- *Minimum violations of restrictions*

The first component of the performance indicator effectiveness is minimum violations of restrictions. The government, hospital and department are restricting the planning and control of the residency program. Examples of these restrictions are that the number of residents at an internship cannot exceed the defined capacity of residents or that the number of residents that are placed with one supervisor cannot exceed the national norm for supervision. These violations of restrictions should be minimized.

- *Effectiveness of the residency program*

The overall goal of the residents is to fulfill the requirements of the residency program and to become a specialist in their medical field. This can be measured in terms of effectiveness of the residency program. The effectiveness of the residency program can be measured in terms of internship continuity and the amounts of days spent at the internship.

- *Balance of the number of residents at internships*

The fluctuations of residents at internships should be decreased. Therefore, the number of residents taking an internship at a sub-specialty should be balanced among time.

Efficiency

Additionally, the planning and control of residents aims to be efficient. In this research the efficiency is measured in two components (Meanhout & Vanhoucke, 2013):

- *Maximum usage of educational bottleneck capacity*

There is a maximum educational capacity for attendance and supervision of internships at the sub-specialties. Some internships are the bottlenecks of the system. These internships should be occupied as much as possible.

- *Maximum fulfillment of residents' tasks*

The second component of efficiency is the maximum fulfillment of residents' tasks. The residents need to fulfill several tasks, which all should be done to provide patient care services.

Job satisfaction

The final performance indicator presented in Figure 2 is the job satisfaction. There are various measures of job satisfaction of residents, such as education environment, autonomy, supervision, physical factors and financial support (Everts, 2006). In this research two components will be considered:

- *Accepting wishes and requests*

Residents are supposed to express their preferences on for instance vacations and taking evening, night and weekend shifts. The job satisfaction is reflected in the degree by which these wishes and requests are granted and residents can determine their own schedule.

- *Fairness among residents*

The fairness among residents in providing certain tasks is also influencing the job satisfaction. For instance, the amount of evening, night and weekend shifts should be fairly distributed among the residents.

The three performance indicators and their defined components can be coupled to the three stakeholder perspectives. This is shown in Figure 3.

Education	Residents	Patient care
•Minimum violations of restrictions *(effectiveness)* •Effectiveness of the residency program *(effectiveness)* •Balance of the number of residents at internships *(effectiveness)*	•Accepting wishes and requests *(job satisfaction)* •Fairness among residents *(job satisfaction)*	•Minimum violations of restrictions *(effectiveness)* •Balance of the number of residents at internships *(effectiveness)* •Maximum usage of educational bottleneck capacity *(efficiency)* •Maximum fulfillment of residents' tasks *(efficiency)*

Figure 3: Performance indicators for the three stakeholders' perspectives

2.4 Research questions

To achieve the research objective, several research questions need to be answered. The formulated research questions are as follows:

- Which guidelines are available for developing a framework for the planning and control of residents' activities? *(Chapter 3)*
- What is the design of the current planning and control system of the residency program of the UMCG? *(Chapter 4)*
- What is the performance of the current planning and control system of the residency program of the UMCG and how can this performance be explained? *(Chapter 5)*
- How can the planning and control of residents be structured to improve its performance? *(Chapter 6)*
- How can the planning and control system of the UMCG be redesigned using the proposed framework and what are the estimated effects of these redesigns? *(Chapter 7)*
- What are the possibilities of the proposed framework for other residency programs? *(Chapter 8)*

2.5 Research plan

The research plan shows the research steps and methods that are used for answering the research questions. In this research, a case study will be performed on the Radiology department of the UMCG. This case study will be used to develop a framework for the planning and control of residents' activities. Before conducting this case study, chapter 3 will address the related literature about planning and control of residents. The chapter will give answer to the research question: *Which guidelines are available for developing a framework for the planning and control of residents' activities?* It will present an initial framework for the planning and control of residents, based on the available literature. After chapter 3, a case study will be conducted to find support for this initial framework and to propose a detailed version of this framework. The steps of the case study are generated by using the research questions defined in the previous section. The research steps are shown in Figure 4. The findings of this case study will be discussed and generalized. It will be concluded if the proposed framework is also applicable at other residency programs.

Figure 4: Steps of the research plan

Step 1: Describe current system

This first step of the research is describing the current planning and control system that is used for the residency program. Chapter 4 will cover this first step and will give answer to the research question: *What is the design of the current planning and control system of the residency program of the UMCG?* The chapter will provide an overview of the requirements of the residency program and the requirements of the patient care services. The current scheduling and planning system of the residency program will be described with the aid of:

- Interviews with all stakeholders; i.e. the residents, supervisors, program coordinator, staff, managers, Chef de Clinique's and the planning department;
- Frequent meetings with experts; i.e. the program coordinator, health care logistic advisor, supervisors;
- Observations of consulted documentation from the residency program and the hospital.

Step 2: Analyze performance of current system
After the description of the current planning and control system, chapter 5 will present the analysis of the system. The research question that is covered in this chapter is: *What is the performance of the current planning and control system of the residency program of the UMCG and how can this performance be explained?* In this performance analysis, the performance indicators described in section 2.3.4 will be used to analyze the system. Furthermore, the chapter will present a cause and effect analysis to explain the performance of the current system. With this analysis, the need for a planning and control framework will be underpinned. To analyze the performance of the current system and to explain this performance, information is derived from:

- Interviews with all stakeholders; i.e. the residents, supervisors, program coordinator, staff, managers, Chef de Clinique's and the planning department;
- Observations of the current planning and control system;
- Data of previous schedules of the residency program and data of the department of Radiology.

Step 3: Framework design
The third research step corresponds to the fourth research question: *How can the planning and control of residents be structured to improve its performance?* The answer to this question will be presented in chapter 6. This chapter will propose a planning and control framework for residents' activities. The framework will be proposed with the aid of:

- Analysis and causes of the current planning and control system;
- Discussions and observations at other hospitals and departments;
- Literature related to the planning and control of residents.

Step 4: Illustration of framework use
The final step of the research plan will cover the research question: *How can the planning and control system of the UMCG be redesigned using the proposed framework and what are the estimated effects of these redesigns?* This question is presented in chapter 7. The framework is used to present three redesigns for the Radiology department of the UMCG. In addition, the estimated effects of these redesigns are gathered. The illustration of the framework will be performed with the aid of:

- Discussions and observations at other hospitals and departments;
- Constructing scenarios and discuss with stakeholders;
- Literature related to the planning and control of residents.

As stated before, after the evaluation, the research will provide an answer to the final research question: *What are the possibilities of the proposed framework for other residency programs?* This question will be answered in chapter 8 by providing a discussion about the possibilities for the generalization of the findings of the case study.

3. PLANNING AND CONTROL OF RESIDENTS

This chapter addresses the first research question: *"Which guidelines are available for developing a framework for the planning and control of residents' activities?"* To answer this question, a literature research is performed. The literature research is done by using Web of Science, Google Scholar and PubMed. This literature search is divided among six sub-questions:

(1) *What are the activities of residents?* (Section 3.1)
(2) *What are the issues faced with the planning and control of residents?* (Section 3.2)
(3) *Which literature is available on planning and control in health care organizations?* (Section 3.3.1)
(4) *Which methods could be used to structure planning and control in health care organizations?* (Section 3.3.2)
(5) *Which literature is available on scheduling of shared resources in health care organizations?* (Section 3.3.3)
(6) *Which framework can be applied to the planning and control of residents?* (Section 3.4)

The keywords that are used in the literature search are in line with the sub-questions and defined as follows: [activities residents], [planning and control residents], [residents scheduling], [problems planning and control residents], [issues planning and control residents], [health care planning and control], [scheduling health care organizations], [scheduling resources health care], [shared resources hospitals], [resource allocation hospitals], [shared staff allocation hospitals], [scheduling policies health care], [framework health care planning and control], [structuring health care planning and control]. During the search, also other relevant articles were identified related to the planning and control of residents. The articles are selected based on the title and the abstract. Besides journal articles, also a search for grey literature is conducted.

The sections of this chapter are divided among the six sub-questions. The first two sections, sections 3.1 and 3.2, define the activities performed by residents and the issues that are faced with the planning and control of these activities. With these two sections, the current planning and control of residents is elaborated. The following section, section 3.3 will research the current literature available on the planning and control in health care organizations. It will address the developments on planning and control in health care organizations and how this planning and control can be structured. The final section, section 3.4 will combine the activities and issues of section 3.1 and 3.2 with the literature of section 3.3. It will present an initial framework for the planning and control of residents. Finally, section 3.5 summarizes the main findings of this chapter.

3.1 ACTIVITIES OF RESIDENTS

After physicians graduate in medicine, they usually practice a specific field of medicine in a hospital under the supervision of an attending physician. This post-graduate stage of medical training is called residency education. Successful completion of a residency program gives the physicians a license to officially practice one of the specialties of medicine. These residency programs take around three to seven years to complete. In these years, residents have a lot of responsibilities, such as providing patient care and attend multidisciplinary care meetings (Anderson & Gamarnik, 2013). In addition, they are also required to take the responsibility of the late-, night- and weekend shifts. All these responsibilities of residents serve two purposes: to provide training to the residents and to provide staffing for the hospitals (Cohn, Root & Kymissis, 2009).

3.2 Issues faced in planning and control of residents

The last couple of years, more and more attention has been directed to the increasing workload of residents (Gaba & Howard, 2002; Prins, Hoekstra-Weebers & Van de Wiel, 2007). Many medical departments of hospitals provide 24h service and the residents are the main providers of this service. Residents are assigned for evening, night and weekend shifts during their training, as well as working during the regular day shifts (Güler, Idi & Güler 2013). According to a survey conducted by The American Alliance of Academic Chief Residents in Radiology, the percentage of evening, night and weekend shifts of Radiology residents has increased from 15% in 2010 to 32% of the total time spend for the residency program in 2015 (Hoffman, Singh, & Peterkin, 2016). Various studies have shown that the addition of evening, night and weekend shifts attended by residents affects resident education both positively and negatively. A recent study by Collins, Gruppen & Bailey (2004) concluded that having 24/7/365 in-house Radiology coverage resulted in greater faculty feedback, but had a negative effect on resident autonomy and educational experience. This residency education puts a lot of mental and physiological burden over the residents (Güler et al., 2013). The burnout levels among medical residents are considered high. Recent research showed that medical residents have a high risk for developing burnout (Thomas, 2004), since they are confronted with high job and educational demands, and few resources, such as limited control and lack of social support and autonomy (van der Heijden, Dillingh & Bakker, 2008; Prins et al., 2007). The literature consistently demonstrates that the long hours of intense clinical work seen in residency training programs raise concerns about residents' stress, mood changes, and capacity to deliver high quality medical care (Topaloglu & Ozkarahan, 2011).

There is a great need for the development of an efficient scheduling procedure that meets the requirements of the residency program and the staff scheduling. To meet both requirements, the program coordinator must build a schedule assigning the responsibilities of the resident. The schedule must ensure that each resident completes the appropriate number of internships and gains the needed competences to complete the requirements of the residency program (Franz & Miller, 1993). In addition, each hospital must have appropriate staffing to meet the needs of the provision of patient care. Finally, each resident has individual requests and preferences that need to considered, such as specific days off to go on a vacation (Guo et al., 2014).

Currently, the task of constructing the schedule is time consuming and frustrating (Cohn et al., 2009). For the individual residents, the quality of the schedule directly affects their quality of life (e.g. the amount of rest they get and their ability to attend family functions). The schedule also impacts the staff, because gaps in the schedule need to be filled (Day et al., 2006). To deal with these problems, a planning and control framework should be defined. By defining a framework, the elements of the planning and control of residents are decomposed and the efficiency of the schedule can be increased.

3.3 Current research on planning and control in health care organizations

To develop a planning and control framework for residents, it is of interest to research the current planning and control in health care organizations. Therefore, this section will present the available literature of planning and control in health care organizations. The first section will discuss various reasons why health care planning and control still lags far behind manufacturing planning and control. The second section will discuss possibilities for structuring the planning and control in health care organizations. It will present frameworks proposed by various researchers for planning and control in health care organizations. The final section will present the current research on shared resources in health care organizations. Residents are a form of shared resources, which is why the planning and control of shared resources is relevant.

3.3.1 Comparison with manufacturing planning and control

Planning and control in health care organizations has received an increased amount of attention over the last ten years, both in practice and in the literature. The rising expenditures in health care organizations activate hospitals to organize their processes more efficiently and effectively. Planning and control comprises integrated coordination of resources (e.g. staff, equipment and materials) and product flows, in such a way that the organization's objectives are realized (Anthony, 1965). Unfortunately, health care planning and control lags far behind manufacturing planning and control. Successful manufacturing planning and control concepts cannot be directly copied, because of the unique nature of health care delivery (Hans, Houdenhoven & Hulshof, 2011). There are common reasons stated in the literature for the fact that health care planning and control lags far behind manufacturing planning and control. These reasons include:

1. Health care organizations are professional organizations which often lack cooperation between involved parties (e.g. doctors, administrators or managers). These groups have their own, often conflicting, objectives (Hans et al., 2011).
2. Due to the state of information systems in health care organizations, crucial information required for planning and control is often not available. The existing information systems tend to be poorly integrated with each other. This lack of integration is impeding the advance of integrated planning and control in health care (Khoumbati, Themistocleous & Irani, 2006).
3. Health care organizations such as hospitals generally consist of autonomously managed departments. Managers tend not to look beyond the border of their department, and planning and control is fragmented (Porter & Teisberg, 2007).
4. While health care managers are generally dedicated to provide the best possible service, they lack the knowledge and training to make the best use of the available resources (Carter, 2002).

From these problems, it is shown that there are still a lot of possibilities in health care organizations to improve the current systems. This includes the planning and control of shared resources.

3.3.2 Structuring planning and control in health care organizations

To improve the current planning and control of health care organizations, the planning and control functions and their interaction should be structured. This section will discuss possibilities for structuring the planning and control process in health care organizations. Various researchers have proposed frameworks to structure the functions and interactions of planning and control in health care organizations. These described frameworks provide guidelines for this research.

The first proposed hierarchical framework that is based on planning and control is introduced by Rhyne and Jupp (1988). This framework considers only resource capacity planning and material planning. De Vries, Bertrand & Vissers (1999) had critic on this framework and elaborated design requirements for health care production control systems themselves. In a follow-up paper, Vissers & Beech (2005) use these requirements and propose a framework for production control in health care organizations. This hierarchical framework for production control of hospitals deals with the balance between service and efficiency, at all levels of planning and control. Many frameworks for health care planning and control focus on just one area- mostly resource planning, as the framework from Vissers & Beech (2005). However, there also exist frameworks that focus on hospitals as a whole. The most recent framework that combines multiple areas of planning and control in health care organizations, is proposed by Hans et al. (2011). They propose a four-by-four generic framework that spans four managerial areas and four hierarchical levels of control. These two are combined to form the overall framework for health care planning and control.

The framework proposed by Hans et al. (2011) forms a basis for decomposing the planning and control activities. The planning and control of residents could be structured by using the four hierarchical

levels of control: structural, tactical, offline operational and online operational planning and control. Structural planning addresses structural decision making, for instance resource capacity extension or implementation of new protocols. “Offline” operational planning reflects the planning level that concerns the in advance planning of operations. It comprises the detailed coordination of activities regarding current demand, for instance staff rostering. “Online” operational planning involves control mechanisms that deal with monitoring the process and reacting to unanticipated events, for instance add-on scheduling or triaging. While strategic planning addresses structural decision making, tactical planning addresses the organization of the operations: what, where, how, when, who. It is similar to operational planning; however, decisions are made on a longer planning horizon. For instance, while capacity is fixed in operational planning, capacity expansions or hiring staff are possible in tactical planning. Examples of tactical functions are block planning or budget allocation (Hans et al., 2011).

The content of the framework for health care planning and control of Hans et al. (2011) should accommodate to the context of the application, the external environment. The external environment is those factors that occur outside of the organization and cause changes inside the organization, for the most part, beyond the control of the company (Noh et al. 2011). A categorization that can be used for the external environmental influences is described by Johnson, Scholes & Whittington (2008) and is called “PESTEL”. “PESTEL” categorizes environmental influences into six main types: political, economic, social, technological, environmental and legal. This categorization will be applied to the initial framework for planning and control of residents in the next section.

3.3.3 Shared resources in health care organizations

Shared resources are a common used concept in improving healthcare performance (Maenhout & Vanhoucke, 2013). A shared resource is defined as a common-capacity source used in two or more ways (Hoekstra & Romme, 1992). In hospital settings, examples of shared resources are diagnostic equipment, beds, or physicians, which are utilized in multiple entities such as different patient groups or multiple departments. The main reason for hospitals to use shared resources is to maximize the use of a scarce resource. For instance, diagnostic equipment is scarce and need to be used by various departments and processes. This usage of multiple departments and processes makes the planning and control of resources complex. Besides diagnostic equipment, shared resources can have all different kind of possibilities. For instance, physicians have a different set of skills and are therefore capable for a different set of treatments. Residents can also be seen as a form of shared resources. They are acting both as students who must attend educational activities and as providers of patient care services.

In the last few decades, the healthcare industry has given a lot of attention to scheduling of shared resources (Van den Bergh, Beliën & De Bruecker, 2013). Most literature on scheduling of shared hospital resources concerns beds (Ridge et al., 1998), outpatient departments (Cayirli and Veral, 2003) and staff (Topalogu, 2006). Currently, there is no research performed on the allocation of residents as shared resources. The allocation of shared resources in hospitals is only researched in the allocation of nurses (Brusco & Showalter, 1993; Maenhout & Vanhoucke, 2013) and in the allocation of physicians (Dannenburg, 2016; Bekkan, 2010; Winands, de Kreuk & Vissers, 2004). Dannenburg (2016) and Bekkan (2010) assess scheduling policies for the allocation physicians. Furthermore, Winands et al. (2004) provide a case study that deals with the process of developing schedules for the activities of medical specialists.

It can be concluded that there is no research available on the allocation of residents as shared resources. However, there are studies conducted on the allocation of nurses and physicians. These studies could provide a basis for the allocation of residents.

3.4 Initial framework for planning and control of residents

The framework for health care planning and control of Hans et al. (2011) can be applied to the context of the planning and control of residents. This section will present an initial framework for the planning and control of residents. Furthermore, it will apply the framework to the context of this research and address its external environment.

Considering the input, output and performance indicators discussed in section 2.3 and combining them with the internal and external aspects of the framework of Hans et al. (2011), the initial framework of Figure 5 can be composed. The model consists of a system that has an input, an output, an external environment and performance indicators. The model consists of the planning and control of the residents and the usage of this planning and control on the work floor, as shown in Figure 5. The planning and control is divided in four steps: structural, tactical, offline operational and online operational planning and control. These steps are in line with the framework of Hans et al. (2011).

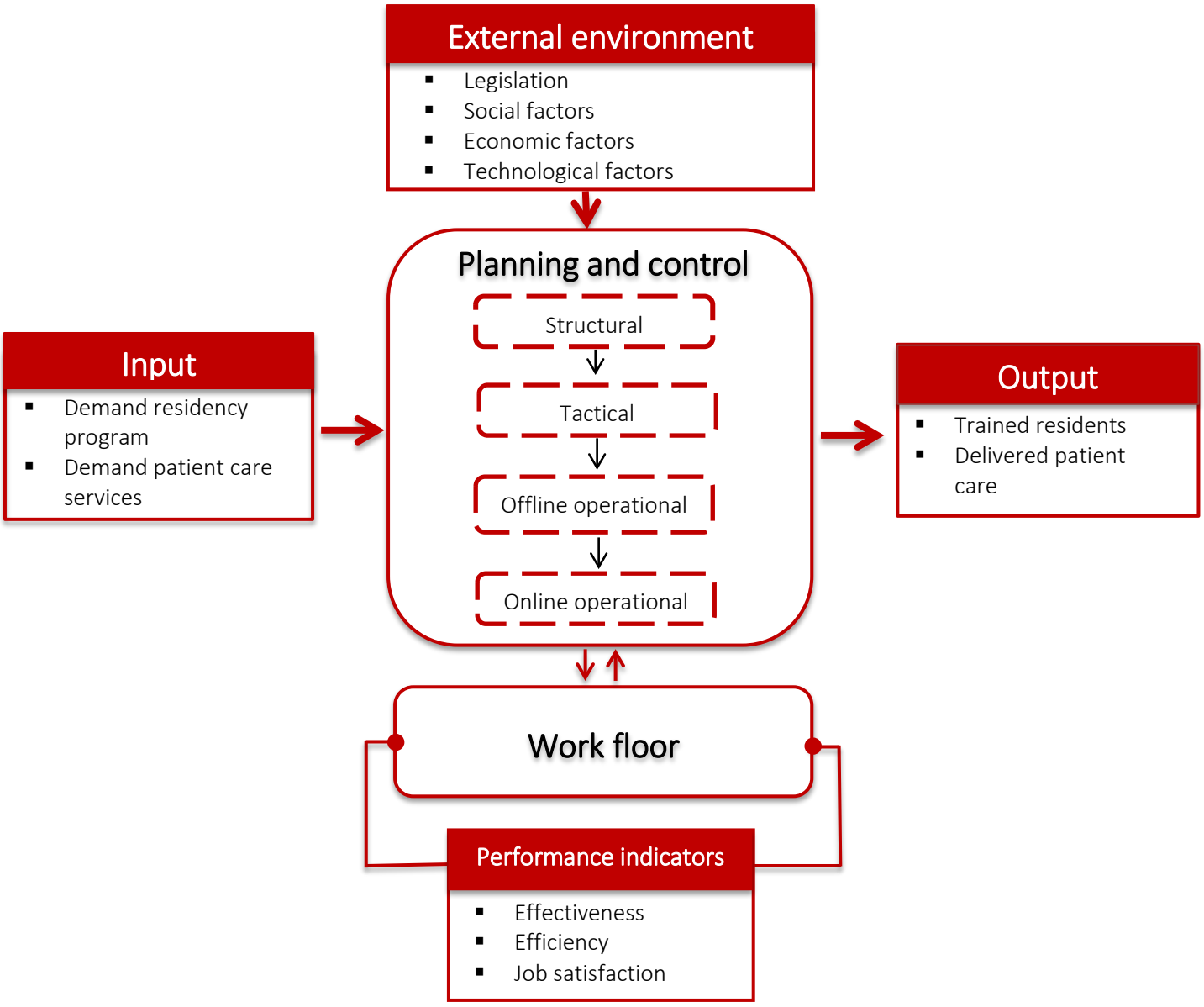


Figure 5: Initial framework for planning and control of residents

The external environment of the initial framework presented in Figure 5 consists of the four external environmental factors: economic, social, technological and legislation. In the initial framework, the environmental and political factors are left out of scope, because the influences of these factors are too small. The external environmental factors are shown in Table 1 and further elaborated below.

Economic factors

The economic factors that are included in the external environment of this research are the funding of the residents and the operational efficiency of the hospital. The funding for the residents is controlled by the government. Furthermore, the operational efficiency of the hospital highly influences the external environment of the planning and control of services in hospitals (Cardoen, Demeulemeester & Beliën, 2010).

Social factors

There are a couple of social factors that cannot be influenced by the hospital, however they influence the planning and control of residents. These include illnesses of residents, vacations and other days off, pregnancies, part time workers and languages.

Technological factors

One of the technological factors that influences the external environment is the current available planning systems. There is no room for improvement in planning systems if a better planning system does not yet exist. Furthermore, the current available software systems for supervision influence the external environment. If there is a software system that makes the supervision of residents faster, it changes the planning and control of residents. Finally, the technology of Medicine is an external factor. If the technology of Medicine changes rapidly, the residency program need to be adjusted and new internships may be added to the residency programs.

Legislation

The final category that influences the external environment is the legislation. There are two forms of legislation that need to be considered: business regulations and the residency program regulations. The business regulations are for instance quality regulations of the hospital and the 'Collective Arbeidsovereenkomst'. The regulations of the residency program are for example the number of internships, the amount of competences that need to be gained or the amount of supervision. These regulations differ for each residency program.

External environment	
Economic factors	Funding residents
	Operational efficiency of the hospital
Social factors	Illnesses
	Vacations
	Pregnancies
	Part-time / full-time
	Languages
Technological factors	Current available planning systems
	Current available software systems for supervision
	Technology of Medicine
Legislation	Business regulations
	Residency program regulations

Table 1: External environment

3.5 SUMMARY OF MAIN FINDINGS

This chapter addresses the question: *"Which guidelines are available for developing a framework for the planning and control of residents' activities?"* The planning and control of residents needs to serve two purposes: provide training to the residents and provide staffing for the hospitals. The schedule must ensure that each resident completes the appropriate number of internships and in addition, the schedule must ensure that the hospital meets the need of the provision of patient care services.

In the last few decades, the healthcare industry has given a lot of attention to scheduling of shared resources (Van den Bergh, Beliën & De Bruecker, 2013). Most literature on scheduling of shared hospital resources concerns beds (Ridge et al., 1998), outpatient departments (Cayirli and Veral, 2003) and staff (Topalogu, 2006). Currently, there is no research performed on the allocation of residents as shared resources.

Due to the many parties with their often conflicting interests and requirements, researchers classify the planning and control of residents as complex (Cohn et al., 2009; Day et al., 2006). In addition, composing schedules for residents' activities is still a time consuming and frustrating process in many hospitals (Gaba & Howard, 2002; Güler et al., 2013; Prins et al., 2007). However, currently there are no solutions presented for the planning and control of residents, which combine both the training and staffing purposes. To deal with the complexity of the planning and control problem, literature suggests to decompose it by defining a planning and control framework. Unfortunately, no such framework for residents' activities yet exists.

To develop a planning and control framework for residents' activities, guidelines from the proposed generic health care framework of Hans et al. (2011) can be used. This four-by-four generic framework spans four hierarchical levels of control and four managerial areas. The framework of Hans et al. (2011) is used to propose an initial framework for the planning and control of residents. This initial framework provides the basis of this research on planning and control of residents.

4. SYSTEM DESCRIPTION

This chapter will describe the setup and operations of the planning and control systems of the Radiology department of the UMCG. It will answer the second research question: *What is the design of the current planning and control system of the Radiology residency program of the UMCG?* The chapter will zoom in on the planning and control of residents and the activities on the work floor, as shown in Figure 6. First, section 4.1 will provide information about the Radiology department and the way the residency program is integrated in the department. Furthermore, it will provide information about the residency program for radiologists and the requirements of the residency program. The second section will elaborate on the current planning and control of residents' activities. It will provide information about the current scheduling system, structured according to the four levels of planning and control shown in Figure 6.

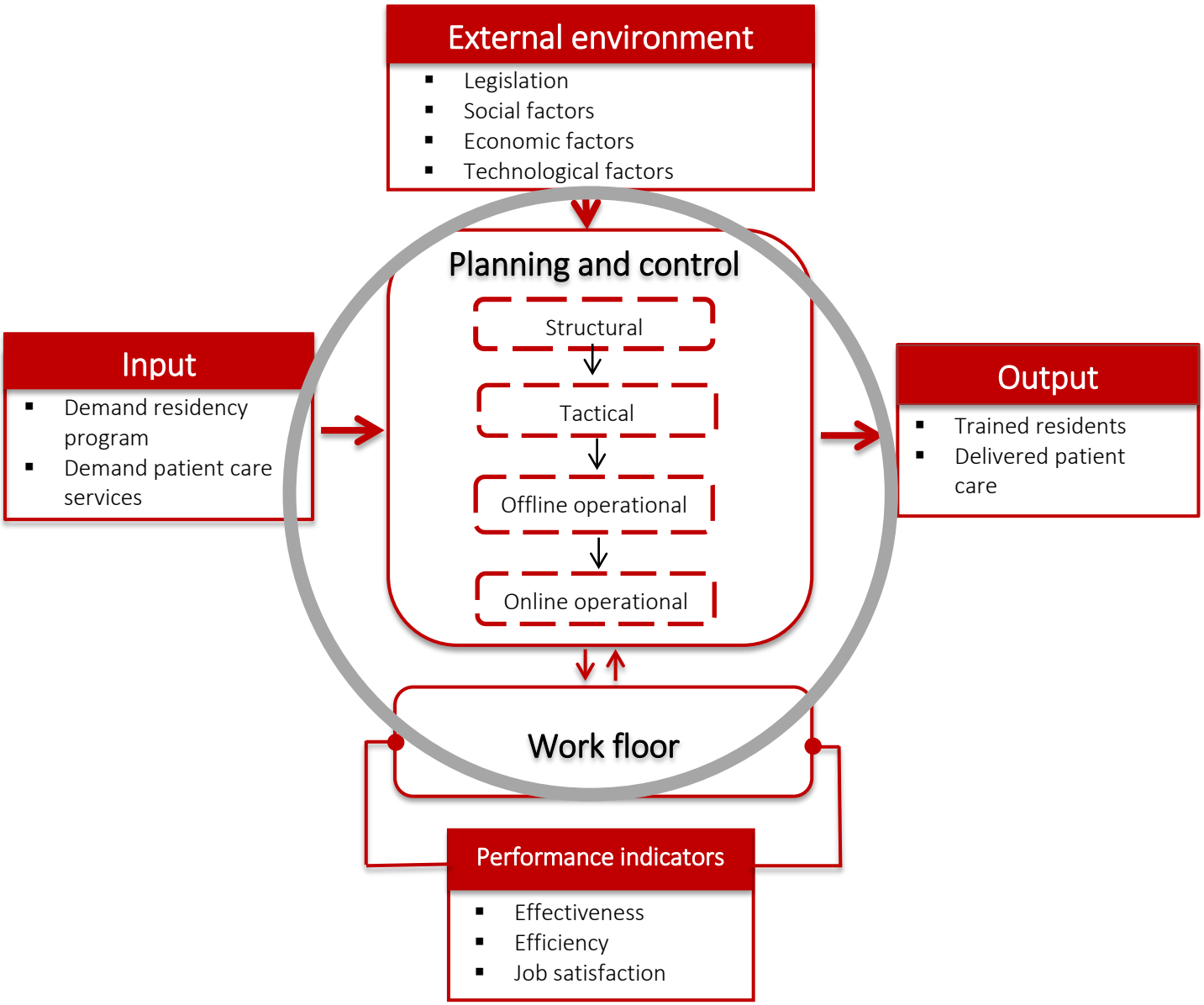


Figure 6: Conceptual model - Focus of chapter 4

4.1 RADIOLOGY RESIDENCY PROGRAM

The Radiology department uses imaging technologies to see within the human body to diagnose diseases and abnormalities. The Radiology department simultaneously educates around 25 residents to become a specialist in the field of Radiology. These residents have many tasks, which both involve tasks that must be completed for the residency program and tasks that are done to contribute to the patient care services.

The department of Radiology is divided into seven sub-specialties. These sub-specialties are also the seven themes that are included in the residency program, together with Nuclear Medicine as the eighth theme. The seven sub-specialties of Radiology are as follows:

1. Cardiothoracic Radiology
2. Abdominal Radiology
3. Interventional Radiology
4. Neuroradiology
5. Musculoskeletal Radiology
6. Mammography
7. Pediatric Radiology

To elaborate on the different tasks residents must complete, the remaining part of this section discusses the Radiology residency program and the tasks they must complete for the patient care services. Figure 7 shows the combination of these various tasks for the patient care services with the internships for the residency program. It is important to note that, although the tasks for the provision of patient care services are not directly a part of the residency program, they contribute to the learning and autonomy of residents. Furthermore, during the internships, the residents contribute to the provision of patient care services. Thus, although these two are separated in Figure 7, they have many integrated components.

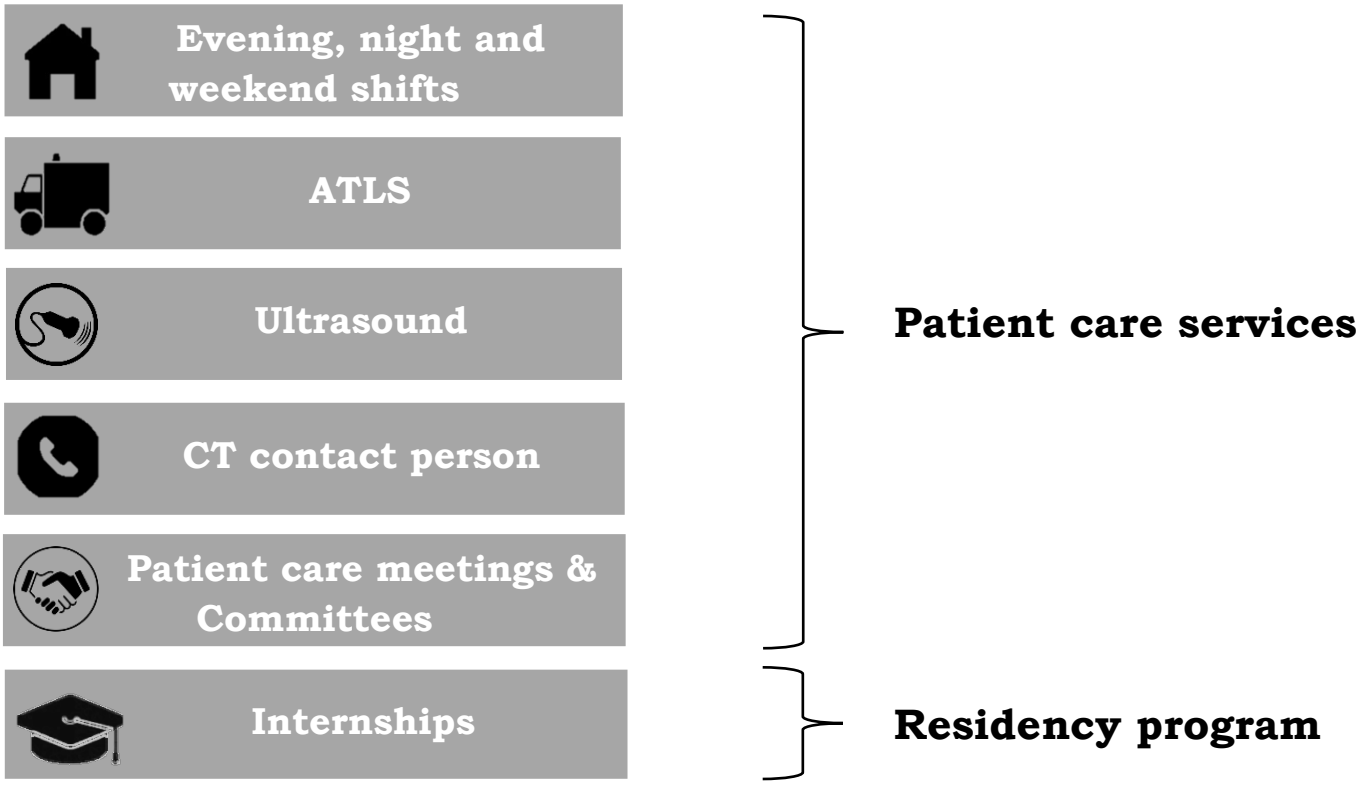


Figure 7: Residents´ tasks

The residency program of radiologists consists of 5 years in which trainees gain experiences with the clinical themes of Radiology. The program consists of two parts: the common trunk and the differentiation phase. The common trunk is the general basis of the program and takes 2.5 years. The common trunk consists of all the seven specialties of Radiology as discussed in the previous section, together with Nuclear Medicine as the eighth theme. The second part of the program is the differentiation phase, in which residents choose one or two of the 8 themes as differentiations to build extensive knowledge and experience on these themes. Furthermore, the differentiation phase consists of 1-year general Radiology. The structure of the residency program is shown in Figure 8.

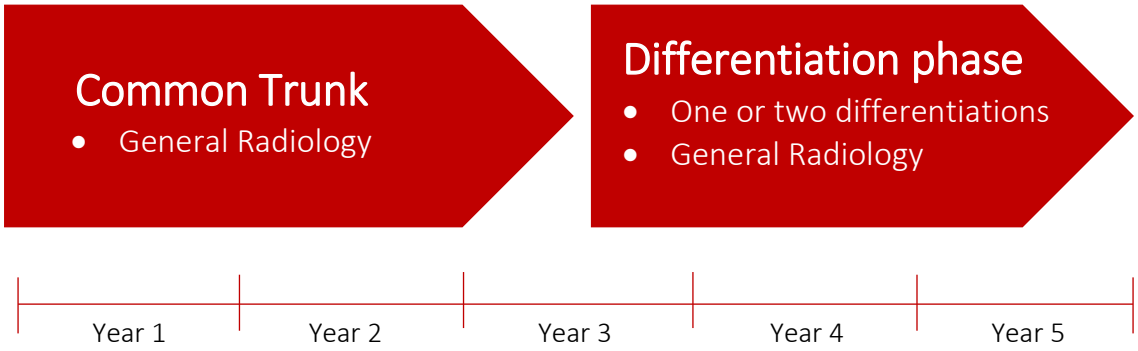


Figure 8: Structure of the Radiology residency program

During the common trunk and the differentiation phase, the residents must attend internships to gain more knowledge in the eight themes of Radiology. These internships consist of providing patient care services under close supervision of a radiologist. The residents must attend a certain number of weeks at each of the specific themes. The required numbers of weeks are stated in the national residency program, the regional residency program and the local residency program. The number of weeks that residents need to spend at their internships conform the local residency program, are shown in Table 2 and 3. The number of weeks that residents need to spend at their internships conform the national and regional residency program are shown in Appendix C and D, respectively. The local residency program may differ 10% per theme from the national residency program. This gives the individual residency programs the opportunity to give their program a 'local touch'. For instance, the UMCG has chosen to increase the number of weeks for the internship of Musculoskeletal Radiology in the first year from 8 to 10 weeks. Furthermore, they have chosen to increase the number of weeks for the internship of Pediatric Radiology of the second year from 8 to 10 weeks, as shown in Table 2.

Residents need to attend certain internships in the first nine months of their residency program in preparation of taking evening, night and weekend shifts. These required internships are also shown in Table 2, represented by the "( )" next to the required number of weeks of the first year. Furthermore, besides the weeks shown in Table 2, all residents have an introduction week in their first week of the residency program.

Theme	Year 1	Year 2	Year 3 1st half	Total common trunk
Cardiothoracic Radiology	12 (8)	4	4	20
Abdominal Radiology	12 (10)	4	4	20
Interventional Radiology		4	4	8
Nuclear Medicine and Molecular Radiology		8		8
Neuroradiology	8 (8)	4	4	16
Musculoskeletal Radiology	10 (8)	4	4	18
Mammography		8		8
Pediatric Radiology		10		4
Radiation hygiene	4			
Subtotal in weeks	46	46	20	114
Choices, conferences, vacations etc.	6	6	6	18
Total in weeks	52	52	26	130
In years	1	1	0,5	2,5

Table 2: Number of internship weeks - Common trunk

Theme	Months	Weeks
Cardiothoracic Radiology	18	78
Abdominal Radiology	18	78
Interventional Radiology	18	78
Nuclear Medicine and Molecular Radiology	18	78
Neuroradiology	12	52
Musculoskeletal Radiology	12	52
Mammography	6	26
Pediatric Radiology	6	26

Table 3: Number of internship weeks - Differentiation

The residency program is structured to develop certain competences. The core of these competences is the integration of the elements of knowledge, skills and attitude conform certain activities. These activities are called Entrustable Professional Activities (EPA's). For each theme, there are developed 10 à 15 EPA's, which means that the total number of EPA's is around 120 for the whole residency program. These EPA's are coupled to the level of skills that the resident manages. Each of these levels is coupled to a level of supervision. For instance, with the level of skills of 1 or 2, the resident gets much supervision from the staff. However, with level of skills of 3 or 4, the resident only gets supervision when he or she asks for it. When a resident is in his or her fifth year of the residency program, it is even possible that the resident already has a level of skills of 5 and does not need supervision anymore in a specific sub-specialty. This resident could even supervise other residents with a level of skills of 1 or 2 in that sub-specialty. The number of weeks defined in Table 2 and 3 are guidelines for the residency program. However, if the resident does not manage a certain level of skills and EPA's, they might have to attend more weeks at an internship.

4.2 Planning and control of Radiology residents

This section will discuss the current planning and control system of Radiology residents. The section is divided in three parts, according to the levels of planning and control presented in the initial framework: structural, tactical and offline and online operational planning and control.

Structural planning and control

The capacity of the Radiology department of the UMCG is based on the availability of staff and other resources, such as MRI scanners. The department has a maximum capacity set by the hospital, which is besides the availability of resources also based on the demand of patient care services. However, the policy is that the patient care services cannot grow further than the capacity of the resources. Therefore, the department first has to decide on the percentage of volume of patient care services that will be satisfied. The department holds 33 FTE of radiologists, together with an average of 25 residents. These radiologists and residents are divided among the seven sub-specialties.

The UMCG is part of an educational region, called the 'Onderwijs- en opleidingsregio Noord-Oost Nederland' (OOR N&O). This region includes the hospitals from the northeast of the Netherlands; Ziekenhuis Groep Twente, Deventer Ziekenhuis, Medisch Spectrum Twente and Isala Zwolle. To gain more experience, residents need to spend a minimum of one year in another hospital of the region. The residency program must take place at least 12 months in an academic hospital and 12 months in a peripheral hospital. This means that all the residents that started in the UMCG will spend a year in a peripheral hospital and the residents of the peripheral hospitals will spend a year in the UMCG. This exchange generally takes place in the third year of the residency program. More information about this OOR N&O regional program can be found in Appendix D.

Tactical planning and control

Currently, the planning and control of residents' activities is done by various different stakeholders. First, the residency program is scheduled by the program coordinator. The schedule for the internships of the residency program is composed in an empirical "trial-and-error"-way, using Microsoft Excel. Furthermore, the evening, night and weekend shifts are scheduled by the residents. The schedule for evening, night and weekend shifts is composed by filling in the preferences of the residents and is constructed in Microsoft Excel. Finally, the planning department of Radiology is the department that plans the patient care services. Thus, they are, among others, planning the residents and staff for the provision of patient care services. The provision of patient care is scheduled in a system called Ortec Multi Resource Planning (OMRP).

At the UMCG, residents fulfill various tasks that include taking evening, night and weekend shifts and attend the ATLS. These tasks are not part of the residency program; however they are currently fulfilled by residents. Although these tasks are not directly a part of the residency program, they contribute to the learning and autonomy of residents. The residents are providing the patient care services under close supervision of a radiologist. The various tasks of the residents will be elaborated below.

Evening, night and weekend shifts

After 9 months of following the residency program, residents are taking evening, night and weekend shifts. The fact that residents are fulfilling these evening, night and weekend shifts is decided by the Radiology department. These decisions could be changed in the future. To be allowed to take evening, night and weekend shifts, residents need to possess the necessary competences gained in the first 9 months. The current structure for the evening, night and weekend shifts is shown in Table 4.

Type of shift	Hours	Comments
Evening shift	5 days between 17.00-23.00h	From 12.30 present at internship
Weekend shift	Saturday-Sunday from 8.00-20.00h	One day off before or after the shift
Night shift 1	4 days Monday-Thursday between 23.00-8.00h	Next day off
Night shift 2	3 days Friday-Sunday between 20.00-8.00h	Friday, Monday and Tuesday off

Table 4: Structure evening, night and weekend shifts of Radiology residents

The night shifts during the weekdays, thus the night shifts from Monday-Thursday, are considered in the internships schedule. The residents do not attend their internship in this week, due to these evening, night and weekend shifts. The other evening, night and weekend shifts are not considered in the internships schedule, because residents still attend a part of their internship the next day.

ATLS

After 9 months of following the residency program, the first-year residents have gained enough competences to take shifts at the Acute Trauma Life Support (ATLS) (in Dutch: Spoed Eisende Hulp). In the 10th month of the residency program, residents will have two weeks of introduction at the ATLS. In these two weeks, they will be taught how to work during their evening, night and weekend shifts. During these two introduction weeks, they are supervised by a fourth- or fifth-year resident. This is the same case for the residents from peripheral hospitals that come to the UMCG in their third year. These residents also have two weeks of introduction at the ATLS together with a fourth- or fifth-year resident. The fourth- or fifth-year residents are in the current situation mostly taken from a Musculoskeletal Radiology internship, because this is the most relevant internship combined with the ATLS.

The ATLS shift are divided in two day shifts; AM and PM shifts. Most of the tasks of the ATLS are answering questions from people that call to the residents. The ATLS shift is done together with a day at the internship. Each day there is a sub-specialty of Radiology that provides the services of the ATLS. For instance, on Monday the Adnominal Radiology provides the services of the ATLS and on Tuesday the Musculoskeletal Radiology provides the services of the ATLS. One of the residents that is attending the internships of the sub-specialty that fulfills the ATLS at that day, is on-call for the ATLS shift. However, there are some exceptions. For instance, when there are only a few residents at the sub-specialty that provides the services of the ATLS, sometimes another resident has to attend the ATLS shift

The two weeks of introduction at the ATLS are considered in the internships schedule, for both the first- and third-year residents and the supervising fourth- or fifth-year residents. The other ATLS shifts are not considered in the internships schedule, because residents can still attend their internships during that day and during the rest of the week.

Ultrasound

Besides the evening, night and weekend shifts and the shifts at the ATLS, the residents are attending the ultrasound internship (in Dutch: echo stage). Each first-year resident must attend an internship of 6 weeks performing ultrasound imaging. At the beginning of these 6 weeks, the residents are introduced to the ultrasound by a technician. The wish of the technicians is that there is only one first-year resident at a time, such that the supervision is minimized. Furthermore, the primary supervision is done by an abdominal radiologist. Besides the ultrasound internship in the beginning of the residency program, residents fulfill ultrasound shifts to provide patient care services. The ultrasound shifts are provided by every resident a couple of times. Thus, the ultrasound shifts are also attended by fourth- and fifth-year residents, such that they don't unlearn the competences they gained for ultrasound imaging. However, for first-year residents these shifts are way more interesting to attend than for older year residents.

CT-contact person

The technicians that perform the CT scans have a contact person who they can call in case of an emergency. There is a special workplace allocated to this contact person, such that this person is close to the emergency that might happen. The resident is alone at this workplace, which makes the supervision difficult. However, residents still perform tasks for their internships while being at this workplace.

Patient care meetings & Committees

The final task of residents is attending patient care meetings and involve in committees. These are divided in three subjects:

- *Intensive Care (IC) meetings*; From the second year of the residency program, residents have an extra task: the IC meetings. These IC meetings are most time-consuming on Monday, due to the events that happened during the weekends. The other days the IC meetings only take around an hour.
- *Multidisciplinary care meetings*; Each sub-specialty has multidisciplinary care meetings with other departments of the UMCG, to discuss diagnosis and treatments of patients. For instance, Musculoskeletal Radiology has a weekly clinical meeting with the department of Rheumatology. Residents are asked to take place in these weekly multidisciplinary care meetings.
- *Committees;* Residents are expected to involve in committees that are relevant for the residency program. These committees include for instance being resident representative for the residency program or being resident member of the regional education committee.

The planning and control of residents has various requirements that need to be considered. One of these requirements is the maximum number of residents that the sub-specialties can accommodate at their internships. For instance, Mammography has a maximum number of residents of one, since they only have one patient at a time. It would cause problems if two residents are assigned to assist one patient. The maximum number of residents at the sub-specialties are shown in Table 5.

Sub-specialty	Maximum capacity
Cardiothoracic Radiology	4
Abdominal Radiology	5
Interventional Radiology	3
Nuclear Medicine and Molecular Radiology	2
Neuroradiology	4
Musculoskeletal Radiology	3
Mammography	1
Pediatric Radiology	2

Table 5: Educational capacity of residents per sub-specialty

Besides the maximum number of residents at a sub-specialty due to capacity, the amount of supervision should also be considered. The number of residents cannot exceed the number of staff available for supervision with the number 1.5. The residents need supervision from staff, to supervise their tasks during the day. At some sub-specialties, there are only a limited number of staff members available for supervision, which needs to be taken into account. The total available staff members in FTE in 2017 for supervision per sub-specialty are shown in Table 6.

Sub-specialty	Supervisors (in FTE)
Cardiothoracic Radiology	3.9
Abdominal Radiology	5.4
Interventional Radiology	5.4
Nuclear Medicine and Molecular Radiology	2.1
Neuroradiology	5.9
Musculoskeletal Radiology	4.7
Mammography	1.4
Pediatric Radiology	2.3

Table 6: Availability of supervisors per sub-specialty in 2016

Offline and online planning and control

The offline and online operational planning and scheduling are the actual allocation of residents to their internships and tasks. As elaborated in the previous section, this allocation is done by various stakeholders. Therefore, these stakeholders are integrating the schedule of the residents manually. They try to frequently share their composed schedules, to make sure the integration of the schedules is up-to-date. Furthermore, to allocate the residents to their tasks, the wishes and requests of residents are considered. Residents can for instance take days off for conferences and vacations. In the current situation, these wishes and requests are almost always satisfied. In addition, for the allocation of residents to their internships, the educational capacity and the availability of supervisors should be taken into account.

5. SYSTEM ANALYSIS

This chapter will provide an analysis of the performance and the causes and effects of the problems regarding the Radiology residency program of the UMCG. It will underpin the need for the development of a framework for the planning and control of residents. The chapter will give an answer to the third research question: *What is the performance of the current planning and control system of the Radiology residency program of the UMCG and how can this performance be explained?* This chapter consists of three parts; measuring the performance, analyzing the causes and effects and underpinning the need for a planning and control framework. It will create a link between the planning and control of residents and the performance of the system, as shown in Figure 9. Section 5.1 will measure and document the current state of the planning and control system. Furthermore, section 5.2 will provide an analysis of the available data to identify root causes of the performance of the system. In addition, section 5.3 will list the main causes of the problems and rates their impact on the system. Finally, section 5.4 will provide a summary of this chapter and present the need for a planning and control framework for residents' activities.

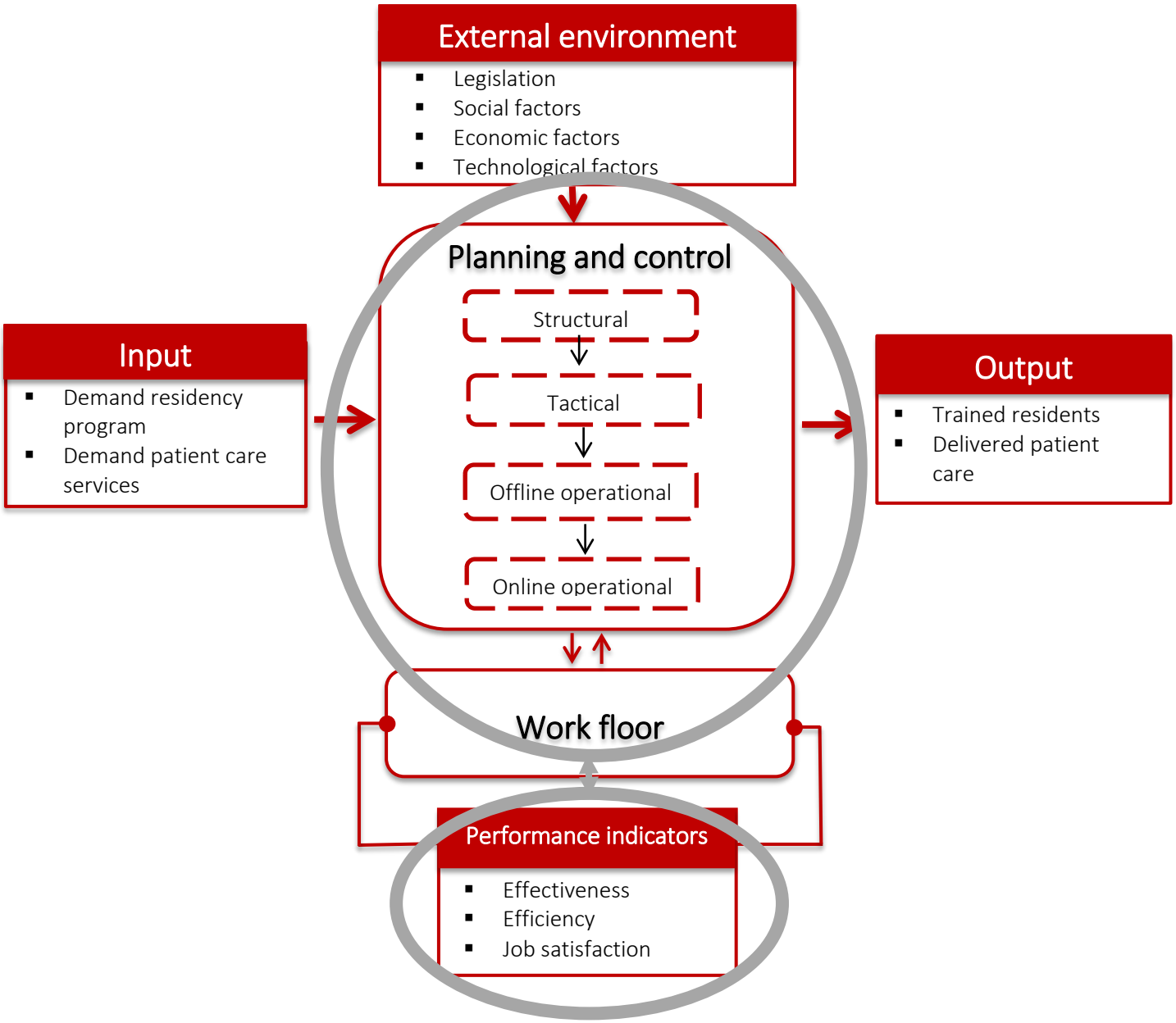


Figure 9: Conceptual model - Focus of chapter 5

5.1 PERFORMANCE OF THE CURRENT SYSTEM

This section measures and documents the current performance of the system. The planning and control of the residents will be measured according to the performance indicators defined in chapter 2. These performance indicators are effectiveness, efficiency and job satisfaction. Each of these performance indicators are measured using the so called proxy indicators. The values of the proxy indicators are presented in the upcoming section.

5.1.1 EFFECTIVENESS

The effectiveness of the planning and control system of residents is measured in minimum violations of restrictions, effectiveness of the residency program and balance of the number of residents at the sub-specialties.

Minimum violations of restrictions

The government, hospitals and sub-specialties define restrictions regarding the planning and control of the residents. Examples of these restrictions are that the number of residents at an internship of the sub-specialty cannot exceed the defined capacity of residents and that the number of residents that are placed with one supervisor cannot exceed the national norm for supervision. These violations of restrictions should be minimized. There are two restrictions that will be elaborated in this research. It should be noted that these restrictions are not limited to the ones mentioned. However, these two restrictions are the most relevant for this research.

The first restriction that is elaborated is: *The number of residents at the sub-specialties cannot exceed the defined capacity.* The sub-specialties have limited capacity in the number of residents they can educate and supervise at their specialty. A good example of a sub-specialty with limited capacity is the Mammography. At the Mammography they only have one patient at a time, thus they cannot educate two residents at the same time. This capacity is not defined on paper; however the program coordinator uses assumptions about the capacity of residents in the planning of scheduling of residents. The numbers of residents at the Mammography in 2016 are shown in Figure 10. The maximum capacity is presented by the black line. There are a couple of violations during the first weeks of the years and zero residents in the middle of the year. This causes complaints from the staff members of this specialty, because they state that the residents should be balanced over the year.

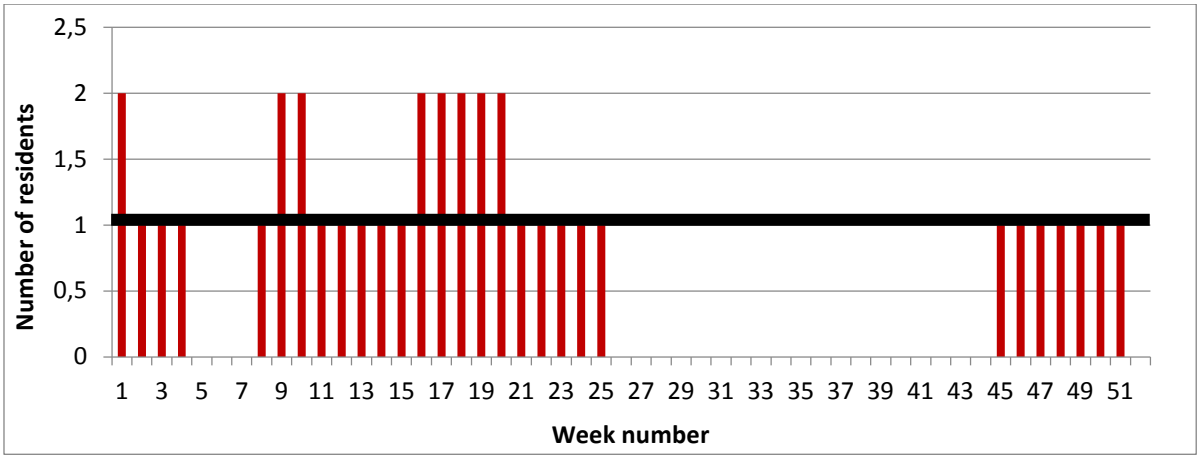


Figure 10: Number of residents at the Mammography department in 2016

These violations of capacity restrictions not only occur at the Mammography. They can also be observed at for instance the sub-specialties of Pediatric Radiology and Musculoskeletal Radiology. However, these capacity restrictions are not representative for all sub-specialties. For instance, at the Abdominal Radiology and the Neuroradiology, they have enough tasks and supervisors to educate the residents and the capacity is less important. In contradiction, they need a minimum capacity of

residents to deliver their patient care services. It is important to note that the capacity restrictions are not clearly defined and documented. The restrictions are communicated by various staff members, but not documented.

The second restriction that is elaborated is: *The number of residents at a sub-specialty should be in line with the availability of supervisors*. There is a norm defined by the Kaderbesluit of the CCMS (2016), which states that there should be 1 supervisor available for each 1.5 resident. In the current situation, it is tried to have enough supervisors available for the residents. However, the number of supervisors is not adapted to the number of residents at the internships. For instance, it occurred that there were three residents attending an internship, with only one supervisor available. This happens easily when all the staff members are taking a day off in the same period or if there is a conference that staff members are going to. These situations are hard to avoid. Generally, the number of available supervisors is conform the norm of 1.5 residents. However, in some cases supervisors have to perform other tasks, such as writing reports and conducting research. In those situations, they are less available for supervision. The number of residents at a day can be calculated together with the availability of staff for supervision on that same day. If the number of staff is lower than 1.5 times the number of residents, it is calculated as a violation. The numbers of violations of supervision for the sub-specialties in 2016 are shown in Table 7. It can be observed that the sub-specialties of Neuroradiology and Cardiothoracic Radiology have the highest number of violations. Therefore, these two sub-specialties are further analyzed. The results of the other sub-specialties might be different, since they have a lower number of violations of supervision. However, the Neuroradiology and Cardiothoracic Radiology give a good example of a high number of residents in combination with a low availability of staff.

Sub-specialty	Number of violations of supervision
Cardiothoracic Radiology	79
Abdominal Radiology	17
Interventional Radiology	0
Nuclear Medicine and Molecular Radiology	0
Neuroradiology	130
Musculoskeletal Radiology	15
Mammography	8
Pediatric Radiology	26

Table 7: Violations of availability of supervisors per sub-specialty in 2016

The total numbers of violations on a specific day of the week in 2016 at the Neuroradiology specialty are shown in Table 8. It can be concluded that the amount of violations is equally divided among the days of the weeks. With the numbers of Table 8, the question rises if the number of violations occurred in the same week of the internship. Thus, that the violations are occurring due to too many residents at the internships at that week. Or on the other hand, that the violations occur in different days of the week, thus that it depends on days that staff members are taking their part-time days-off. Figure 11 shows the number of violations at the Neuroradiology during the weeks of 2016. The numbers show that there are a lot of zeros and a lot of high numbers of violations. This can be concluded due to a too high number of residents at that moment at the internships. Together with Table 8, it is shown that it is not the case that for instance many staff members take a day off on Friday and there are too less supervisors available.

Days	Monday	Tuesday	Wednesday	Thursday	Friday
# of violations	27	27	30	25	21

Table 8: Violations of availability of supervisors of Neuroradiology in 2016

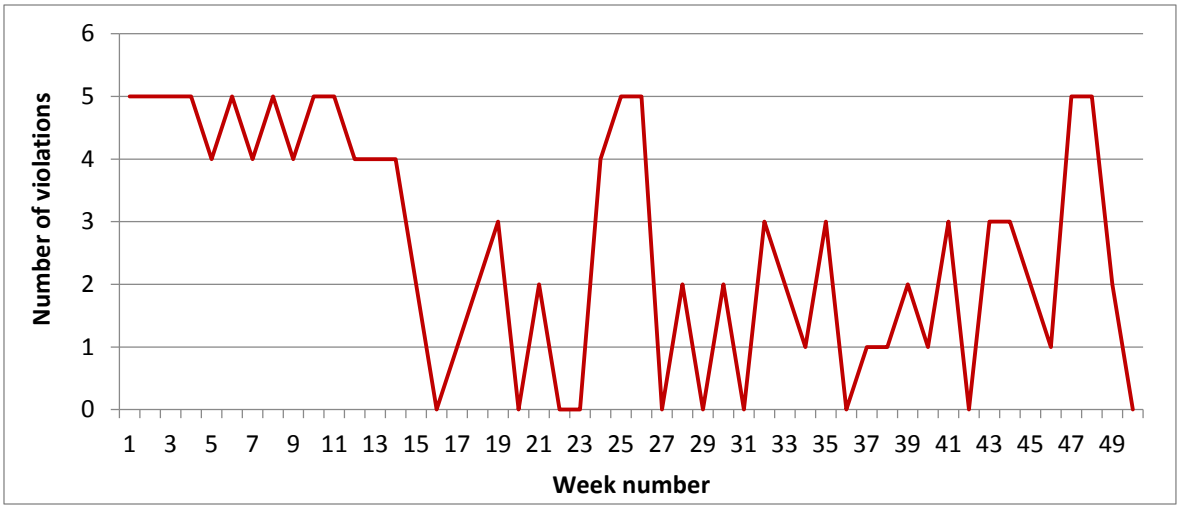


Figure 11: Violations of availability of supervisors at Neuroradiology during the weeks in 2016

Besides Neuroradiology, the numbers of violations of Cardiothoracic Radiology are calculated. The total numbers of days that there was a violation in 2016 at the Cardiothoracic Radiology are shown in Table 9. It can be concluded that the amount of restrictions at this specialty are not equally divided among the days of the weeks. For instance, the numbers of violations on Friday are three times higher than the violations on Wednesday. This is among others due to the fact that one of the part-time workers has a day off on Friday. The higher number of supervision on the other days can be explained due to radiologists working at other specialties or performing other tasks. To show that the number of violations is also dependent on the number of residents at that week, the numbers of violations at the Cardiothoracic Radiology during the weeks of 2016 are show in Figure 12. Figure 12 shows that there are a lot of zeros and a lot of high numbers of violations. Thus, besides the days off from part-time workers, also the high numbers of residents are influencing the number of violations.

Days	Monday	Tuesday	Wednesday	Thursday	Friday
# of violations	17	14	7	19	22

Table 9: Violations of availability of supervisors of Cardiothoracic Radiology in 2016

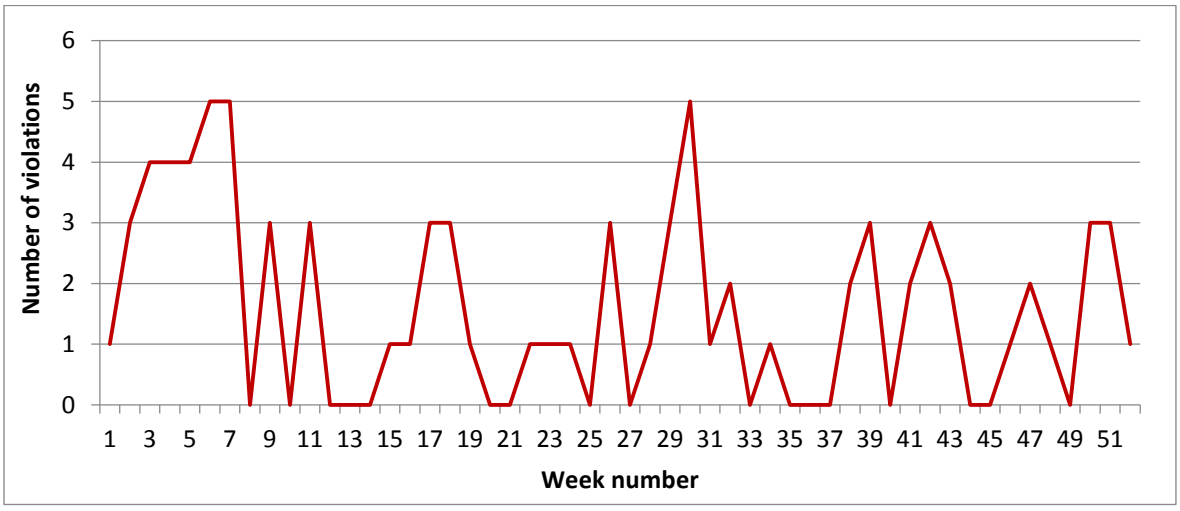


Figure 12: Violations of availability of supervisors at Cardiothoracic Radiology during the weeks in 2016

There are many violations in the provision of supervision to residents of both the Neuroradiology and Cardiothoracic Radiology specialties. These violations are explained due to high amounts of residents at an internship in certain weeks, days off from part-time workers and radiologists that perform other tasks that hardly can be combined with providing supervision to residents. At the Neuroradiology and Cardiothoracic Radiology, there are many violations on the availability of supervisors. These high numbers of violations are not representative for every sub-specialty; however, the causes of the high violations are also occurring at the other sub-specialties.

Concluding:

- There is no strict capacity defined on paper, however there are assumptions about the capacity of residents used in the planning of scheduling of residents.
- The maximum capacity of the sub-specialties is violated several times per year. This is mainly due to the fact that residents are not equally divided among the weeks.
- It is tried to have a high availability of supervisors for the residents. However, the number of supervisors is not adjusted to the number of residents at the internships.
- There are many violations in the availability of supervision of residents at the sub-specialties, especially at the Neuroradiology and Cardiothoracic Radiology.
- The violations in availability of supervisors are explained due to high numbers of residents at an internship in certain weeks. Furthermore, they are explained due to days off from part-time workers and radiologists that perform other tasks that hardly can be combined with providing supervision to residents.

Effectiveness of residency program

The overall goal of the residents is to fulfill the requirements of the residency program and to become a specialist in the field of Radiology. This goal can be measured in terms of effectiveness of the residency program. The effectiveness of the residency program is measured in terms of internship continuity and the amount of days spent at the internship.

The first aspect of effectiveness that will be elaborated is the internship continuity. The educators of the Radiology residency program wish to have 4 consecutive weeks of an internship at one sub-specialty. When having 4 consecutive weeks, residents can practice and learn more than attending just one week at a certain internship. When the residents would have a schedule with a different internship each week, gaining the required competences would be much harder. Therefore, the internship continuity is one of the terms of effectiveness of the residency program. In this situation, the internship continuity is assumed to be effective if it is equal to or higher than 4 weeks at a certain internship. The internship continuity of 20 residents in 2016 is shown in Figure 13. Not all Radiology residents of the UMCG are shown in Figure 13, because some residents spend more than half of their time at an external hospital or they just started or finished their residency program. If the resident is spending <10 weeks at the UMCG, they are not considered in the figure. Therefore, the total percentages of the Figure 13 are not adding up to 100%. The figure is used to show that in many weeks the majority of the internships are lower than four weeks. The figure shows a lot of fluctuations in the number of total weeks, which is due to residents that go to external hospitals or residents that have just started or finished their residency program. It can be observed that no resident has a schedule that consists of only internships that are equal to or more than 4 consecutive weeks. The mean of the number of internships that are lower than 4 consecutive weeks of all residents is 37.9%. This means that 37.9% of the week's spent at internships has a lower number of consecutive weeks than 4 weeks. The most occurring reason for internships to be interrupted are the night shifts, holidays and weeks at the ATLS. The night shifts, holidays and weeks at the ATLS are planned without integration with the internship schedule, which is why the internships are interrupted.

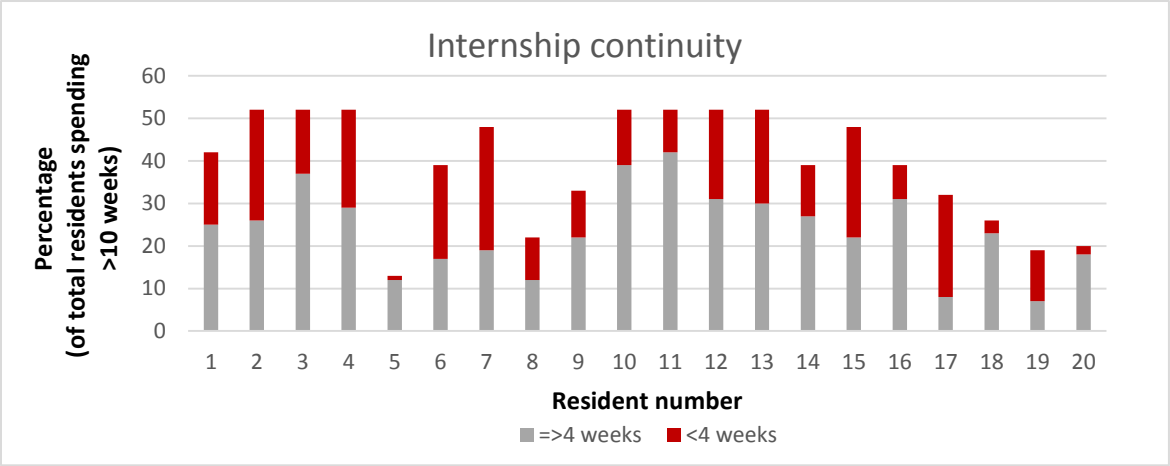


Figure 13: Internship continuity in 2016

The second aspect of effectiveness is the amount of days spent at the internships. Residents can only perform a certain percentage of their time on doing other tasks than for the residency program. These other tasks are described in chapter 4.1.2. and are for instance the ATLS and the evening, night and weekend shifts. To show the schedule of residents and their days spent at the internships, three residents are taken as an example. These three residents are all in a different part of their residency program: a first-year resident, a third-year resident, and a fifth-year resident. For each of these three residents the days actual spent at the internships during a week of 5 working days are calculated. The mean of these days in 2016 are shown in Table 10. The weeks of night shifts, holidays and ATLS internships are left out of this calculation. This means that only the weeks that they are planned at an internship are considered. It can be observed that the mean of the days actual spent at the internships is decreasing when the resident is at a higher year of the residency program. This is because residents have to perform more tasks for the provision of patient care services during higher years of the residency program.

	Mean (days)
First-/second-year resident	3.48
Third-year resident	2.84
Fourth-/fifth-year resident	2.54

Table 10: Mean days spent at the internships in 2016

To explain the mean of the amount of days actual spent at the internships, for each of the three residents an internship of 5 weeks will be discussed. Table 11 shows the schedule of a first-year resident that is attending an internship at the sub-specialty of Neuroradiology for 5 consecutive weeks. It can be observed that this resident is attending his internship at the Neuroradiology almost every working day. There are two days empty, which are days off. Furthermore, starting from week 4 he has to attend two shifts at the ultrasound. Besides the days at the internship, this resident does have some appointments with educators and committees. However, most of the time he is attending the internship. There are no night shifts or holidays that are disturbing the schedule.

Week		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	AM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology		
	PM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology		
2	AM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology		Internship Neuroradiology		
	PM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology				
3	AM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology		
	PM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology		
4	AM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology *+ Ultrasound*	Internship Neuroradiology		
	PM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology *+ Ultrasound*	Internship Neuroradiology		
5	AM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology			
	PM	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology	Internship Neuroradiology + ultrasound			

Table 11: Internship schedule of a first-year resident

The internship schedule of a third-year resident is shown in Table 12. This resident is attending an internship at the sub-specialty of Interventional Radiology for five consecutive weeks. The schedule consists of a lot of days off and days with no patient care services, although the resident is a full-time resident. This decreases the days spent at the internship highly. Furthermore, the resident takes evening shifts during the week and in weekends, which also decreases the amount of days spent at the internship. The resident also spends a day at the ATLS and a day at the ultrasound.

Week		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	AM	Night shift		No patient care services		Internship Interventional		
	PM			No patient care services		Internship Interventional		
2	AM	No patient care services	Ultrasound		Internship Interventional			Evening shift
	PM	No patient care services	Ultrasound		Ultrasound			Evening shift
3	AM	Internship Interventional	Internship Interventional		Internship Interventional	Internship Interventional		
	PM	Ultrasound	Internship Interventional		Internship Interventional	Internship Interventional		
4	AM	Evening shift	Evening shift	Evening shift		Evening shift		
	PM	Internship Interventional +Evening shift	Internship Interventional +Evening shift	Internship Interventional +Evening shift		Internship Interventional +Evening shift		
5	AM	Internship Interventional	Internship Interventional	Internship Interventional	Internship Interventional		Evening shift	
	PM	Internship Interventional	ATLS	Internship Interventional	Internship Interventional		Evening shift	

Table 12: Internship schedule of a third-year resident

Finally, the internship schedule of a fifth-year resident is shown in Table 13. This resident is attending an internship at the sub-specialty of Cardiothoracic Radiology for five consecutive weeks. This resident has a lot of days off during this internship, for instance due to night shifts.

Week		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	AM	ATLS	Internship Cardiothoracic	Internship Cardiothoracic + CT contact person		Internship Cardiothoracic + ATLS	Evening shift	
	PM	Internship Cardiothoracic	Internship Cardiothoracic	College / les		Internship Cardiothoracic	Evening shift	
2	AM						Night shift	Night shift
	PM					Night shift	Night shift	Night shift
3	AM	Night shift						
	PM							
4	AM	Evening shift	Evening shift	Evening shift	Evening shift	Evening shift		
	PM	Internship Cardiothoracic + Evening shift	Internship Cardiothoracic + Evening shift	Internship Cardiothoracic + Evening shift	Internship Cardiothoracic + Evening shift	Internship Cardiothoracic + Evening shift		
5	AM	Internship Cardiothoracic	Internship Cardiothoracic + ATLS	Internship Cardiothoracic + CT-contact person		Internship Cardiothoracic + ATLS		
	PM	Internship Cardiothoracic	Internship Cardiothoracic + ATLS			Internship Cardiothoracic		

Table 13: Internship schedule of a fifth-year resident

Conducting the analysis on the effectiveness of the residency program, a few possible causes are found. First, the internship schedule is not always consistent with the actual schedule of the resident. For instance, the first-year resident attended an ultrasound internship, but the internship schedule stated that he was attending the ATLS. This could be caused by the fact that there is no integration between the two schedules and there is a lack of communication between the schedulers. For instance, the last-minute changes are not communicated and this causes inconsistency between the schedules. Second, the percentage of the actual days of residents spending at their internship is highly influenced by illnesses of the residents. The residents are often not attending their internship due to illnesses. Third, the ATLS is most of the times combined with a day of an internship. This day is counted in the actual days spent at het internship; however the resident can be interrupted by the ATLS calls. The amount of interruptions differs per day and per moment of the day. The PM shifts are quite busy, thus these often result in spending less time at the internships. Fourth, many days off in the schedule of residents are days off from night shifts taken in the week before. The residents take around 30% evening, night and weekend shifts. These shifts are compensated with days off, which mean that residents are spending less days at their internship. Furthermore, the evening shifts are combined with a day at the internship. In practice, this results in only a few hours of effective time at the internship.

Concluding:

- The internship continuity shows much room for improvement. The mean of the number of internships that comprise less than 4 consecutive weeks of all residents is 37.9%.
- The main reasons for the interruptions of internships are night shifts, holidays and ATLS. There is no integration with scheduling these tasks, thus they are planned in the middle of internships.
- The mean of the days spent at an internship is 3.48 days for a first-year resident, 2.84 days for a third-year resident and 2.54 days for a fifth-year resident. It can be observed that the mean of the days actual spent at the internships is decreasing when the resident is at a higher year of the residency program.
- The schedule consists of a lot of days off and days with no patient care services, although the resident is a full-time resident.
- Many days off in the schedule of residents are days off from night shifts taken in the week before. The residents take around 30% evening, night and weekend shifts.
- The internship schedule is not always consistent with the actual schedule of the resident.
- The percentage of the actual days of residents spending at their internship is highly influenced by illnesses of the residents.

Balance of the number of residents at the internships

The final performance measurement of effectiveness is the balance of the number of residents at the internships. In the current situation, there are many fluctuations of residents at internships. These fluctuations should be minimized, thus the number of residents taking an internship at a sub-specialty should be balanced over time. To analyze the current balance of residents, the numbers of residents at the various sub-specialties in 2016 are shown in Figure 14. The figure shows a high number of fluctuations at all the sub-specialties. The highest fluctuations are shown by the dark blue, blue and orange lines, the sub-specialty of Neuroradiology, Abdominal Radiology and Cardiothoracic Radiology, respectively. The fluctuations at these sub-specialties are higher since the capacity of these sub-specialties is higher. For instance, Mammography only fluctuates between 0-2, because it is not possible to place more than two residents at this sub-specialty.

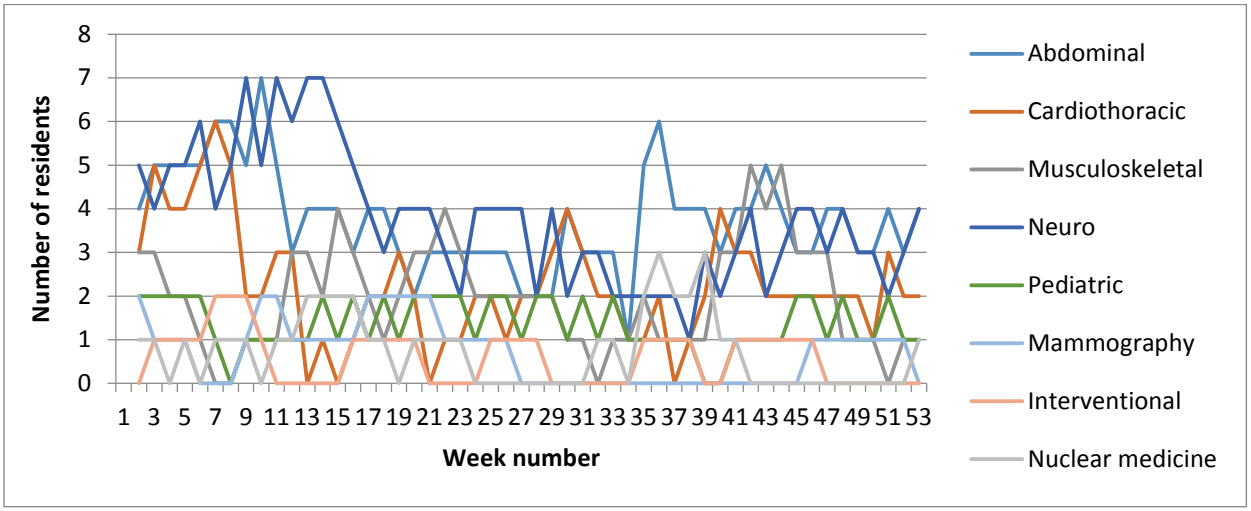


Figure 14: Variability of residents at the sub-specialties in 2016

Concluding:

- There are a high number of fluctuations at the various sub-specialties, especially the sub-specialty of Neuroradiology, Abdominal Radiology and Cardiothoracic Radiology.
- These fluctuations should be minimized, by balancing the number of residents over time.

5.1.2 EFFICIENCY

The efficiency of the planning and control system of residents is divided in maximum usage of bottleneck capacity and maximum fulfillment of residents' tasks.

Maximum usage of educational bottleneck capacity

As stated in chapter 4, there is a limited educational capacity for taking the internships at the sub-specialties. Some internships are forming a bottleneck of the system, due to restrictions of this educational capacity. These internships should be occupied as much as possible. Therefore, the usage of the bottleneck capacity should be maximized.

To analyze the usage of the capacity, two sub-specialties are taken as an example. The results of these two sub-specialties are representative for the other sub-specialties. Again Mammography is taken as an example, since they only have one patient at a time. In addition, Nuclear and Molecular Radiology is analyzed, because they also have a clear maximum number of residents they are able to educate. Figure 15 shows the number of residents at the sub-specialty of Mammography in 2016. The maximum desirable number of residents is showed with the bold black line, which is one resident for this sub-specialty. It can be observed that the maximum number of residents is exceeded 7 times in 2016. However, there are also a lot of weeks where there are zero residents at this sub-specialty. A better division would be to balance the residents over the year to not exceed the maximum capacity.

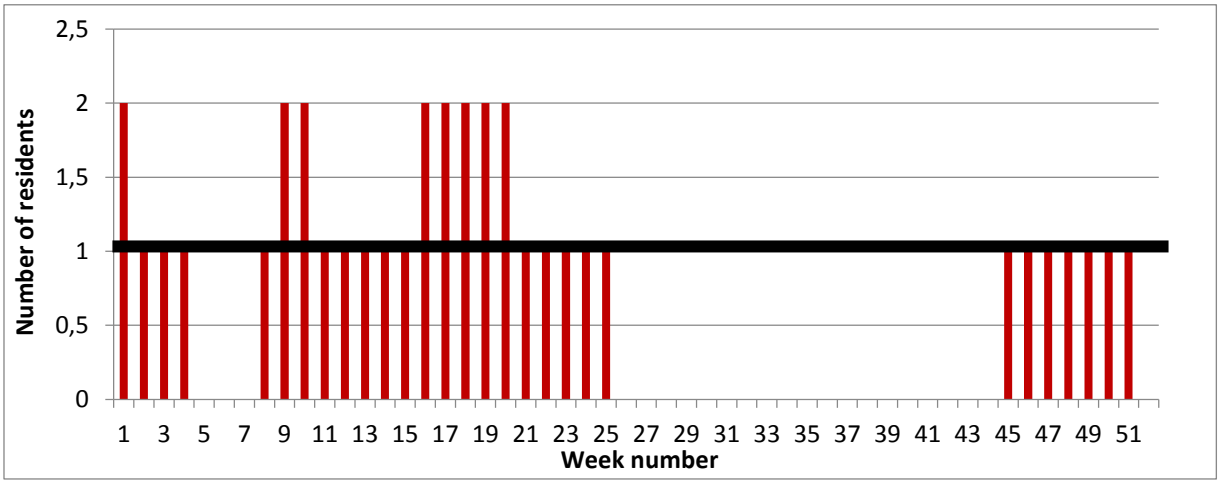


Figure 15: Number of residents at the Mammography in 2016

Figure 16 shows the number of residents at the sub-specialty of Nuclear Medicine and Molecular Radiology. The maximum number of residents is showed with the bold black line, which are two residents for this sub-specialty. It can be observed that the maximum number of residents is exceeded 2 times in 2016.

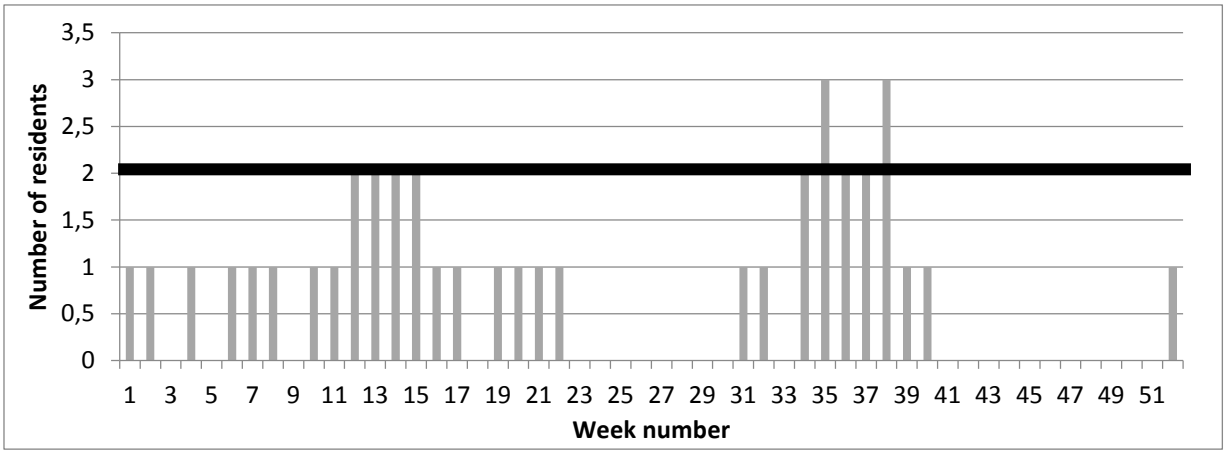


Figure 16: Number of residents at the Nuclear Medicine and Molecular Radiology in 2016

Maximum fulfillment of residents' tasks

The second component of efficiency is the maximum fulfillment of residents' tasks. In the current planning and control system, the residents need to fulfill several tasks, which all should be done to provide patient care services. First, the evening night and weekend shifts should be fulfilled. The fulfillment of these evening, night and weekend shifts is 100% in the current situation. It is impossible to skip a shift, because the treatment of patients in these shifts might be urgent.

Furthermore, the ultrasound task is fulfilled by the residents. When there are no residents available to do this task, technicians and staff members are also performing the ultrasounds. There is no clear division on which day the ultrasounds are provided by residents and on which days by technicians or staff members. Sometimes when technicians are ill, the residents need to take over these ultrasounds. In 2016, it happened only two times that there were no technicians available and all the ultrasounds were performed by residents (0.5%). Only 10.68% of the days there are more residents available than technicians. The performance of ultrasounds is also often done by staff members of the Radiology department. On the other hand, the fulfillment of ultrasound imaging is not optimal. For instance, residents that are attending an internship at Neuroradiology are planned to perform ultrasounds some parts of the week.

Concluding:

- The educational bottleneck capacity is not maximally used. For instance, there are a lot of weeks where there are zero residents at the Mammography, one of the sub-specialties that could be the bottleneck.
- There are possibilities for a better division in balancing the residents over the year.
- The current tasks of residents for the provision of patient care services are fulfilled. For instance, all the evening, night or weekend shift are fulfilled.
- However, there are possibilities for improvement for the provision of the ultrasounds. Residents that are taken from their internship to perform these ultrasounds.

5.1.3 Job satisfaction

The final performance indicator of the planning and control of residents is job satisfaction. Job satisfaction can be divided in various measures such as education environment, autonomy, supervision, physical factors and financial support (Everts, 2006). In this research two components will be considered; accepting wishes and requests and fairness among residents. These two components are considered since they have a direct relationship with scheduling the internships.

Accepting wishes and requests

Residents are supposed to express their preferences on for instance vacations and taking evening, night and weekend shifts. The job satisfaction is reflected in the degree by which these wishes and requests are granted and residents can determine their own schedule. By conducting interviews with the stakeholders, it can be concluded that the wishes and requests are satisfied almost anytime. The schedule is adjusted to satisfy the wishes and requests of the staff and residents. This might be one of the main causes of the scheduling issues of the UMCG. If during a week too less residents or staff members are available, this could be due to accepting all the wishes and requests for vacations and other days off. In the current planning and control system, the wishes and requests are in the lead of the schedule. However, this differs for the schedule of the evening, night and weekend shifts. For this schedule, there always needs to be a resident scheduled for each shift, so it is not possible to accept the fact that many residents do not want to take an evening, night or weekend shift at a specific date. For instance, the evening, night and weekend shifts during Christmas need to be fulfilled, even though this might not be the wish and request of the resident.

Fairness among residents

Besides accepting the wishes and requests, job satisfaction is expressed in fairness among residents. This fairness among residents is for instance the fair division of evening, night and weekend shifts among the residents or the fairly division of the ATLS shift among the residents. The information on the fairly division of tasks is gathered by conducting interviews with stakeholders. First, it can be concluded that it is tried to fairly distribute the evening, night and weekend shifts among the residents. The scheduling program keeps track of the total number of shifts taken by a resident, the type of shifts taken by a resident and the number of satisfied wishes and requests. With this overview, it is tried to divide the evening, night and weekend shifts equally among the residents. Besides the evening, night and weekend shifts, the other tasks in the provision of patient care services are also tried to be equally divided among the residents. The planning department for instance tries to vary the residents that are taking the ATLS shift as much as possible.

In summary:

- The wishes and requests of residents concerning vacations and days off are satisfied almost anytime.
- In the current planning and control system, the wishes and requests are in the lead of the schedule, which is a possible cause for the current problems.
- There is a fairly distribution of the evening, night and weekend shifts among the residents
- There is also tried to have a fairly distribution of the other tasks in the provision of patient care services among residents.

5.2 Analysis of current system

In this section a detailed analysis of the current planning and control system of residents of the Radiology department of the UMCG will be performed. The root causes and effects and the relationships between these cause and effects will be identified. Section 5.2.1 will show a cause and effect analysis of the planning and control system. Furthermore, section 5.2.2 will provide a waste analysis of the current system.

5.2.1 Cause and effect analysis

This section will present a cause and effect analysis of the planning and control system of residents of the UMCG. The first step of a cause and effect analysis is to determine the exact problem of the research. In this analysis, the problem can be defined as an insufficient schedule. The sufficiency of a schedule is measured in the performance indicators efficiency, effectiveness and job satisfaction. There are many factors influencing the planning and control process of the residents. All these factors lead to an output that is not sufficient. The next step in the cause and effect analysis is to identify the factors that may be part of the problem. In this cause and effect analysis, six generic categories are used: performance, process, product, environment, organization and technology. In reality, there are many more categories that influence the planning and control of residents. However, in this analysis only the most relevant categories will be used. For each of these categories, possible causes can be identified. The possible causes are identified by brainstorming and by using the performance analysis of chapter 5.1. Furthermore, possible causes are discovered by conducting interviews with all the stakeholders and by using the observations of the current planning and control system. Each of these possible causes is coupled to one of the six factors. The cause and effect diagram is shown in Figure 17.

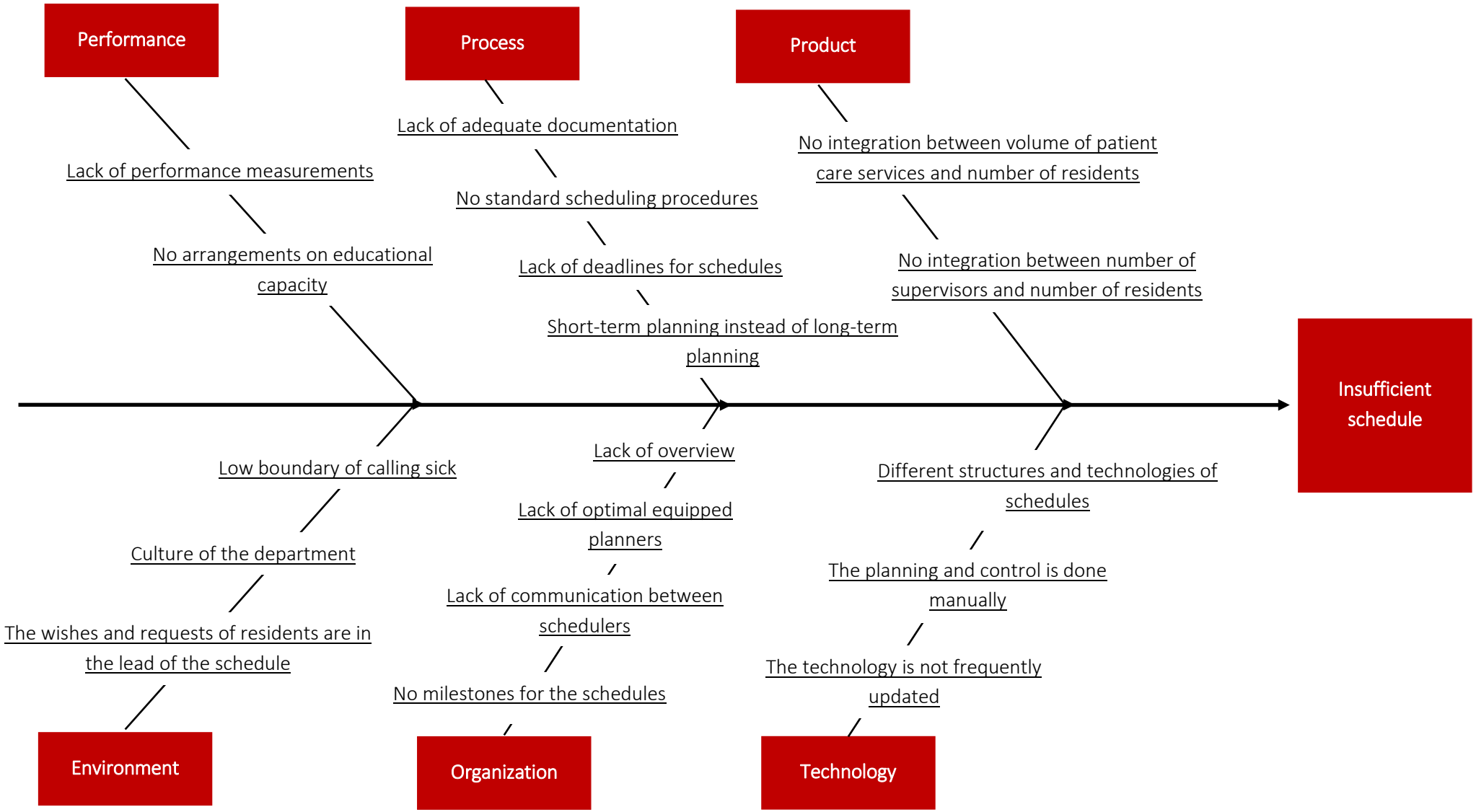


Figure 17: Cause and effect diagram of the planning and control of residents

5.2.2 WASTE ANALYSIS

One key principle of lean management is the elimination of waste in an organization. Waste is typically categorized as the non-value adding activities of a process. In hospitals, this refers to any activity that is not necessary in providing excellent patient care. Waste should be removed, such that only the steps that are required, the value-adding activities, are used to deliver the service to the patient. Eliminating the non-value adding activities can be done by performing a waste analysis. In performing a waste analysis, waste can be divided in eight activities: transportation, overproduction, motion, defects, delay, inventory, processing and people. In this case, the three activities motion, overproduction and inventory are left out of scope. With motion, bending, turning, reaching and lifting is analyzed. This is not relevant in the case of the planning and control of residents. Furthermore, there is no inventory or overproduction.

The five principles of the waste analysis that can be analyzed in the planning and control of residents at the UMCG are: transportation, defects, delay, processing and people. The transportation of information is one of the main waste elements. This information is for instance information between schedulers that goes multiple times to another scheduler before there is a final version. The second principle, defects, is defined as the incorrect planning and control or errors that occur due to the current planning and control system. These errors are the problems currently faced by the Radiology department of the UMCG. It includes lack of integration schedules, lack of consistency of schedules, fragmentation of internships and high fluctuations in number of residents at the internships. The third principle is delay, which is in this case waiting time for the transport of information. For instance, waiting on the evening, night and weekend shift schedule and waiting for the wishes and requests of residents. The fourth principle is processing, which are non-value adding activities during the process. These waste elements are for instance that there is a lack of quality measurements for the planning and control of residents and that there are not enough manual checks. The final principle is people, which can be for instance underutilizing the use of people's capabilities and ideas or the inadequate training of the planners. The waste elements of the five principles of lean management are summarized in Table 14.

Waste type	Waste element
Transportation	▪ Information on requests and preferences of residents ▪ Information between schedulers which is transported multiple times
Defects	▪ Lack of integration schedules ▪ Lack of consistency of schedules ▪ Fragmentation of internships ▪ High fluctuations in number of residents at the internships
Delay	▪ Waiting for evening, night and weekend shift schedule ▪ Waiting for wishes and requests of residents ▪ Waiting for internship schedule ▪ Waiting for information of peripheral hospitals ▪ Waiting for approval of residency program
Processing	▪ Lack of quality measurements ▪ Not enough manual checks ▪ Lack of communication between scheduling steps
People	▪ No focus on process improvement ▪ Under utilizing the use of people's capabilities and ideas ▪ Lack of optimal equipped planners

Table 14: Waste analysis

5.3 RANKING CAUSES

This section lists all possible causes related to the problems of the planning and control of residents. This is not an extensive list of all causes, in reality there are many more causes that could contribute to not achieving the desired performance. However, the causes mentioned are providing an indication of the main causes of the problems. The causes are listed using the cause and effect analysis and the waste analysis presented in this chapter. The causes are rated by various stakeholders from ++ very high impact to -- very low impact. The rates from the stakeholders can be found in Appendix E. A weighted overview of the possible causes and their impact is presented in Table 15.

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	+/-
1.2 There is a lack of deadlines for defining the capacity of the residency program.	++
1.3 There is a lack of communication with the peripheral hospitals.	--
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	+/-
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	+/-
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	+/-
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	+/-
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	--
3.4 There is no definition of educational capacity of the sub-specialties.	++
3.5 There is a lack of an optimal equipped planner for the residency program.	-
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	+/-
4.2 There are no defined milestones for the planning and control of the residency program.	+/-
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	-
5.2 There is a lack of an automatic planning and control system for the residency program.	+/-
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	--
5.4 There is a lack of an optimal equipped planner for the patient care services.	++
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	+
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	++

6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	+/-
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	+/-
7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	+
7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	+/-
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	+
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	+/-
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	+/-
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	+
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	+
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	++
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	+
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	+
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	++
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	++

Table 15: List of causes and impacts

5.4 Summary of system analysis

This chapter provided an analysis of the performance of the planning and control of the residency program of the Radiology department of the UMCG. In addition, it analyzed the causes and effects of the problems with the planning and control of this residency program.

The performance has been analyzed according to the performance indicators effectiveness, efficiency and job satisfaction. The first performance indicator, effectiveness, showed much room for improvement in the current system. The availability of supervisors is not always sufficient, especially at the Neuroradiology and Cardiothoracic Radiology. Furthermore, 37.9% of the internships of all residents are scheduled for less than 4 consecutive weeks. This is not sufficient, since following less than 4 consecutive week's causes fragmentation of the internships and affects the learning curve of residents. In addition, the mean of the days spent at an internship is 3.48 days for a first-year resident, 2.84 days for a third-year resident and 2.54 days for a fifth-year resident. These means of the days spent at an internship are considered to be too low. Finally, there are high fluctuations in the number of residents at the various sub-specialties, especially at the sub-specialty of Neuroradiology, Abdominal Radiology and Cardiothoracic Radiology. These performance measurements of effectiveness show much room for improvement.

The second performance indicator that is measured is efficiency. The performance analysis showed that the educational bottleneck capacity is not maximally used. For instance, there are a lot of weeks where there are zero residents at the Mammography. There are possibilities for a better division in balancing the residents over the year to not exceed the capacity. Furthermore, in the current planning and control system, the residents need to fulfill several tasks to provide patient care services. These tasks are all fulfilled in the current situation. For instance, no evening, night or weekend shifts are skipped, because the treatment of patients in these shifts might be urgent.

The final performance indicator is job satisfaction. The wishes and requests of residents concerning vacations and days off are satisfied almost anytime. Furthermore, there is a fairly distribution of the evening, night and weekend shifts among the residents. It is also tried to have a fairly distribution of the other tasks in the provision of patient care services among residents.

To identify the causes of the problems at the Radiology department of the UMCG, a cause and effect analysis is performed. During this analysis, many possible causes are identified. These possible causes are rated by various stakeholders, to identify the most important causes at the Radiology department of the UMCG. The most important causes can be divided into four main categories. First, there is no explicit planning and control architecture. Second, there is no clear division of planning levels, horizons and tasks. Third, improvements on the planning and control of residents are stagnated due to problem complexity. This confirms the complexity of designing a schedule for residents, suggested by various researchers. Finally, there is a lack of integration between the schedules of the residency program and the patient care services.

The identified causes of this analysis suggest to structure and to develop guidelines for the planning and control of residents. Thus, the observed performance proposes the need to develop a framework for the planning and control of residents. A specific requirement for the framework followed from this analysis is a clear division between the various parties. Currently, there is a lack of overview, which should be provided by the framework. Furthermore, the framework should provide steps and deadlines that should be made at a specific time. Thus, besides a clear division of the parties, also a planning horizon should be included.

6. Framework design

This chapter addresses the research question: *How can the planning and control of residents be structured to improve its performance?* The chapter will present the design of the planning and control framework for residents' activities. It will expand the initial framework shown in Figure 18 and develop a detailed planning and control framework for residents' activities. The detailed planning and control framework is developed by using the analysis of the Radiology department of the UMCG. Furthermore, the analyses from other departments and hospitals are used. Besides the analyses of current planning and control systems, the framework is proposed by using relevant literature. For instance, the study of Hans, Houdenhoven & Hulshof (2011) is used to structure the various planning and control activities. This chapter will propose the planning and control framework in four sections. The first section will discuss the approach of the framework design. In addition, the second section will present the planning and control framework and its activities. Furthermore, the third section will discuss the various activities and propose a first version of the design parameters of the framework. Finally, the fourth section will illustrate various possible parameters by providing best practices from planning and control systems of other departments and hospitals.

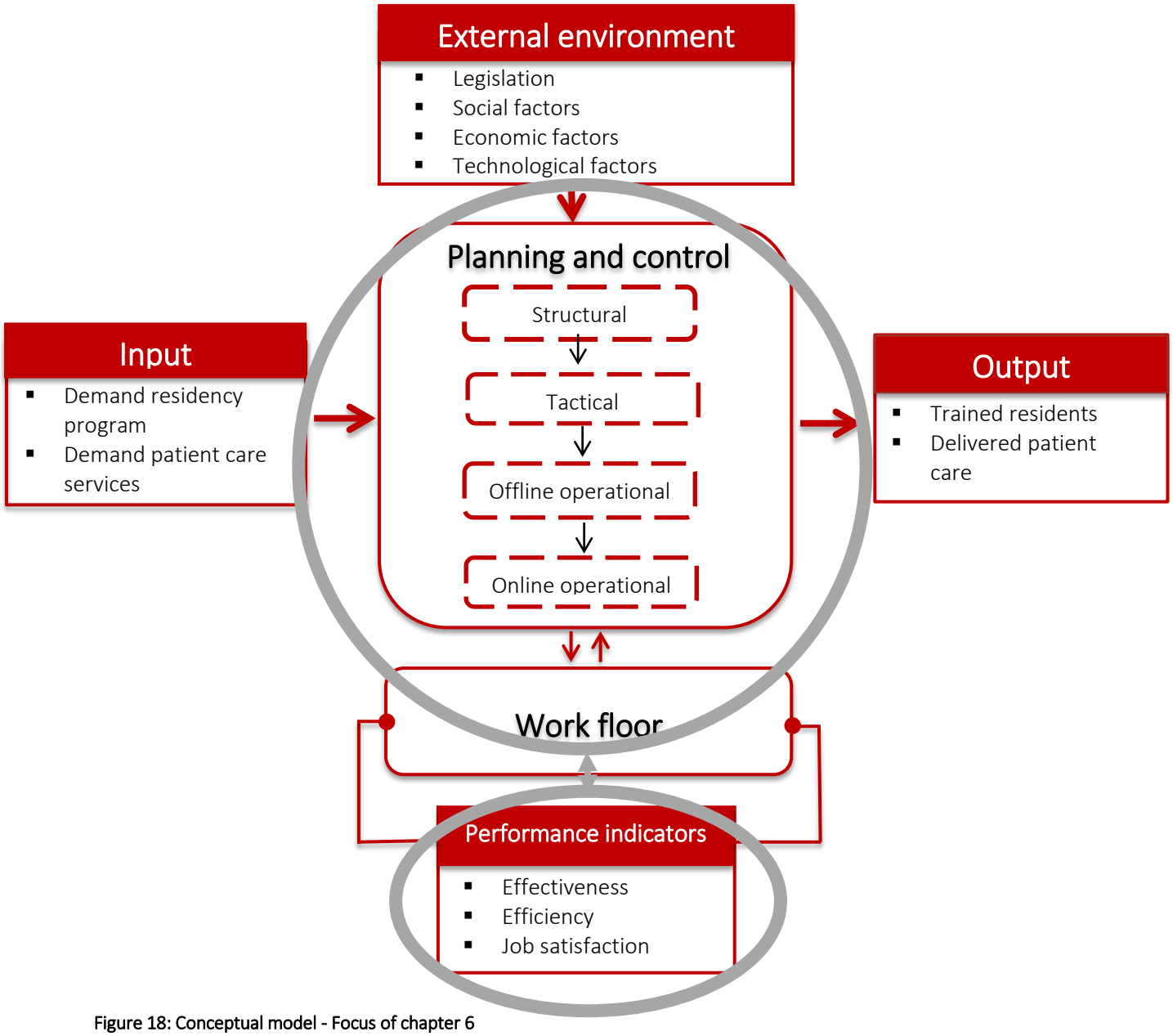


Figure 18: Conceptual model - Focus of chapter 6

6.1 Approach for framework design

The analysis on the Radiology department presented in chapter 5 suggested to structure and to develop guidelines for the planning and control of residents. It proposed the need to develop a framework for the planning and control of residents' activities. Specific requirements for the framework followed from this analysis are a clear division between the various planners and a timeline that should be included. To develop the planning and control framework for residents' activities the four hierarchical levels proposed by Hans, Houdenhoven & Hulshof (2011) are used. These four levels are structural, tactical, offline operational and online operational planning and control. The four levels of planning and control are each decomposed in activities specific for the planning and control of residents. The proposed framework consists of two streams of activities; a stream for the residency program and a stream for the patient care services. The streams consist of a total of eight activities. By identifying planning levels and planning activities, it is meant to guide the planning and control system design.

6.2 Framework for the planning and control of residents' activities

The planning and control framework for residents' activities is presented in Figure 19. The framework is structured in various planning levels and planning activities. The four planning levels are structural, tactical, offline operational and online operational planning and control. These four levels of planning and control are each decomposed in activities specific for the planning and control of residents. These levels and activities will be further elaborated in the upcoming paragraphs.

The first level of the planning and control is the structural level. As shown in Figure 19, there are two inputs at the start of this level: the demand of residents and their educational needs and the demand of patient care services. These two demands are going into two streams of activities; one stream for the residency program and one stream for the patient care services. The first activity of the structural planning and control is defining the capacity of the residency program. The second activity of the structural planning and control is in the stream of the patient care services and is defining the staff capacity of the patient care services. This is the definition of the percentage of demand that will be fulfilled, thus the volume of patient care services that will be delivered. The two outputs of this structural planning and control are the capacity of the residency program and the capacity of the patient care services.

When the decisions on the capacity of the residency program and the capacity of the patient care services are made, the activities of the tactical level should be performed. The tactical planning and control consists of four activities; two activities in the stream for the residency program and two activities in the stream for the patient care services. The first activity for the residency program is building the internship schedule. This contains for instance the number of days in the planning horizon or the number of consecutive weeks of internships. The second activity is defining the remaining capacity of residents. This is the capacity of residents that can be used to fulfill patient care services. The remaining capacity can be calculated using the percentage of time residents need to spend at their internship. This percentage needs to be decided among the various stakeholders.

For the stream of the patient care services, there are also two activities. The first activity is building the schedule of the patient care services. This includes for instance the days in the planning horizon or the number and type of tasks that should be fulfilled. The second activity in this tactical planning and control is the division of tasks. This is the division of all the tasks of the patient care services among the staff, technicians and residents. The two outputs of this structural level are the remaining capacity of residents available for the provision of patient care services and the volume of tasks that need to be fulfilled. In the ideal situation, these two outputs are the same.

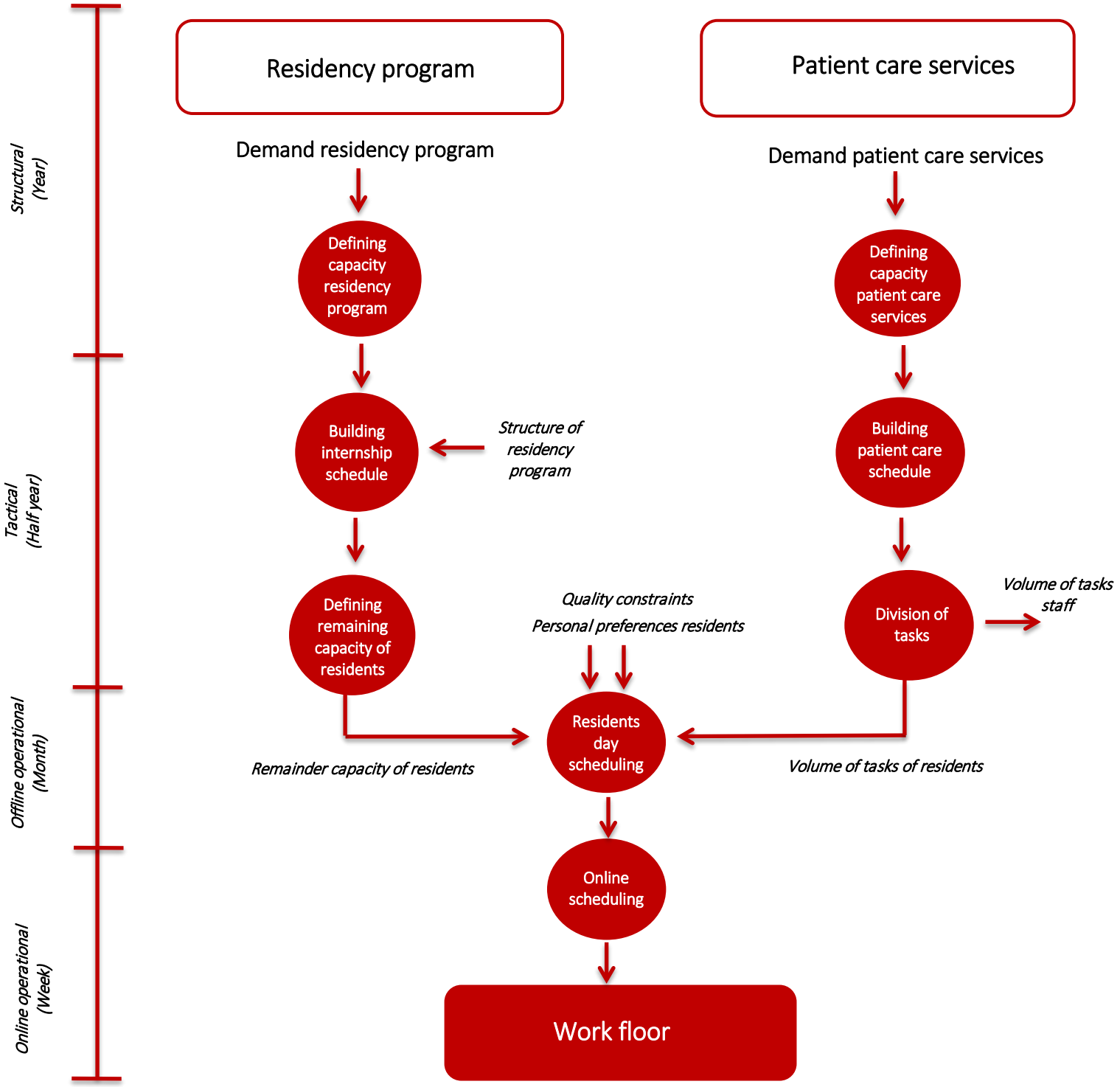


Figure 19: Expanded framework for planning and control of residents

The third level of the planning and control of residents is the offline operational level. This level performs the detailed planning and control of residents. The offline operational planning and control consists of one activity; the day scheduling of residents. This means that all the decisions about the schedule are made in the previous levels and this operational level only performs the actual scheduling process. Therefore, as said before, in the ideal situation the capacity of residents and the volume of tasks are the same. When these are not the same, there will be a feedback loop to the previous activities of both the structural and tactical activities. The output of this level is a day schedule for the residents.

The final level of the planning and control is the online operational level. This level consists of only one activity: online scheduling. Online scheduling is scheduling the last-minute changes, for instance due to illnesses or other circumstances. The output of this level is a day schedule for the residents, which includes the last-minute changes. The activities of the planning and control framework are summarized in Table 16.

Level	Activities
Structural	1 Defining capacity of residency program
	2. Defining capacity of patient care services
Tactical	3. Structuring internship schedule
	4. Defining remaining capacity residents
	5. Structuring patient care schedule
	6. Division of tasks of patient care services
Offline operational	7. Day scheduling of residents
Online operational	8. Online scheduling

Table 16: Activities of the planning and control of residents

The planning and control framework has three performance indicators, which are not shown in Figure 19. These performance indicators are effectiveness, efficiency and job satisfaction. These performance indicators are measured on the work floor, the final level of the framework.

6.3 Design parameters of residents' activities

The presented planning and control framework has eight activities, which each have their own variables. This final section will discuss these various activities in more detail and propose a first version of the variables of the framework. By identifying levels and variables of the planning activities, it is meant to guide the planning and control system design. It is important to note that the presented variables are a first version and more research is needed to expand these variables.

1. Defining capacity of residency program

The first activity of the structural planning and control is defining the capacity of the residency program. A variable of the definition of capacity is the duration of the residency program. The duration of the residency program is defined by the government. Another variable is the inflow moment of residents, for both first year residents and residents from peripheral hospitals. The inflow moments of both first year residents and peripheral residents can be decided by the hospitals. Using the volume of the residency program and the inflow moments of first year residents and peripheral residents, the total number of residents can be calculated. This total number of residents can be calculated for a certain period of time, for instance for a year. The variables for the definition of capacity of the residency program can be summarized as follows:

- Duration of the residency program;
- Inflow moments of first year residents;

- Inflow moments of peripheral hospitals;
- Total number of residents for a certain period of time.

2. Defining capacity of patient care services

The second activity of the structural planning and control is defining the capacity of the patient care services. This is the definition of the percentage of demand that will be fulfilled, thus the volume of patient care services that will be delivered. It includes the definition of all the tasks and shifts that need to be fulfilled and the definition of number of residents and staff members should be available to fill these shifts. This also includes other types of staff, such as technicians and fellows. The variables for the definition of capacity of the patient care services can be summarized as follows:

- Volume of patient care services;
- Number of staff.

3. Structuring internship schedule

When the decisions on the capacity of the residency program and the capacity of the patient care services are made, the activities of the tactical level should be performed. The first activity for the residency program is structuring the internship schedule. This consists of decisions about the structure of the schedule, such as the number of days in the planning horizon and the number of consecutive weeks of internships. Furthermore, also the type of planning should be determined. For instance, if the schedule is a day schedule or a week schedule. In addition, decisions about the resources of the schedule should be made. These are decisions about the planner and the technology of the planning program. The variables for structuring the internship schedule can be summarized as follows:

- Number of days in planning horizon;
- Number of consecutive weeks of internships;
- Type of planning;
- Type of planner;
- Technology of planning program.

4. Defining remaining capacity residents

With the defined capacity of the residency program, the remaining capacity of residents can be calculated. This remaining capacity is the capacity of residents that can be used to fulfill patient care services. It is calculated by subtracting the time residents need to spend at their internships from the capacity of residents. Another variable is the percentage this time spend at their internships can be violated. The variables for defining the remaining capacity of residents can be summarized as follows:

- Time residents need to spend at their internship;
- Percentage of the time residents need to spend at the internship can be violated.

5. Structuring patient care schedule

Another activity of the tactical planning and control is structuring the patient care schedule. This activity is comparable with activity three, the structuring of the internship schedule. It contains decisions about the structure of the schedule, such as the number of days in the planning horizon and the number and type of tasks. Furthermore, also the type of planning should be determined. For instance, if the schedule is a day schedule or a week schedule. In addition, decisions about the resources of the schedule should be made. These are decisions about the planner and the technology of the planning program. The variables for structuring the patient care schedule can be summarized as follows:

- Number of days in planning horizon;
- Number and type of tasks;
- Type of planning;
- Type of planner;
- Technology of planning program.

6. Division of tasks of patient care services

The second activity in the tactical planning and control of the patient care services is the division of tasks. This is the division of all the tasks of the patient care services among the staff, technicians and residents. Another variable of this activity is the availability of supervisors for the residents. The variables for division of tasks of patient care services can be summarized as follows:

- Allocation of tasks
- Availability of supervisors for residents

7. Day scheduling of residents

The seventh activity is the day scheduling of residents and is the only activity of the offline operational planning and control. At this activity the actual scheduling process is performed. In the ideal situation the capacity of residents and the volume of tasks are exactly the same. When these are not the same, there will be a feedback loop to the previous activities of both the structural and tactical activities. The output of this activity is a day schedule for the residents. The offline operational planning and control consists of the allocation of both internships and tasks of patient care services. Furthermore, this activity consists of the percentage of accepting personal preferences of residents. Another variable of this activity is the integration of the various schedules. For instance, there should be integration between the patient care services and internships schedules. If the previous activities have been performed well, the integration of the schedules could be done easily. A final variable is the communication between the various parties. For instance, if there are multiple schedulers, arrangements between these schedulers could make the scheduling process more structured. The various variables of the day scheduling of residents can be summarized as follows:

- Allocation of internships;
- Allocation of tasks of patient care services;
- Percentage of accepting personal preferences of residents;
- Integration of schedules;
- Arrangements on communication.

8. Online scheduling

The final level of the planning and control is the online operational level, which consists of only one activity: online scheduling. Online scheduling is scheduling the last minute changes, for instance due to illnesses or other circumstances. A variable of online scheduling is the percentage of accepting last minute personal preferences of residents. This is for instance accepting a last minute day off due to birthday party of a friend. Furthermore, a variable is the culture of the department. For instance, if the department has a low boundary of calling sick, this influences the online scheduling process. The variables of the online scheduling can be summarized as follows:

- Percentage of accepting last minute personal preferences of residents;
- Culture of department.

The above eight paragraphs present variables of the planning and control framework, coupled to the eight activities. By identifying these various variables of the planning activities, it is meant to guide the planning and control system design. The presented variables provide a first version of the variables. More research is needed to expand these variables and guide the planning and control system design.

6.4 PARAMETERS OF OTHER PLANNING AND CONTROL SYSTEMS

The previous section presented design parameters for each of the eight activities. This section will illustrate these design parameters, by presenting possible parameters from five other planning and control systems of residents. These five planning and control systems are analyzed by site visits to these departments and hospitals. The first three planning and control systems are from Radiology residency programs of other University Medical Centers. The University Medical Centers that are analyzed are University Medical Center (UMC) in Utrecht, Academical Medical Center (AMC) in Amsterdam and Erasmus Medical Center (MC) in Rotterdam. The other two planning and control systems are of the UMCG; the Gastroenterology and Hepatology department and the Anesthesiology department, respectively. The departments are analyzed by conducting in-depth interviews with the persons that are performing the planning of residents. These interviews were semi-structured, thus pre-formulated questions combined with open questions and there was no strict order of the questions. The remaining part of this section will provide brief summaries of the design parameters of the five planning and control systems. Furthermore, the section will be summarized with the best practices of the five departments and hospitals. For more information of the planning and control systems, Appendix F provides an in-depth, expanded analysis of the other hospitals and departments.

Radiology department of UMC Utrecht

The first planning and control system of residents that is analyzed is of the UMC Utrecht. The Radiology department of UMC Utrecht is comparable with the department of the UMCG. The UMC Utrecht has around 30 residents that follow the challenging Radiology residency program. The difference with internships of the UMC Utrecht is that the internships are divided a step further. For instance, they divided the internship of Abdominal Radiology in Abdominal Radiology 1, Abdominal Radiology 2 and Abdominal Radiology 3. In this case, Abdominal Radiology 1 is interpreting the MRI scans and Abdominal Radiology 2 is making CT scans etc. The conclusions from analyzing the UMC Utrecht are:

- At the UMC Utrecht they are quite satisfied with the current structure of the planning and control of residents. However, they do not have a clear overview of the amount of weeks residents are attending the internships.
- The UMC Utrecht has a month schedule and is more working conform the EPA perspective.
- The UMC Utrecht has three fellows for the provision of patient care services, which decreases the tasks of residents.
- The program that is used for the planning of internships of residents is Microsoft Excel. Furthermore, also the planning of the evening, night and weekend shifts and the planning and control of staff are performed in Microsoft Excel. In addition, they use Monaco for the calculation of the residents' hours.
- The UMC Utrecht is looking for a new planning and control program called MedSpace.

Radiology department of AMC Amsterdam

The second hospital that is analyzed on the planning and control of Radiology residents is the Academic Medical Center (AMC) in Amsterdam. The structure of AMC Amsterdam is comparable with the UMCG, the residents follow the themes of Radiology defined in the national residency program. However, the difference with the AMC is that the ATLS internships are divided differently. The ATLS internships are divided together with the themes of Radiology. For instance, two weeks of internships of Musculoskeletal Radiology are translated into two weeks of ATLS internship. This can be done because there are many Musculoskeletal cases at the ATLS, as for instance many broken bones. Furthermore, the AMC has evening, night and weekend shift blocks of a month. This causes less fragmentation of the internships; however, in turn the residents are fulfilling too many evening, night and weekend shift blocks during their residency program. The conclusions from analyzing the Radiology department of AMC Amsterdam are:

- The planning and control of the internships is performed by the residents themselves. There are six residents performing the planning and control: two residents for the common trunk, two residents for the differentiations and two residents for the evening, night and weekend shift blocks.
- The AMC Amsterdam has evening, night and weekend shift blocks of a month, which are causing less fragmentation of the internships, because the residents are not fulfilling shifts during their internship weeks. However, the residents have many shift blocks, which still fragmentizes the overall days of residents attending their internship during a year.
- There are 4 fellows working at the Radiology department, who are fulfilling for instance the evening, night and weekend shifts. Furthermore, these fellows are providing supervision to the residents.
- Violations of educational capacity requests are not often occurring, since they divided the schedules of the common trunk and the differentiations.
- The planning and control is performed in Microsoft Excel. Furthermore, they use Rostar Flex for the calculation of the total hours. On the 1st of February, they are getting Matrickx, a new planning and control program.

Radiology department of Erasmus MC

The third and final Radiology department that is analyzed is the department of the Erasmus Medical Center (MC) in Rotterdam. The Radiology department of Erasmus MC is comparable with the department of the UMCG; the schedule is also constructed using the eight specialties. The main difference with the UMCG is that Erasmus MC has two chief residents, which construct all the schedules for the residents. These two chief residents are fifth-year residents who have experience with scheduling residents at the Radiology department. They construct both the internship schedule and the schedule for providing the patient care services. Another remarkable difference at the Erasmus MC is that the residents have many teaching tasks. Almost every afternoon they have to give a lecture to medical students or give a tour to medical students at the Radiology department. The conclusions from analyzing the Radiology department of Erasmus MC are:

- The Erasmus MC has around 14 fellows at their Radiology department. These fellows are divided among the eight sub-specialties. The main advantage of these fellows is that they give more flexibility in the schedule of the residents.
- All the planning and control of the residents is done by two chief residents. They construct the internship schedule, both also the evening, night and weekend shifts schedule and the schedule for the patient care services.
- The schedule of the residents at the Erasmus MC is composed for a fixed number of 8 weeks; two blocks of 4 weeks. This schedule is composed each 8 weeks for the upcoming 8 weeks.
- The internships of the common trunk have a set sequence at the Erasmus MC. Thus, each resident of the common trunk follows the same sequence of internships.
- Both the internship schedule and the patient care services schedule are composed using Microsoft Excel. The construction of the schedule is done by many macros and functions of Microsoft Excel. Furthermore, the Erasmus MC uses HARMONY WebAccess for their day schedule.

Gastroenterology and hepatology department of UMCG

Besides the three Radiology departments of other University Medical Centers in the Netherlands, two departments of the UMCG are analyzed. First, the Gastroenterology and Hepatology (GH) (in Dutch: Maag-, darm- en leverziekten) department of the UMCG. The residency program of the GH department differs in structure from the Radiology department. The internships are much longer and there are much less residents following the residency program. This results in less problems concerning the planning and control of residents. However, external variables are still influencing the schedule, such as illnesses and pregnancies. Besides these external variables, the GH department states that they are succeeding in planning and control in a way that all the stakeholders are satisfied. The main points from analyzing the GH department are:

- The planning of residents is done together with the planning of staff members. The schedules are integrated in one schedule.
- The schedule is made by a member of the secretariat and checked by an educator and a staff member. This creates calmness for the planner, because if staff members or residents complain they go to the representative of the staff or the educator.
- There is a clear number of the FTE of supervision available for the residency program. In the schedule, the residents are already coupled to one of the available supervisors.
- The planning and control is done by knowing the bottlenecks of the system and planning them first.

Anesthesiology department of UMCG

The final department that is analyzed is the Anesthesiology department of the UMCG. The Anesthesiology department has around 70 residents, which is a high number of residents compared to the other residency programs. This high number of residents makes the planning and control of the residents challenging. Furthermore, many of the residents of the Anesthesiology department are women. This results in many pregnancies and part-time workers. Therefore, the Anesthesiology department also has many problems with fragmentation of the internships. The main points from analyzing the Anesthesiology department are:

- The inflow moments of residents are strict and there are three residents together at each inflow moment.
- There is one planner that is responsible for the planning and control of residents, as well as for the staff planning and control and the evening, night and weekend shifts. There is an educator involved in this process to ask questions, but the main responsibilities lie with the planner from the secretary.
- The schedules for both the staff and residents are integrated into one Microsoft Excel file using macros.
- The evening, night and weekend shifts are divided into three blocks. However, they are not satisfied with these three blocks and want to go back to a schedule with only two blocks of 16 hours. This would result in more people on the work floor the next day, which is both positive for the residency program as for the provision of patient care services.
- The residents of the Anesthesiology department are coupled to the supervisors of a sub-specialty for a certain period.

Best practices

The problems that arise at the UMCG can also be found at the other hospitals and departments. All the hospitals and departments have problems with the hours of the evening, night and weekend shifts taken by residents. Furthermore, the other Radiology departments also identify fragmentation of the internships. The residents have many other tasks for the provision of patient care services. During the analysis of the five departments, various possible design parameters for the planning and control framework have been identified. For instance, the three other Radiology departments all made use of fellows to create more space in the delivery of patient care services. Furthermore, many hospitals were looking for new planning programs, such as Matrickx and MedSpace. The best practices of the five departments are summarized in Table 17.

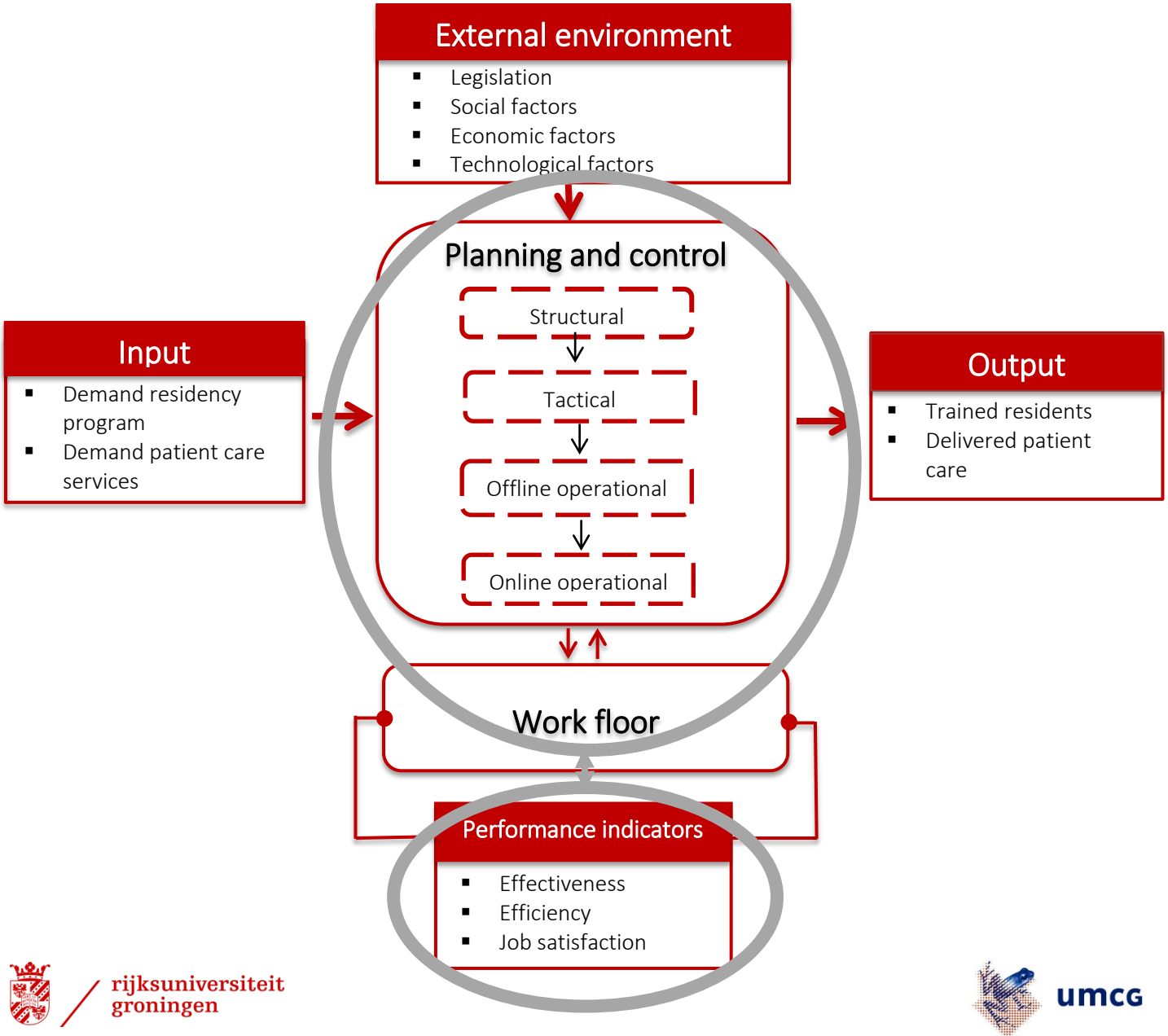
Structural planning and control
▪ Hiring fellows that contribute to the provision of patient care services and decrease the tasks of residents. ▪ Create awareness among staff and residents about the importance of the quality of the schedule. ▪ Introducing strict inflow moments for the residents.
Tactical planning and control
▪ The internship schedule structured in months. ▪ The internship schedule structured in blocks of 4 weeks. ▪ The internship schedule structured with a same sequence of internships. ▪ The evening, night and weekend shifts structured in blocks of a month, to integrate with the internship schedule. ▪ Planning the residents with a strict planning horizon of 2 months. ▪ The internship schedule composed by the residents themselves. ▪ The internships and the patient care services scheduled by the same person and/or department. ▪ The internships and patient care services scheduled by the same person and/or department, in combination with an educator and two chief residents.
Offline and online operational planning and control
▪ Integration of both schedules in one Microsoft Excel file. ▪ Present an overview of FTE of supervisors and couple to residents at their sub-specialties. ▪ Coupling residents with supervisors for supervision. ▪ Looking for new planning programs, such as MedSpace or Matrickx. ▪ Harmony integration into Microsoft Excel file.

Table 17: Best practices of other hospitals and departments

7. ILLUSTRATION OF FRAMEWORK USE

This chapter will illustrate the use of the proposed planning and control framework. It will answer the research question: *How can the planning and control system of the UMCG be redesigned using the proposed framework and what are the estimated effects of these redesigns?* Thus, to illustrate the use of the framework, the Radiology department of the UMCG will be used as an example. The illustration of the framework on the planning and control system of the Radiology department is an initial step. In future research, empirical studies at other departments and hospitals should expand and detail the proposed planning and control framework.

To illustrate the framework, various redesigns for the scheduling problems of the Radiology department have been identified. This chapter is structured in three sections. The first section will present possible solutions for the planning and control of the Radiology department. In addition, the second section will organize these possible solutions by presenting three proposals for the redesign of the system. This section will propose a redesign in the ideal situation for the residency program, a redesign in the ideal situation for the patient care services and a redesign which integrates both perspectives. Finally, the third section will estimate the effect of the three proposed redesigns by conducting a survey among residents and staff of the Radiology department. The outcomes of the survey will give a direction for the design of the planning and control system of the Radiology department.



7.1 Identifying possible design parameters

This section will present possible design parameters to improve the performance of the planning and control of residents of the Radiology department of the UMCG. The parameters are created using the identified causes of chapter 5. For this chapter, only the most important causes are considered, which are causes rated with + or ++. The possible design parameters are identified using the analysis of the current cause, the analysis of the other hospitals presented in the previous section and relevant literature related to the planning and control of residents. This section will present the possible design parameters for each of the four levels of planning and control of residents.

Structural planning and control

The important identified cause on the structural level of planning and control is the lack of deadlines for defining the capacity of the residency program. The possible solutions for this cause are presented in Table 18.

There is a lack of deadlines for defining the capacity of the residency program.
▪ Developing standard deadlines for defining the capacity of the residency program throughout one year. ▪ Developing standard deadlines for defining the capacity of the residency program that are communicated with all the stakeholders. ▪ Introducing a set date for the planning and control of the residency program, for instance the first day of every month. ▪ Introducing a strict planning horizon for the residency program, for instance a planning horizon of two months.

Table 18: Possible solutions - Lack of deadlines for defining capacity of residency program

Tactical planning and control

Besides an identified cause on the structural level of planning and control, there are four important causes identified for the tactical level of planning and control. The first identified cause of the tactical level is that there is no definition of the educational capacity of the sub-specialties. Although there is no clear definition, the various stakeholders have a number for the capacity in their mind, this is just not the same number for the each of the stakeholders. The possible solutions for this cause are presented in Table 19.

There is no definition of educational capacity of the sub-specialties.
▪ Introducing frequent meetings with one representative of each stakeholder to define the educational capacity. ▪ Adjusting the educational capacity of sub-specialties to the expected number of residents for the upcoming residency year. ▪ Adjusting work processes and/or staff schedules to create a higher educational capacity of residents. ▪ Dividing the first-, second- and third-year residents from the fourth- and fifth-year residents to create less burden on the educational capacity.

Table 19: Possible solutions - No definition of educational capacity

The second cause that has a lot of impact on the tactical planning and control is that there is a lack of an optimal equipped planner for the patient care services. The possible solutions for this cause are presented in Table 20.

There is a lack of an optimal equipped planner for the patient care services.
▪ Developing a structure for the planning and control of the patient care services. This includes defining procedures for performing the planning and control process. ▪ Making residents responsible for scheduling the patient care services. ▪ Implementing a new planning program, such as Matrickx or MedSpace.

Table 20: Possible solutions - Lack of an optimal equipped planner for the patient care services

Another cause is that the culture of the department can be stated as classical. This influences the division of tasks and the capacity of patient care services. The possible solutions to this cause are presented in Table 21.

The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.
▪ Restructuring the division of tasks of staff and residents for the provision of patient care services. ▪ Restructuring the tasks of staff and residents, where the staff takes over tasks from the residents on voluntary basis. ▪ Restructuring the tasks of staff and residents, where the staff takes over compulsory evening, night and weekend shifts. ▪ Restructuring the tasks of staff and residents, by hiring fellows or by shifting tasks to technicians.

Table 21: Possible solutions - Classical culture of the department

The final important cause of the tactical planning and control is that there is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program. The possible solutions to this cause are presented in Table 22.

There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.
▪ Coupling residents to one staff member for supervision during each internship. ▪ Calculating the total number of FTE of staff for supervision and adjusting the availability of staff for supervision to the number of residents in the upcoming residency year. ▪ Showing which supervisors are available on a certain day for supervision in the internship schedule. ▪ Using fourth- and fifth-year residents with the gained competences to provide supervision.

Table 22: Possible solutions - No integration of supervision and residents

Offline operational planning and control

Besides the causes on the structural and tactical level of planning and control, there are many causes on offline operational level. The first cause is the lack of overview of tasks of the patient care services. The possible solutions for introducing an overview of the tasks are presented in Table 23.

There is a lack of overview of all tasks of the patient care services that need to be scheduled
▪ Composing both the schedules of the residency program and the patient care services by the planning department. ▪ Composing the residency schedule by residents, such that the responsibility lays with the residents themselves. ▪ Introducing frequent meetings with one representative of each stakeholder to create a better overview. ▪ Creating more integration between the schedule of the internships and the schedule of the patient care services (see Table 26).

Table 23: Possible solutions - Lack of overview of all tasks

Another cause on the offline operational level is that the wishes and request of residents are in the lead for the schedule of the residency program. If residents' requests certain internships at certain weeks, most of the times these requests are accepted. The possible solutions for this cause are presented in Table 24.

The wishes and requests of residents are in the lead for the schedule of the residency program.
▪ Composing the schedule of internships from educational capacity perspectives, not from residents' wishes and requests. ▪ Applying a numerus fixus for certain differentiations to meet the educational capacity. ▪ Introducing strict deadlines for the delivery of wishes and requests of residents.

Table 24: Possible solutions - Wishes and requests in the lead for the schedule

Two of the main causes of the problems with the planning and control of residents, is the communication and integration between the two schedules. The solutions for these causes have a lot in common. The solutions for the lack of communication are presented in Table 25. Furthermore, the solutions for the lack of integration are presented in Table 26.

There is a lack of communication between the various stakeholders considering the planning and control of residents.
▪ Communicating through one representative of each party. Thus, a representative of the residents, a representative of the educators, a representative of the staff and a representative of the planners. ▪ Introducing strict procedures and deadlines, to smoothen the communication. ▪ Introducing an automatic created overview of changes in the internship schedule. ▪ Composing the internship schedule at a specific day, for instance the first day of each month.

Table 25: Possible solutions - Lack of communication

There is a lack of integration between the schedules of the residency program and the patient care services.
▪ Composing both the schedules of the residency program and the patient care services by the planning department. ▪ Composing the schedule of the residency program by residents, such that the responsibility lays with the residents themselves. ▪ Composing the residency program by the planning department. However, chief residents are checking the schedule on priorities of interests. ▪ Designing one planning program for both the schedules of the internships and the patient care services. For instance, both schedules combined in one Excel sheet. ▪ Showing which residents are following their internships at which sub-specialties in the internship schedule, instead of showing the schedule per individual resident. ▪ Integrating the two schedules by coupling certain days of internships to tasks of the patient care services. For instance, performing ultrasounds on Friday if a resident is following the Mammography internship, since there is no patient care on Fridays.

Table 26: Possible solutions - Lack of integration

In addition, an important cause is that there is no clear definition of the priority of interests that should be followed in composing the schedules. The solutions that could help to define this priority are shown in Table 27.

There is no definition of priority of interests between the schedules of the residency program and the patient care services.
▪ Introducing frequent meetings with one representative of each stakeholder to prioritize the interests. Thus, frequent meetings with representative of the residents, a representative of the educators, a representative of the staff and a representative of the planners. ▪ Composing the residency schedule by residents themselves, such that the residents prioritize the interests.

Table 27: Possible solutions - No definition of priority of interests

The final two causes are related to the causes mentioned before, considering the lack of integration between the two schedules. These two causes are about the difference in structure and the difference in planning program used for both the schedules. The possible solutions for the differences in structure of the schedules are presented in Table 28. The possible solutions for the different planning programs are presented in Table 29.

The structure of the schedules (day, week) is different for the residency program and the patient care services.
▪ Structuring the internship schedule with shifts blocks of 4 weeks, such that the evening, night and weekend shifts are adjusted to the structure of the internships. ▪ Structuring the internship schedule with a same order of internships for the common trunk. Thus, every resident follows the same sequence of internships in the common trunk. ▪ Structuring the internship schedule with a strict number of weeks of internships, such that the residents are switching for the internship at the same moment. For instance, structuring the schedule in four weeks of internships.

Table 28: Possible solutions - Different structure for schedules

The planning programs used for the planning and control are different for the residency program and the patient care services.
▪ Combining the schedules in one integrated Microsoft Excel file. ▪ Combining the schedules in one integrated planning program. ▪ Combining the schedules by integrating the internships schedule with Harmony blocks in Excel.

Table 29: Possible solutions - Different planning program

Online operational planning and control

The final level, online operational planning and control, has two important identified causes. The first cause is that the department has a low boundary of calling sick. This, in turn, influences the scheduling of the patient care services. The solutions for this cause are presented in Table 30.

The department has a low boundary of calling sick, which influences the scheduling of patient care services.
▪ Coupling residents to staff members, for the continuity of the patient care services. When the resident is absent, the staff member takes over the responsibilities of the coupled resident. ▪ Introducing a back-up schedule, such that there is a continuity of the delivery of patient care services. ▪ Arranging replacement themselves by residents and staff members, when someone is called sick.

Table 30: Possible solutions - Low boundary of calling sick

The second cause of the online operational level is the fact that it is not clear if all last-minute wishes and requests should be accepted. The solutions for this cause are presented in Table 31.

It is not clear if all last-minute wishes and requests should be accepted in the schedule of the patient care services.
▪ Defining when to accept wishes and requests of residents and staff. ▪ Introducing strict deadlines for the delivery of wishes and requests of residents and staff, such as days off and holidays. ▪ Composing the schedule for the next two months and in turn only accept last-minute requests and wishes if person arranges replacement themselves and it has no negative consequences for residency program.

Table 31: Possible solutions - Accepting last-minute requests and wishes

7.2 Proposals for redesign

This section will propose three redesigns for the Radiology department of the UMCG. The redesigns are structured using the levels of the planning and control framework: structural, tactical and offline and online operational planning and control. The first redesign will present the ideal situation for the residency program. In addition, the second redesign will present the ideal situation for the patient care services. These first two redesigns have the goal to show the perspectives of both stakeholders. They are discussed to understand the ideal situations of a specific stakeholder and to illustrate the differences between the stakeholders. Both redesigns are used to create awareness among the stakeholders and to understand the requirements of each other. To combine the perspectives of the stakeholders, the third redesign integrates the design of both ideal situations. The final section of this chapter will give a summary of the proposed redesigns.

7.2.1 Proposal 1: Ideal situation residency program

For the residency program, the most ideal situation is in favor of the residents and the program they are following. The educators want to provide an effective residency program and they want to minimize the violations of restrictions of the residency program, such as the number of supervisors that need to be available for the residents. Furthermore, they want the fragmentation of the internships to be minimized and the days spent at the internships to be high enough to gain the required competences. In addition, the educators want to offer the residents a full choice of internships and differentiation themes.

Structural planning and control

In the ideal situation for the residency program, the provision of patient care services of the department of Radiology is independent of the residents. This means that the Radiology department should be able to provide the patient care services, without the availability of residents. This is an ideal situation for the residency program, because the residents can attend any internship they want and the fragmentation of the internships is minimized due to less tasks for the provision of patient care services. To create this ideal situation, the division of tasks for the provision of patient care services needs to be restructured. This restructuring can be done in various ways. For instance, the current staff could perform a part of the evening, night and weekend shifts. Furthermore, they could take over the ultrasound shifts or fill in the gaps of the ultrasounds when there are not enough technicians available. Another possible solution to make the provision of patient care services independent of residents, is hiring fellows. These fellows can take over the current tasks of the residents. Hiring fellows would provide more space in the provision of patient care services and restructure the Radiology department, such that they are more independent of the residents.

The possible structural elements of the ideal situation for the residency program are summarized in Table 32.

- The provision of patient care services of the department of Radiology is independent of the residents.
- The division of tasks for the provision of patient care services is restructured, such that residents have more time for their residency program.
- The current staff could be performing a part of the evening, night and weekend shifts.
- The tasks could be restructured, where fellows take over current tasks of the residents, such as evening, night and weekend shifts.

Table 32: Redesign proposal 1 - Structural planning and control

Tactical planning and control

For the effectiveness of the residency program, educators wish a minimum number of consecutive weeks at one internship. The residents should spend a minimum of four weeks at one internship, to gain competences in a certain specialty. This minimum of four consecutive weeks at an internship is a

possibility for the structure of the internship schedule to create the ideal situation for the residency program. Another possibility is changing the structure of the evening, night and weekend shifts. For instance, shift blocks of 4 weeks could be introduced to adjust the internship schedule to the structure of the evening, night and weekend shifts and minimize the fragmentation of the internships.

Another element of the ideal situation for the residency program is that the residents can choose any differentiation they want to follow or can choose any extra internships they might want to attend, irrespective of the educational capacity of the sub-specialties. For instance, the residents could follow an extra internship of Pediatric Radiology, although there are already residents following this internship. To make this possible, the educational capacity should be increased. The educational capacity can be increased by restructuring the work processes of the sub-specialties and/or change staff schedules. Furthermore, the educational capacity could be adjusted to the expected number of residents for each upcoming residency year.

The possible tactical elements of the ideal situation for the residency program are summarized in Table 33.

- At least four consecutive weeks at one internship, to increase the effectiveness of the residency program.
- Shifts blocks of 4 weeks, such that the evening, night and weekend shifts are adjusted to the structure of the internships.
- Residents choosing their own residency program, irrespective of educational capacity.
- Adjusting work processes and/or staff schedules to create a higher educational capacity of sub-specialties.
- Adjusting the educational capacity of sub-specialties to the expected number of residents for the upcoming residency year.

Table 33: Redesign proposal 1 - Tactical planning and control

Offline and online operational planning and control

In the offline and online operational planning, the actual schedule is composed. In these levels, ideally the residency program would be in favor in the various steps of composing the schedule. To compose the best schedule for the residents, it would be a possibility to perform the scheduling by the residents themselves. In this way, the schedule would always be in favor of the residents and the program they are following. However, in this situation the residents should know which tasks should be scheduled and which problems would arise. Therefore, in the ideal situation there would be a frequent meeting with one representative of each of the stakeholders. Thus, a frequent meeting with a representative of the residents, a representative of the educators, a representative of the staff and a representative of the planners. Het final element in the ideal situation for the residency program is that there is always enough supervision for the residents. This can be reached by calculating the total number of FTE available for supervision of residents and adjust this availability to the number of residents in the upcoming residency year.

The possible offline and online operational elements of the ideal situation for the residency program are summarized in Table 34.

- Schedule performed by residents themselves.
- Frequent meetings with one representative of each stakeholder to prioritize the interests. Thus, frequent meetings with representative of the residents, a representative of the educators, a representative of the staff and a representative of the planners.
- Calculating the total number of FTE for staff calculation and adjusting the availability of staff for supervision to the number of residents in the upcoming residency year.
- Using fourth- and fifth-year residents with the gained competences to provide supervision.

Table 34: Redesign proposal 1 - Offline and online planning and control

7.2.2 Proposal 2: Ideal situation patient care services

In the ideal situation for the provision of patient care services, the capacity of providing the services for patient care of the Radiology department is fulfilled. Furthermore, it is ideal to have a continue delivery of the patient care services. This means that the fluctuations of delivery of patient care services are minimized.

Structural planning and control

For the patient care services, it is ideal to fulfill the total capacity that is defined by the department of Radiology. To reach this, the capacity available from the residents should be fully used. This available capacity is for instance the time that residents are available for evening, night and weekend shifts. If the occupation of the available time for the tasks of the patient care services is maximally used, the staff has time for other tasks. These tasks include for instance conducting research in the Radiology field. In the future, the occupation of residents for patient care services is decreasing, due to the decreasing number of available positions of residents. To fulfill the same number of tasks for the provision of patient care services in the future, other solutions should be implemented. One of these solutions is to restructure the tasks of residents and staff by hiring fellows or shifting tasks to technicians. The possible structural elements of the ideal situation for the patient care services are summarized in Table 35.

- Maximum occupation of residents' capacity.
- Restructuring the tasks by hiring fellows or shifting tasks to technicians.

Table 35: Redesign proposal 2 - Structural planning and control

Tactical planning and control

For the patient care services, it is ideal if the residency schedule is structured in such a way that the number of residents at the sub-specialty is balanced. Thus, that there is a stable; minimum and maximum number of residents during the months of the residency year. A first element that could be introduced to balance the number of residents, is introducing a same order of internships for the residents of the common trunk. Combining this option with strict inflow moments that are divided among the year, the number of residents for the common trunk should be balanced. Another element in the ideal situation for the patient care services is structuring the internship schedule in a strict number of weeks. For instance, the internship schedule could be structured by internships of four weeks. With these strict numbers of weeks, there exists a schedule where the residents switch at the same moment. Consequently, the numbers of residents are more structured and for the sub-specialties it is clear when the residents switch from internships.
Another element to balance the number of residents among the sub-specialties, is frequently communicating the capacity of the sub-specialties. When frequently stating the educational capacity, the internship schedule can take this into account. To meet this educational capacity, it would be an option to introduce numerus fixus for certain sub-specialties. For instance, a numerus fixus could be applied to the differentiation of Pediatric Radiology.

- Introducing the same order of internships for the common trunk. Thus, every resident should follow same sequence of internships in the common trunk.
- Scheduling the internships in a strict number of weeks, such that the residents are switching for the internship at the same moment. For instance, a strict number of four weeks.
- Frequent meetings with one representative of each stakeholder to define the educational capacity.
- Numerus fixus for certain sub-specialties to meet the educational capacity.

Table 36: Redesign proposal 2 - Tactical planning and control

Offline and online operational planning and control

The final schedule of the ideal situation of the patient care services is composed by scheduling from the perspective of the capacity of the sub-specialties, instead of accepting all wishes and requests of residents. Thus, satisfying both the minimum and maximum capacity of the sub-specialties has priority in composing the final schedule. This element is summarized in Table 37.

▪ Scheduling the internships from the viewpoint of the educational capacity, instead of the wishes and request of residents.

Table 37: Redesign proposal 2 - Offline and online operational planning and control

7.2.3 Proposal 3: Integrating both ideal situations

The first two proposals show the ideal situations for the residency program and the provision of patient care services. This section will present a final proposal which tries to integrate the two ideal situations into one. This integrated ideal situation would be sufficient for both the residency program and the patient care services.

Structural planning and control

The most important element of the integrated ideal situation is to introduce a structure with defined agreements and deadlines. This structure could be formed in a timeline, such that it is clear which steps should be taken in which phase of the year. For instance, the educational capacity could be defined yearly and be accepted by all stakeholders. Furthermore, also deadlines could be introduced on for instance the delivery of holidays and days off or deadlines for the delivery of the chosen differentiation. The elements for the structural level of the ideal integrated situation are presented in Table 38. These elements include introducing a set date for composing the schedule, introducing a strict planning horizon and introducing frequent meetings with representatives of each party.

- Developing standard deadlines for defining the capacity of the residency program throughout one year.
- Developing standard deadlines for defining the capacity of the residency program that are communicated with all the stakeholders.
- Introducing a set date for the planning and control of the residency program, for instance the first day of every month.
- Introducing a strict planning horizon for the residency program, for instance a planning horizon of two months.
- Introducing frequent meetings with one representative of each stakeholder to define the educational capacity.

Table 38: Redesign proposal 3 - Structural planning and control

Tactical planning and control

For the tactical level of planning and control, both the residency program and the patient care services want to create more flexibility in their schedules. In the ideal situation, this can be reached by task shifting to either fellows or technicians. For instance, fellows could be hired and take part in the evening, night and weekend shifts. Furthermore, technicians could perform more tasks, as performing more ultrasounds. Another element that is both in favor of the residency program and the patient care services is using fourth- and fifth-year residents with the gained competences to provide more supervision. The fourth- and fifth-year residents learn from providing this supervision, whereas the staff members have more time to perform other tasks. In addition, this could be used even in more detail by dividing the first-, second- and third-year residents from the fourth- and fifth-year residents. The fourth- and fifth-year residents are seen as staff members and provide more staff related tasks than the first-year residents.

- Restructuring the tasks of staff and residents, by hiring fellows or by shifting tasks to technicians.
- Using fourth- and fifth-year residents with the gained competences to provide supervision.
- Dividing the first-, second- and third-year from the fourth- and fifth-year to create less burden on the educational capacity.

Table 39: Redesign proposal 3 - Tactical planning and control

Offline and online operational planning and control

The final levels of the planning and control of residents, consists of various integrated planning elements. The first element is about communicating through one representative of each party. As stated before, there are many stakeholders considering the planning of residents. The communication would be much smoother if there is one representative of each group of stakeholders that communicates with the rest of the persons. Another element of the offline and online operational planning and control, is composing the schedules of the residents by one planner. This could either be the planning department who composes both the schedules of the residency program and the patient care services, or the residents who compose the schedule themselves. This option could also be combined, such that the planning department composes the schedule but the schedule is checked by responsible residents. The benefits of switching to one planner is that in this way the planning and control is done by one person or department and the schedules can be easier integrated. For instance, the schedules could be integrated by coupling certain days of the internships to tasks of the patient care services. If a resident is following an internship at the Mammography specialty, he/she could perform ultrasounds on Friday, since there are no patient care services on Friday at this specialty. When the planning is performed by one person or department, this integration is more easily done. Besides integrating planners, also the schedules could be integrated into one program. There are various options to integrate the programs, for instance by combining the schedules in one Microsoft Excel file, or by copying the Harmony blocks in Excel. Finally, a new planning program, such as Matrickx or MedSpace could be implemented to better integrate the two schedules. The elements for the offline and online level of the ideal integrated situation are summarized in Table 40.

- Communicating through one representative of each party. Thus, a representative of the residents, a representative of the educators, a representative of the staff and a representative of the planners.
- Composing both the schedules of the residency program and the patient care services by the planning department.
- Composing the schedule of the residency program by residents, such that the responsibility lays with the residents themselves.
- Composing the residency program by the planning department. However, chief residents are checking the schedule on priorities of interests.
- Integrating the two schedules by coupling certain days of internships to tasks of the patient care services. For instance, performing ultrasounds on Friday if a resident is following the Mammography internship, since there is no patient care on Fridays.
- Combining the schedules in one integrated Microsoft Excel file.
- Combining the schedules by integrating the internships schedule with Harmony blocks in Excel.
- Implementing a new planning program, such as Matrickx or MedSpace.

Table 40: Redesign proposal 3 - Offline and online operational planning and control

7.2.4 SUMMARY OF PROPOSALS FOR REDESIGN

This section focused on the redesign of the current system, while improving the performance indicators efficiency, effectiveness and job satisfaction. Summarizing the possible solutions of section 7.1, three redesigns have been proposed. The first two redesigns show the perspectives of both stakeholders; the residency program and the patient care services. These two redesigns are discussed to understand the ideal situations of a specific stakeholder and to illustrate the differences between the stakeholders. To combine the perspectives of the stakeholders, the third redesign integrates the design of both ideal situations.

1 - The first proposed redesign focused on the ideal situation for the residency program. It consists of a department of Radiology that provides patient care services independent of residents. In this ideal situation, there would be a restructuring of tasks of residents, such that either staff, fellows or technicians would perform more tasks of the residents. In addition, residents can choose their own residency program, irrespective of educational capacity. The educational capacity will be adjusted to the expected number of residents for the upcoming residency year. Furthermore, the effectiveness of the residency program would be increased by introducing at least four consecutive weeks at one internship. Finally, the supervision will be adjusted to the number of residents and fourth- and fifth-year residents with the gained competences will be more used to provide supervision.

2 - The second proposed redesign focused on the ideal situation for the patient care services. For the patient care services, it is ideal to fulfill the total capacity that is defined by the department of Radiology. To reach this, the capacity available from the residents should be fully used. Furthermore, for the patient care services, it is ideal if the residency schedule is structured in such a way that the number of residents at the sub-specialty is balanced. Thus, that there is a stable; minimum and maximum number of residents during the months of the residency year. One of the ways to reach a balanced number of residents is scheduling the internships in a strict number of weeks, such that the residents are switching for the internship at the same moment. For instance, a strict number of four weeks. In addition, for the patient care services the tasks of residents and staff could be restructured, by hiring fellows or shifting tasks to technicians. Finally, the schedule of the ideal situation of the patient care services is composed by scheduling from the perspective of the capacity of the sub-specialties, instead of accepting all wishes and requests of residents.

3 – The third proposed redesign focused on the ideal situation that integrates these both perspectives. The most important element of the integrated ideal situation is that there is introduced a structure with defined agreements and deadlines. This structure could be formed in a timeline, such that it is clear which steps should be taken in which phase of the year. For instance, the educational capacity could be defined yearly. Furthermore, both the residency program and the patient care services want to create more flexibility in their schedules. In the ideal situation, this can be reached by task shifting to either fellows or technicians. Finally, an integrated design would consist of integrated planners and planning programs. There exist various solutions for an integrated planning, for instance by composing the overall schedule by the planning department.

Concluding, the most important element of the integrated ideal situation is that there is introduced a structure with defined agreements and deadlines. Therefore, the proposed framework presents a first step in improving the effectiveness, efficiency and job satisfaction of the schedule of residents at the Radiology department of the UMCG. This framework should be further developed and adjusted to form as a redesign for the planning and control of residents.

7.3 Initial assessment of redesigns

This section evaluates the redesigns proposed in section 7.2. It will evaluate the proposed redesigns by the various stakeholders. The evaluation will give a direction for the design parameters of the planning and control system of the Radiology department. It will evaluate the support for the various solutions by the stakeholders. Furthermore, it will create awareness among the stakeholders in organizing the planning and control of residents. To gather information from the stakeholders, two methods have been used. First, a survey is created and distributed among the Radiology department. Through distributing this survey, a larger sample-size could be reached. In total 26 members of the Radiology department have filled in the survey, from which 11 residents. Second, in-depth interviews with each of the stakeholders are performed. With the combination of these two methods, the evaluation of the stakeholders is gathered. The section will discuss the evaluation of the stakeholders following the three proposed redesigns of the previous section. More information about the questions and results of the survey distributed among the Radiology department can be found in Appendix G.

7.3.1 Proposal 1: Ideal situation residency program

As discussed in chapter 6, in the ideal situation for the residency program the provision of patient care services of the Radiology department is independent of residents. When the department is independent of residents, the residents can attend their internships fully and the fragmentation of the internships is minimized due to less tasks for the provision of patient care services. This situation is highly supported by the residents, as shown in Figure 21. However, 73% of the staff disagreed or strongly disagreed with this situation. The main reason for this disagreement is that the current structure of the department is not designed to function without residents. When the schedule should function independently of residents, the staff members state that many radiologists should be hired to fulfill the same capacity of patient care services.

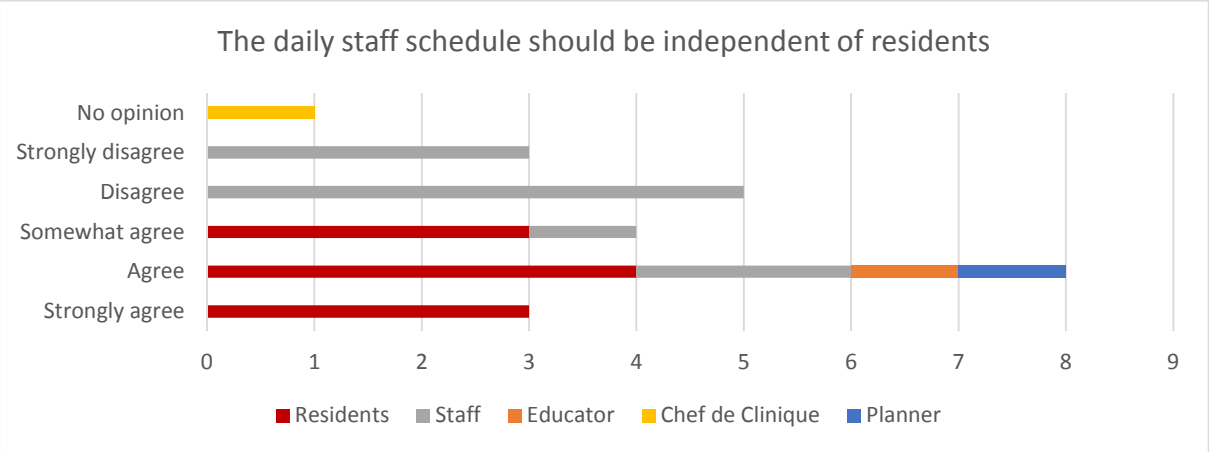


Figure 20: Evaluation by stakeholders - Statement 1

Although the staff members disagreed with an independent schedule for residents, the possibilities for creating an ideal situation for the residency program have been evaluated. One of these possibilities is restructuring the tasks of residents. As expected from the previous statement, 91% of the staff members disagreed with restructuring tasks and activities of residents and staff. However, 70% of the residents agreed strongly with a restructuring of tasks and activities. One comment that was given is that restructuring tasks is fine, as long as also technicians are taken into account. The opinions on restructuring the tasks and activities of residents and staff are shown in Figure 22.

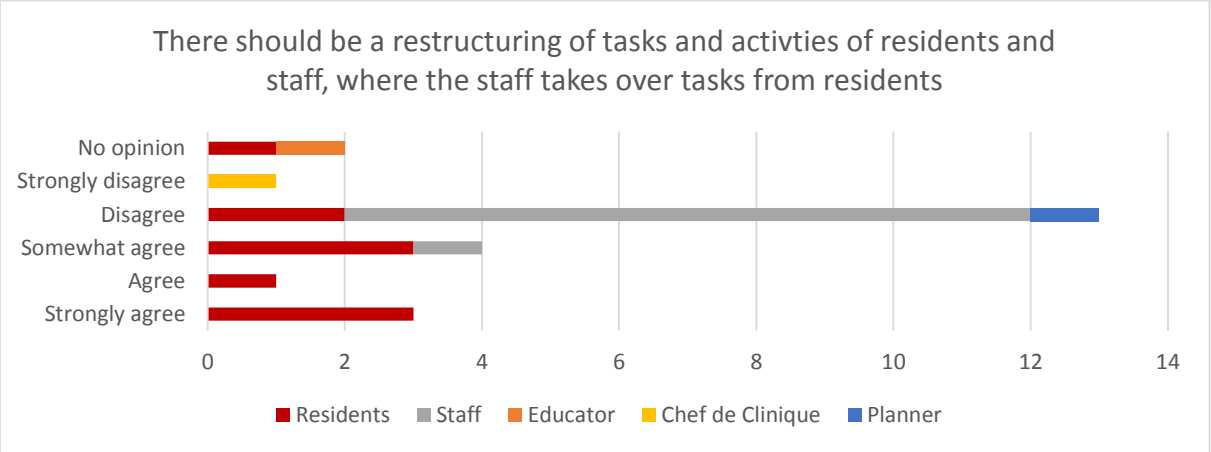


Figure 21: Evaluation by stakeholders - Statement 2

One of the possibilities to restructure the tasks and activities of residents and staff is to perform a part of the evening, night and weekend shifts by staff members. The results of this form of restructuring are comparable with previous statement. In total 42% agreed with staff members performing evening, night and weekend shifts (of which mostly residents) and 33% disagreed (of which mostly staff).

Besides restructuring the tasks and activities of residents, another factor of the ideal situation is the optimal provision of supervision. One of the aspects that is evaluated structuring the supervision, by coupling residents to one supervisor for each internship. This statement is highly disagreed on, 87.5% disagreed with coupling supervisors to staff members, whereas only 12.5% agreed. The main reason that was given on disagreeing with the coupling of residents with one supervisor is that residents learn more from different staff members, each with his/her own perspectives. On the other hand, almost everyone agreed with making more use of fourth- and fifth-year residents for providing supervision, as seen in Figure 23. The staff states that residents can learn a lot from giving supervision to other residents. It will prepare themselves for the future when they are radiologist.

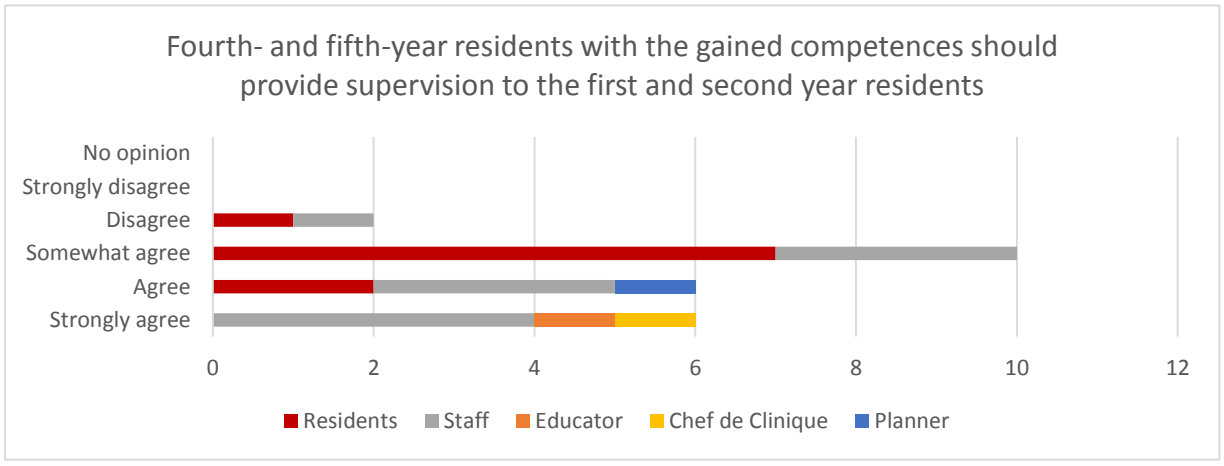


Figure 22: Evaluation by stakeholders - Statement 3

A final aspect of the ideal situation of the residency program that is evaluated is introducing evening, night and weekend shift blocks of 4 weeks, such that the structure of the evening, night and weekend shifts adjust better with the internship schedule. This change of structure gives mixed opinions among residents and staff. In total 45% agreed, whereas 27% disagreed. The other 27% had no opinion on the statement. These mixed opinions would suggest to further investigate the introduction of shift blocks of 4 weeks.

7.3.2 Proposal 2: Ideal situation patient care services

In the ideal situation for the provision of patient care services, there the capacity of the patient care services is fulfilled. To fulfill this capacity, it would be ideal to use residents for tasks for the provision of patient care services. However, 87.5% of the staff and residents think that it is important that the internships of the residents are not fragmented by tasks from the patient care services. Only 12.5% disagrees with this statement, as shown in Figure 24. This means that although residents are wishes to fulfill tasks for the provision of patient care services, the members of the Radiology department think that it should not harm the internships.

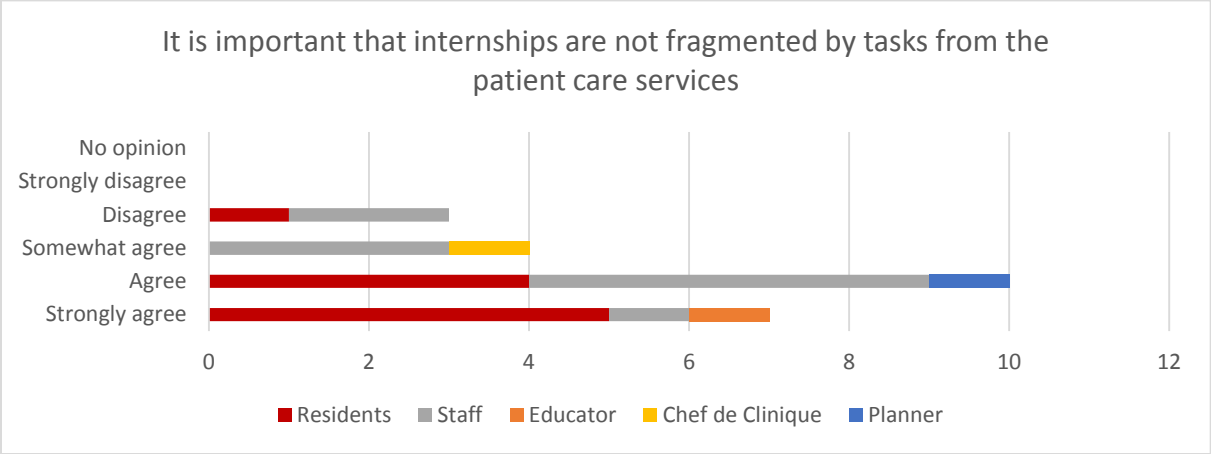


Figure 23: Evaluation by stakeholders - Statement 4

Furthermore, for the patient care services it is ideal if the residency schedule is structured in such a way that the number of residents at the sub-specialties is balanced. Thus, that there is a stable; minimum and maximum number of residents during the months of the residency year. An element that could be used to balance the number of residents, is introducing a same order of internships for the residents of the common trunk. More than 55% of the members of the Radiology department agreed with this principle. However, 36% disagreed or strongly disagreed, whereas the rest had no opinion. Another element in the ideal situation for the patient care services is structuring the internship schedule in a strict number of weeks. For instance, the internship schedule could be structured by internships of four weeks. With these strict numbers of weeks, there exists a schedule where the residents switch at the same moment. Consequently, the numbers of residents are more structured and for the sub-specialties it is clear when the residents switch from their internships. More than 68% agreed with this principle, only 9% disagreed, whereas the rest had no opinion or somewhat agreed, as shown in Figure 25.

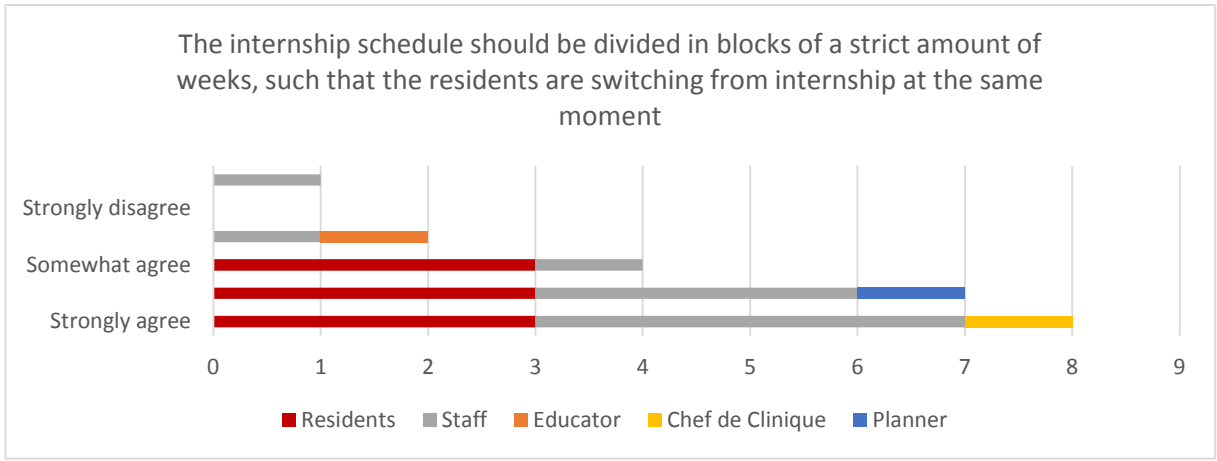


Figure 24: Evaluation by stakeholders - Statement 5

A final aspect of the ideal situation for the patient care services that is discussed is that the capacity of the sub-specialties should frequently be communicated. Besides this frequent communication, the internships should be scheduled from the viewpoint of the educational capacity of the sub-specialties, instead of from the wishes and requests of residents. For instance, a numerus fixus could be applied to certain sub-specialties. The opinions on this statement are mixed, as shown in Figure 26. From the residents, 70% disagrees or strongly disagrees with the statement. In contraction, 73% of the staff members agree with the statement.

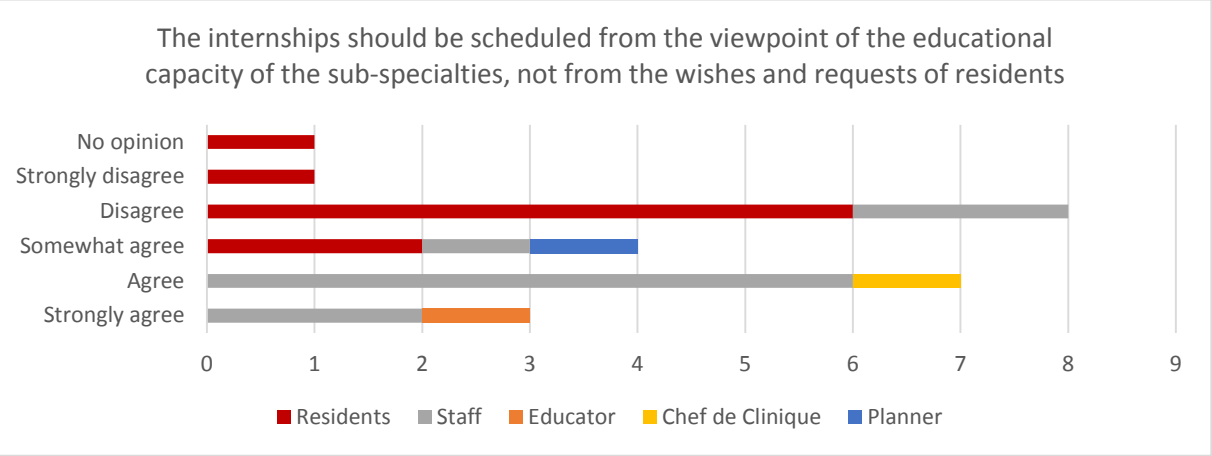


Figure 25: Evaluation by stakeholders - Statement 6

7.3.3 Proposal 3: Integrating both ideal situations

The final proposed redesign integrates the two ideal situations for the residency program and the patient care services. The most important element of this integrated situation is that there is introduced a structure with defined agreements and deadlines. One of the elements of this structure is a better communication between the various stakeholders. On the question if the communication of the planning and control of residents should be clearer, all the members of the Radiology department agreed. The results of this statement are shown in Figure 27.

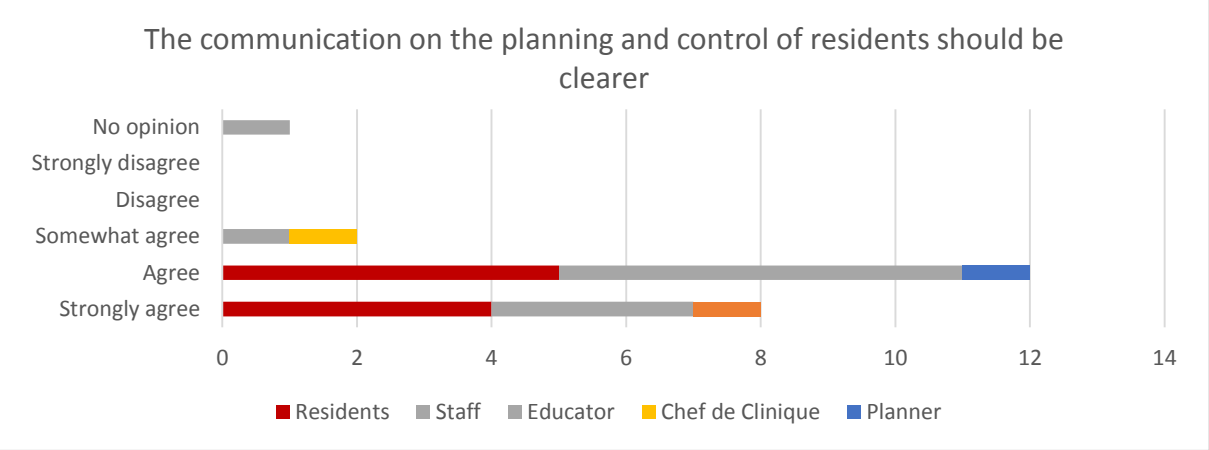


Figure 26: Evaluation by stakeholders - Statement 7

Besides the fact that the communication should be made clearer, the proposed structure also consists of agreements that need to be followed. In the current situation, 48% states that the agreements considering the planning and control of residents are not followed. In addition, almost everyone agreed with making one person presentative for each party. The introduction of a frequent meeting with a representative of each party, thus a resident, a staff member, an educator and a planner is also agreed by 78%.

Another part of the proposed structure is the introduction of strict timelines. Currently, the internship schedule is not composed at a specific day. However, 68% thinks that there should be a specific day for the composition of the internship schedule, for instance the first of the month. The comments that were given state that this would provide more clearness on the start of the internships. Besides introducing a strict day for the composition of the internship schedule, also deadlines for the delivery of wishes and requests could be introduced. For the wishes and requests of internships and differentiations, all residents agreed with the introduction of deadlines. Furthermore, on introducing deadlines for the delivery of wishes and requests such as holidays and days off, 74% of the staff and residents agreed. The results of the statement on deadlines for delivery of wishes and requests are shown in Figure 28.

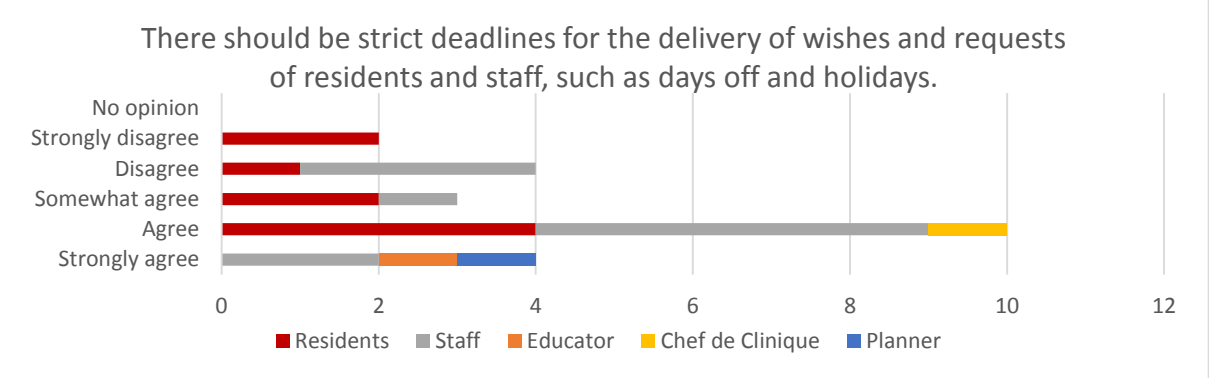


Figure 27: Evaluation by stakeholders - Statement 8

Besides the proposed structure, also various options for the composers of the schedules are evaluated. More than 35% thinks the current division of planners is not sufficient, whereas 35% has no strong opinion. On the question if residents should schedule the internships mixed opinions are raised. Most of the residents somewhat agreed or had no opinion on residents composing the schedule. However, comments were given that it might be an extra task adding to the already high workload of residents. Another option is to schedule both the internships and the patient care services at the planning department. This is support by 65%, as shown in Figure 29. The educator and the current planner of the internships strongly disagreed, because they are worried that the patient care services will be in the lead of the residency program when both schedules will be composed by the planning department. To make sure the quality of the residency program remains, there is also an option where the planning department composes the internship schedule, together with two responsible residents. Although this option is more agreed by residents, there are more staff members disagreeing with this statement, as presented in Figure 30.

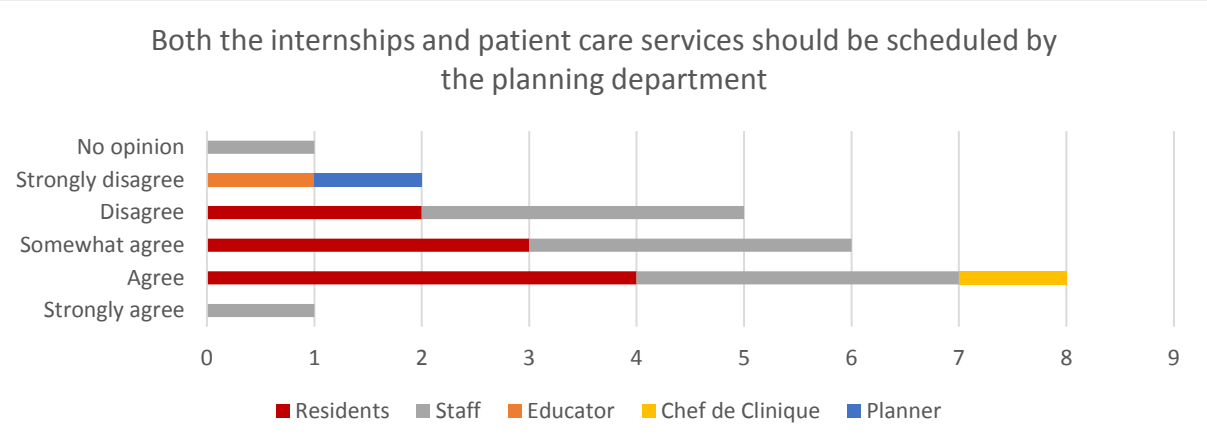


Figure 28: Evaluation by stakeholders - Statement 9

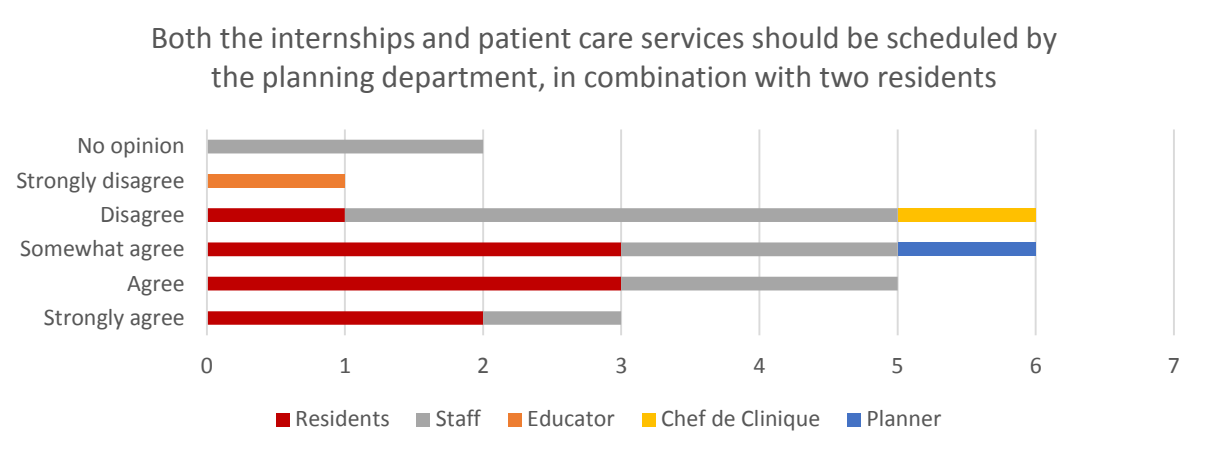


Figure 29: Evaluation by stakeholders - Statement 10

7.3.4 *Summary of initial assessment of redesigns*

This section evaluated the proposed redesigns by conducting a survey among the various stakeholders. The main reason for the evaluation is that it will give a direction for the design parameters of the planning and control system of the Radiology department. It will evaluate the support for the various solutions by the stakeholders. Furthermore, it will create awareness among the stakeholders in organizing the planning and control of residents. The main conclusion from this evaluation is that all stakeholders agree on introducing a structure with defined agreements and deadlines. This includes deadlines for the delivery of wishes and requests of internships, but also deadlines for days off, such as holidays. Furthermore, all stakeholders agree that there should be one representative for each party who is responsible for the communication with the rest of the stakeholders. In addition, these representatives should have meetings to frequently define the structure of the planning and control of residents. Besides these agreements, the stakeholders also disagreed on various points. These include restructuring the tasks and activities of residents and staff and defining the schedulers for the internships and the patient care services. These points need further investigation. The evaluation by the stakeholders is summarized below in three categories.

Do's

- ✓ Introducing a structure with defined agreements and deadlines.
- ✓ Making more use of fourth- and fifth-year residents for providing supervision
- ✓ Structuring the internship schedule in a strict number of weeks. For instance, the internship schedule could be structured by internships of four weeks.
- ✓ Composing the internship schedule on a specific day, for instance the first day of the month.
- ✓ Introducing deadlines for the delivery of wishes and requests for internships and differentiations.
- ✓ Introducing deadlines for the delivery of wishes and requests for both residents and staff, such as holidays and days off.
- ✓ Choosing one representative for each party who is responsible for the communication.
- ✓ Having a frequent meeting with a representative of each party, thus a resident, a staff member, an educator and a planner.

Don'ts:

- ✘ Structuring the supervision, by coupling residents to one supervisor for each internship.
- ✘ Introducing a same order of internships for the residents of the common trunk.

Further investigation:

- ± Introducing evening, night and weekend shift blocks of 4 weeks.
- ± Restructuring tasks and activities of residents and staff.
- ± Scheduling from the viewpoint of the educational capacity of the sub-specialties, instead of from the wishes and requests of residents.
- ± Composing the internship schedule by the planning department or by residents themselves.

The most important element of these redesigns is that there is introduced a structure with defined agreements and deadlines. Therefore, the proposed framework presents a first step in improving the effectiveness, efficiency and job satisfaction of the schedule of residents at the Radiology department of the UMCG.

8. DISCUSSION

This study proposed a framework for the planning and control of residents' activities, in order to improve the resulting schedule of residents. To design the framework, the Radiology department of the UMCG is used as a research vehicle for gathering data. In addition, also analyses from other hospitals and departments are used. This chapter will evaluate the designed planning and control framework. Furthermore, it will consider generalization of the research findings by discussing the possibilities of the proposed framework for other departments and hospitals. Finally, it will discuss the possibilities for the proposed framework in future scenarios.

Many hospitals face a difficult challenge in designing schedules for their residents. During the residency program, residents are considered both learners and providers of medical services. Therefore, the schedules need to satisfy both the educational requirements and the demand of providing patient care. The combination of these two activities results in many issues regarding the planning and control of residents, which are widely discussed in the literature (Day et al., 2006; Güler et al., 2013). For instance, many hospitals face challenges with guaranteeing the learning curve of internships and the high number of tasks residents are fulfilling at the departments. Furthermore, many hospitals face problems with high numbers of evening, night and weekend shifts taken by residents. The percentage of evening, night and weekend shifts of Radiology residents have increased from 15% in 2010 to 32% of the total time spend for the residency program in 2015 (Hoffman, Singh, & Peterkin, 2016). These problems are raising concerns about residents' stress, mood changes, and capacity to deliver high quality medical care (van der Heijden, Dillingh & Bakker, 2008; Prins et al., 2007; Thomas, 2004; Topaloglu & Ozkarahan, 2011). Besides the widely elaboration in literature, the problems with the planning and control of residents were also identified during the analysis of the five other departments, discussed in chapter 6.4. All the five analyzed departments faced difficulties with the planning and control of residents' activities. These difficulties affect both performance of the residency program and effective employment of residents at the department.

To deal with these problems and the complexity of the planning and control of residents, this research developed a framework for the planning and control of residents' activities. The aim of the framework is to enhance the effectiveness, efficiency and job satisfaction of the department, the residency program and the residents. The framework is designed with specific requirements followed from the performance analysis of the Radiology department of the UMCG. One of these requirements is a clear division of planning levels, horizons and tasks. To develop the planning and control framework for residents' activities, the four hierarchical levels proposed by Hans, Houdenhoven & Hulshof (2011) are used. These four levels are structural, tactical, offline operational and online operational planning and control. The four levels of planning and control are each decomposed in activities and design parameters for the planning and control of residents. By identifying planning levels, activities and parameters, it is meant to guide the planning and control system design. However, the designed planning and control framework for residents´ activities is an initial version. More research is needed to expand the planning and control framework. Currently, the framework consists of levels, activities and parameters. However the framework could be more expanded, for instance by detailing the proposed design parameters. In addition, the framework only includes one managerial area of the framework of Hans et al. (2011), namely the resource planning. The framework could be expanded in the other three levels: medical planning, materials planning and financial planning. For instance, it would be interesting to research the total costs of residents and the financial effects of the various possibilities of restructuring tasks of residents. Concluding from these limitations, the proposed framework can be seen as an initial step in guiding the planning and control system design of residents´ activities.

This study designed a planning and control framework by using the Radiology department of the UMCG as a research vehicle. Furthermore, the planning and control framework is illustrated by

designing solutions for the Radiology department. In addition, this study included five analyses from other hospitals and departments. Further research should illustrate the possibilities of the planning and control framework for these other departments. However, there are a few opportunities that the framework provides to any department. First, the planning and control framework creates awareness among the various departments. Second, the framework is a good start to evaluate any planning and control system of residents´ activities. Although it might need some adjustments for other departments and hospitals, the levels and activities will be the same for any planning and control system. Besides the proposed framework, this study provides many possibilities for other departments to improve the planning and control of residents. For instance, many possible design parameters are mentioned, which could give inspiration to design solutions for other cases.

In addition to the problems mentioned before and the ones acknowledged in literature, there are problems that will play an important role in the future and stress the need for a framework. One of these problems is that the numbers of resident positions are decreasing, due to decreasing funding from the government. The percentage of residents at the UMCG in 2017 has decreased with 18.1% since 2013. This number of residents will only decrease even more in the future. Besides the decreasing number of residents, also the structure of the residency programs is changing. In the past, the time that residents followed a program was according to a certain number of weeks. When the resident was successfully following these weeks, the residency program was completed. In the current situation, the time residents follow a program is according to the development of competences. When a resident has gained the needed competences, he or she completes the residency program. This current situation can lead to shorter residency programs. Both of these developments are increasing the problems with the planning and control of residents, since residents will be less available for employment at the departments. These problems ask even more for a clear division in planning levels, horizons and tasks. The planning and control of residents needs to change to adapt to the future developments. Therefore, the designed planning and control framework will be needed in the future. When redesigning the planning and control of residents due to the developments in the future, the framework proposed in this study can be used as a guideline for the departments.

The designed framework for residents´ activities is a first step in guiding the planning and control system design. The framework addresses the problem complexity and the division of planning levels, tasks and horizons. However, more research is needed to expand the designed framework. The planning and control framework can be used by any other department to create awareness about the planning and control of residents and to start evaluating their own planning and control system of residents. The arising problems around residents will force almost any department to redesign their planning and control system. When coping with these problems, the proposed framework can be used to guide the redesign of the planning and control system.

9. CONCLUSION

This study aimed to propose a framework for the planning and control of residents' activities, in order to enhance the effectiveness, efficiency and job satisfaction. To design the framework, the Radiology department of the UMCG is used as a research vehicle to gather data. In addition, also observations from other hospitals and departments are used. The developed framework is meant to serve as a reference architecture for designing systems for the planning and control of residents' activities. The setup of the framework acknowledges the need to address problem complexity by a hierarchical decomposition of the planning and control tasks. By identifying planning levels, planning activities and performance criteria, it is meant to guide the planning and control system design. The framework is designed by use of the three main objectives of this study:

1) Underpinning the need for a planning and control framework;
2) Developing requirements for the planning and control framework;
3) Illustrating and evaluating the possible use of the planning and control framework.

The performance of the planning and control of residents has been analyzed according to the performance indicators effectiveness, efficiency and job satisfaction. The performance analysis showed that especially effectiveness of the residency program has much room for improvement. For instance, the mean of the days spent at an internship is 3.48 days for a first-year resident, 2.84 days for a third-year resident and 2.54 days for a fifth-year resident. These means of the days spent at an internship are considered to be too low. In addition, 37.9% of the internships contain less than four consecutive weeks at one internship for all residents. This is not sufficient, since following less than four consecutive week's causes fragmentation of the internships and affects the learning curve of residents. To identify the causes of the problems at the Radiology department of the UMCG, a cause and effect analysis is performed. During this analysis, many possible causes are identified. These possible causes are rated by various stakeholders, to identify the most important causes at the Radiology department of the UMCG. The most important causes can be divided into four main categories. First, there is no explicit planning and control architecture. Second, there is no clear division of planning levels, horizons and tasks. Third, improvements on the planning and control of residents are stagnated due to problem complexity. This confirms the complexity of designing a schedule for residents, suggested by various researchers. Finally, there is a lack of integration between the schedules of the residency program and the patient care services. The identified causes of this analysis suggested to structure and to develop guidelines for the planning and control of residents. Thus, the observed performance proposes the need to develop a framework for the planning and control of residents.

Based on the findings of the performance analysis, a framework for the planning and control of residents' activities is developed. The planning and control framework for residents' activities is structured using the four hierarchical levels proposed by Hans, Houdenhoven & Hulshof (2011): structural, tactical, offline operational and online operational planning and control. The proposed framework is used to improve the performance of the planning and control system of the UMCG. To improve the performance of the current system, various possible solutions are identified. These possible solutions are organized into three redesigns, structured using the planning and control framework. To evaluate the three redesigns, a survey is conducted among the various stakeholders. The main reason for the evaluation is that it gives a direction for the design parameters of the planning and control system of the Radiology department. It evaluated the support for the various solutions by the stakeholders. Furthermore, it created awareness among the stakeholders in organizing the planning and control of residents. The main conclusion from the evaluation is that all stakeholders agree on introducing a structure with defined agreements and deadlines.

Concluding, the planning and control of residents is acknowledged to be complex, due to the many parties with their often conflicting interests and requirements. This scheduling complexity is also acknowledged by the analysis of this study. To guide the planning and control of residents, this study designed a planning and control framework for residents' activities. The developed framework is meant to serve as a reference architecture for designing systems for the planning and control residents' activities. The setup of the framework acknowledges the need to address problem complexity by a hierarchical decomposition of the planning and control tasks. By identifying planning levels, activities and design parameters, it is meant to guide the planning and control system design.

The proposed framework is an initial step in guiding the planning and control system design of residents´ activities. Therefore, there are several suggestions for future research:

- The performance indicators of this study are effectiveness, efficiency and job satisfaction. These performance indicators are measured using the so-called proxy measures. These proxy measures are limited in this research, based on the available data of the department. However, there are many more proxy indicators that could be used to measure the performance of the current planning and control of residents. Other relevant proxy measures could be defined and measured in future research.
- This study only evaluated the redesign with an initial assessment by stakeholders. There is no real-life implementation yet that could be evaluated on the performance indicators effectiveness, efficiency and job satisfaction. In the future, the design could be evaluated by a real-life study and the results could be adjusted with means of this evaluation.
- In this research a case study is performed on the Radiology department of the UMCG. Further research could investigate the possibilities of redesign and the application of the proposed framework for other departments.
- The scope of the research is limited to only one managerial area of the framework of Hans et al. (2011), namely the resource planning. However, the framework could be expanded in the other three levels: medical planning, materials planning and financial planning. For the medical planning, this means that the research only focused on the fulfillment of shifts for patient care services, not on the appointment with patients specifically. Another managerial area of the framework of Hans et al. (2011) that is left out of scope is the financial planning. In future research, the financial part of residents could be investigated. It would be interesting to research the total costs of residents and the financial effects of the various possibilities of restructuring tasks of residents.
- The final and most important suggestion for future research is detailing the proposed framework. Currently, the framework has levels, activities and design parameters. However, the framework could be expanded further.

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APPENDICES

A. Stakeholder analysis
B. Organogram
C. National residency program
D. Regional residency program
E. Ranking causes
F. Analyses other departments and hospitals
G. Survey

Appendix A: Stakeholder analysis

There are eight stakeholders involved in the planning and control of residents at the Radiology department of the UMCG:

- The residents
- The educators
- The program coordinator
- The staff
- The planning department
- The managers
- The Chef's de Clinique

The stakeholders can be mapped in the Mendelow's Power-interest grid, depending on the interest and power of the stakeholders. This Mendelow's Power-interest grid is shown in Figure 31.

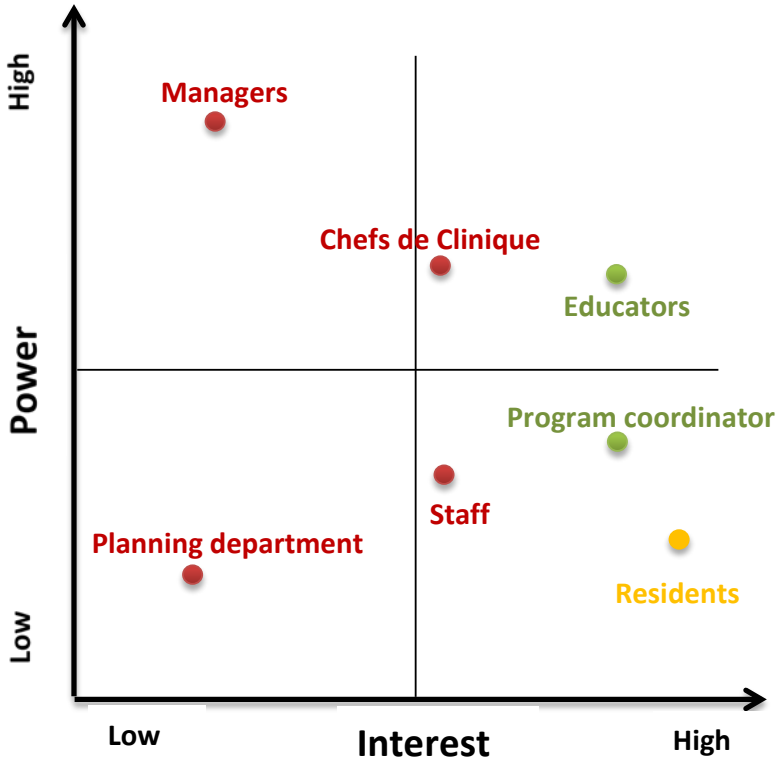

Figure 30: Stakeholders in Mendelow's Power-Interest grid

Residents

The main subjects of this research are the residents. They are following a challenging medical training to become a specialist in the field of Radiology. The residents want the best residency program possible; they want to learn as much as they can. The residents want to contribute to the provision of patient care services on the work floor, but they also want sufficient days at their internships. Their main requirement for this research is that the planning minimizes the number of residents of the same year of the program at the internships. Some scans are rare, and if there are multiple residents of the same year at one internship, they have to fight about who can work out this scan. Furthermore, the residents state that the tasks on contributing to the patient care services are useful, because they learn a lot from it. However, they think there is a maximum on these tasks and on for instance the number of evening, night or weekend shifts. In summary:

- The residents want the best residency program possible.
- The residents want both to contribute to the provision of patient care services and attend sufficient days at their internships.

- The residents want to balance the number of residents of the same year of the residency program at an internship.
- The residents want a fair and maximum amount of evening, night and weekend shifts.

Educators

Other stakeholders of this research are the educators. There is one main educator and three subsidiary educators. Furthermore, each differentiation has each own differentiation educator. The educators want to deliver the best residency program possible. They want the planning and control to be more optimal, because they recognize the problems that are happening now. The educators want less fluctuations and less fragmentation of the internships. Their main goal is to have a good quality of the residency program. However, in the end, they also want the other stakeholders to be happy. In summary:

- The staff wants to balance the number of residents at an internship.
- The staff wants the residents to provide patient care services, such as evening, night and weekend shifts, to have more time to perform their own tasks.
- The staff wants clearness and transparency on what happens with the planning and control and why problems are arising.

Program coordinator

The Radiology residency program has a program coordinator, which works closely together with the residents and the educators. The program coordinator has various tasks related to the residency program. The most important task for this research is that she does the planning and control of the residency program. Furthermore, the program coordinator is involved in the creation and implementation of policies on regional and local level. He/she coordinates the quality of the residency program and supports the educators. The program coordinator acknowledges that there are two sides of the problem that are conflicting: the requirements of the residency program and the requirements of the provision of patient care. For her it is simply not possible to make everyone happy in the current situation. She admits that the current planning and control is not optimal. There are many parties that are not satisfied with the current results. For the program coordinator, it would be great if it becomes clear what the different interests are and which have the most priority compared to others. In that way, he/she can just show the requirements to others and there is clearness on what happens and why.

- The program coordinator wants clearness on the requirements and interests of the various stakeholders.
- The program coordinator wants arrangements on which interests to follow.
- The program coordinator wants to deliver the best residency program possible.

Staff

- Besides the educators, the staff members are involved in the residency program. They are supervising the residents, but are also involved in the division of tasks of residents at the internships. The staff members do not want too many residents at one internship. Sometimes there are four residents at one internship, but then the supervisors do not know what to do with them anymore. Furthermore, they want the residents to do the 'residents tasks', because they want time to do their own tasks. "When we need to take shifts of the residents, we lose time for our other core tasks, on supervision and researching". One of the requirements of the staff for this research is that they want clearness on what happens with the planning and control. "We want to provide good supervision." The staff wants to balance the number of residents at an internship. In summary:
  - The staff wants the residents to provide patient care services, such as evening, night and weekend shifts, to have more time to perform their own tasks.
  - The staff wants clearness and transparency on what happens with the planning and control and why problems are arising.

Planning department

The planning department of Radiology is the department that plans the patient care services. Thus, they are, among others, planning the staff shifts. When they are planning the shifts, they are also planning the residents with use of the education schedule. They use residents to fill gaps and to make sure that there is a doctor for every shift. *"We know that it is not good for the residency program to take the residents from their internships to fulfill other tasks. However, sometimes you just don't have a choice in fulfilling the various tasks."* Furthermore, they recognize that there are high fluctuations at the various internships. They are wondering why the division of residents is done in this way. For them it is an unknowing process, they just get the data about the internships and they plan with this data. When they see a possibility that should be different, they contact the program coordinator. But for them it is unclear why there are fluctuations in the planning of residents.

- The planning department wants enough residents and staff members to fulfill the provision of patient care services.
- The planning department wants clearness and transparency on what happens with the planning and control of the residency program and why problems are arising.

Managers

The managers of the Radiology department are responsible for everything that includes the non-medical section of the department. There are two managers; one is responsible for the financial business and one is responsible for the logistics and the personnel. They have a stake in the research because they are involved in the final decision making. If something can be more efficient, it is of their interest and they will be the ones implementing it. The planning and control influences their business and they also recognize the problems faced. The final result that is of interest to them is an advice on what they can improve.

- The managers want the planning and control to be more effective.
- The managers want advice on want they can improve in the current situation.

Chef's de Clinique

The Chef de Clinique is the radiologist that is in charge of the medical part of the Radiology department. Thus, the radiologists and residents are led by the Chef de Clinique. At the Radiology department of the UMCG this task is fulfilled by two Chef de Clinique's. The Chef de Clinique's are stakeholders of this research, because the structure of the residency program influences the way of working at the department. The department needs residents to fulfill tasks and help in the provision of patient care. The planning of the residents cannot be optimized without affecting the radiologists of the department. The Chef de Clique's state that they need the residents to fulfill tasks, however they recognize the problems with the internships as well.

- The Chef de Clinique's want the residents to provide patient care services, such as evening, night and weekend shifts, such that the staff has more time to perform their own tasks.
- The Chef de Clinique's want the planning of the residents to be optimized, with minimizing the effect on the staff members and the department.

Summary

There are seven stakeholders, which can be divided among three perspectives as shown in Figure 32. The educators and the program coordinator want to deliver the best residency program possible. At the other hand the staff, the planning department, the managers and the Chef's de Clinique are on the side of delivering patient care services. They want the residents to perform many other tasks that involve the provision of patient care, which might decrease the effectiveness of the residency program. The final stakeholders are the residents, who are in the middle of these two perspectives.

Figure 31: Three stakeholders' perspectives

APPENDIX B: ORGANOGRAM

The Medical Imaging Center (MIC) is a section of the University Medical Center Groningen (UMCG) that consists of the departments of Radiology and Nuclear Medicine and Molecular Imaging. This research only focuses on the department of Radiology. Therefore, the organizational structure of the Radiology department is further discussed. In Figure 33 the organizational structure of the Radiology department is shown. The chair of the MIC is on top, followed by the managers healthcare and business and the head of the department. There are various sub sections that contribute to the MIC, such as the secretariat, the R&D department and the general support. In the end, the department of Radiology consists of three sections: the medical administration, the medical microbiology (MMB) and the work floor of Radiology. The medical administration has a coordinator and various employees. The medical microbiology has a manager, medical microbiologists, care supervisors and nurses. Finally, the work floor consists of Chefs de Clinique's, who are in charge of the medical part of the Radiology department, radiologists and residents.

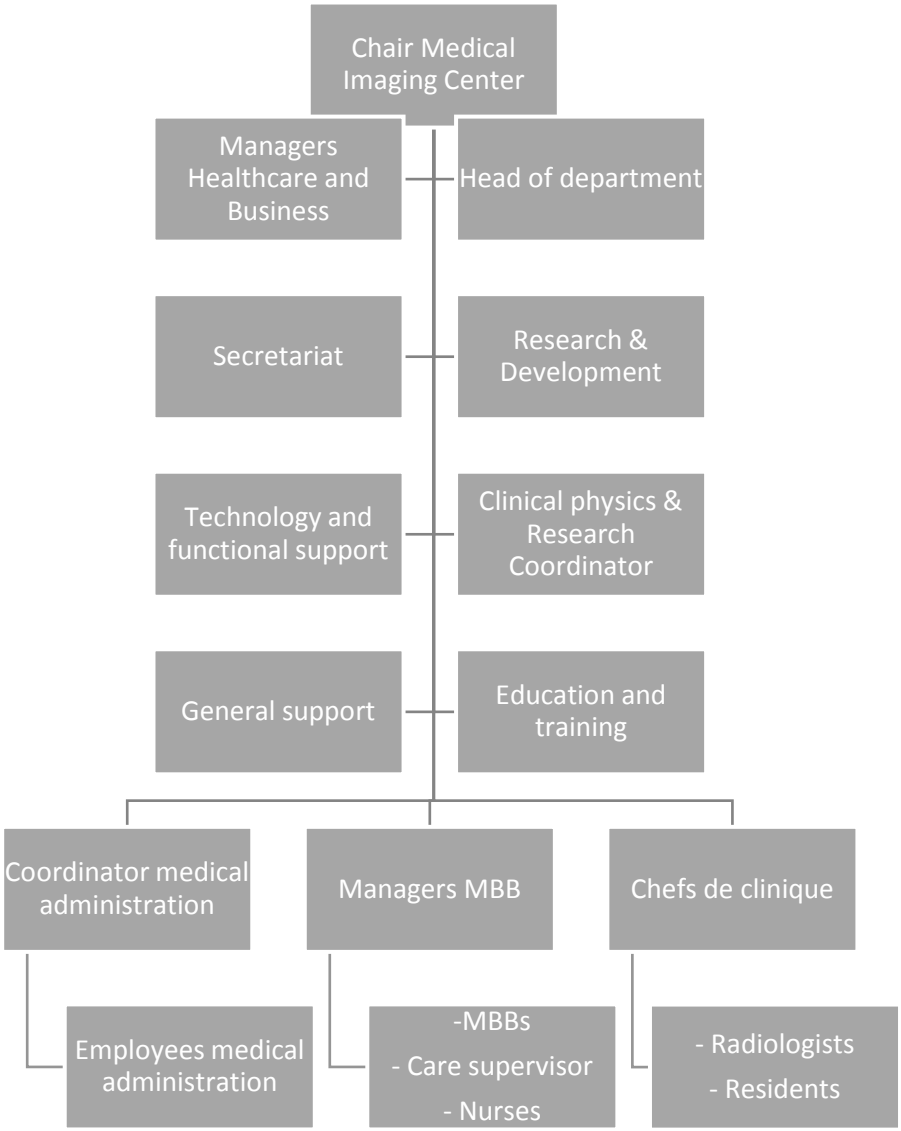

Figure 32: Organogram of the Radiology department of the UMCG

APPENDIX C: NATIONAL RESIDENCY PROGRAM

This section will provide the structures of the national Radiology residency program. The residency program takes 5 years, divided in both common trunk and differentiation. The structure of the common trunk conform the national residency program is shown in Table 41. The structure of the differentiation phase, thus both the differentiations and the general Radiology internships, are shown in Table 42 and 43, respectively.

Theme	Year 1 (weeks)	Year 2 (weeks)	Year 3 1st half (weeks)	Total common trunk (weeks)
Cardiothoracic Radiology	12	4	4	20
Abdominal Radiology	12	4	4	20
Interventional Radiology		4	4	8
Nuclear Medicine and Molecular Radiology		8		8
Neuroradiology	8	4	4	16
Musculoskeletal Radiology	10	4	4	18
Mammography		8		8
Pediatric Radiology		10		4
Radiation hygiene	4			
Subtotal in weeks	46	46	20	114
Choice, conferences, vacations etc.	6	6	6	18
Total in weeks	52	52	26	130
In years	1	1	0,5	2,5

Table 41: Structure of national residency program - Common trunk

Theme	Months	Weeks
Cardiothoracic Radiology	18	78
Abdominal Radiology	18	78
Interventional Radiology	18	78
Nuclear Medicine and Molecular Radiology	18	78
Neuroradiology	12	52
Musculoskeletal Radiology	12	52
Mammography	6	26
Pediatric Radiology	6	26

Table 42: Structure of national residency program - Differentiation themes

Theme	Weeks
Cardiothoracic Radiology	8
Abdominal Radiology	8
Interventional Radiology	4
Nuclear Medicine and Molecular Radiology	
Neuroradiology	8
Musculoskeletal Radiology	8
Mammography	8
Pediatric Radiology	8
Subtotal in weeks	52

Table 43: Structure of national residency program - Differentiation General Radiology

APPENDIX D: REGIONAL RESIDENCY PROGRAM OOR N&O

The residency program of Radiology is divided among 8 education regions in the Netherlands. The UMCG is part of the northeast region of the Netherlands, called "Noord-Oost" (N&O). The exchange year has to take place in the Onderwijs- en Opleidingsregio (OOR). The OOR N&O consists of five local hospitals:

- Ziekenhuis Groep Twente (ZGT), Almelo
- Deventer Ziekenhuis (DZ), Deventer
- Medisch Spectrum Twente (MST), Enschede
- Isala, Zwolle
- Universitair Medisch Centrum Groningen (UMCG), Groningen

There is a regional residency program to provide collaboration between the five hospitals, called the Lokale Opleidingsplannen (LOP). The LOP consist of how the regional structure of the residency program. Each hospital offers different internships, which means that certain internships need to be followed in other hospitals. The structure of differentiations in each hospital is shown in the Table 44.

	UMCG	DZ	ZGT	MST	Isala
Cardiothoracic Radiology			x	x	x
Abdominal Radiology	x	x	x	x	x
Interventional Radiology	x			x	x
Nuclear Medicine and Molecular Radiology	X				
Neuroradiology	x			x	x
Musculoskeletal Radiology	x	x	x	x	x
Mammography	x	x	x	x	x
Pediatric Radiology	x				

Table 44: Structure of regional residency program - Differentations

The division in offering the differentiations means a few things for the UMCG. First, each resident that comes from a periphery hospital needs to spend 10 weeks at the Pediatric Radiology, because this can only be done in the UMCG. Furthermore, the differentiation cardiothoracic cannot be done in the UMCG. If a resident wants to choose this differentiation, they need to go to a periphery hospital.

APPENDIX E: RANKING CAUSES

E.I RATES OF RESIDENT

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	+
1.2 There is a lack of deadlines for defining the capacity of the residency program.	++
1.3 There is a lack of communication with the peripheral hospitals.	+
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	-
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	-
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	+
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	-
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	++
3.4 There is no definition of educational capacity of the sub-specialties.	+
3.5 There is a lack of an optimal equipped planner for the residency program.	+/-
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	-
4.2 There are no defined milestones for the planning and control of the residency program.	+
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	--
5.2 There is a lack of an automatic planning and control system for the residency program.	+/-
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	+/-
5.4 There is a lack of an optimal equipped planner for the patient care services.	+/-
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	-
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	++
6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	-
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	+/-

7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	+/-
7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	-
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	++
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	+/-
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	+
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	++
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	--
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	+
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	-
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	--
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	+
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	+

E.II RATES OF EDUCATOR 1

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	+/-
1.2 There is a lack of deadlines for defining the capacity of the residency program.	+
1.3 There is a lack of communication with the peripheral hospitals.	--
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	-
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	-
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	--
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	-
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	-
3.4 There is no definition of educational capacity of the sub-specialties.	+
3.5 There is a lack of an optimal equipped planner for the residency program.	--
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	-
4.2 There are no defined milestones for the planning and control of the residency program.	--
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	+
5.2 There is a lack of an automatic planning and control system for the residency program.	-
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	-
5.4 There is a lack of an optimal equipped planner for the patient care services.	+
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	+
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	++
6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	++
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	-
7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	+

7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	+
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	-
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	-
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	-
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	+
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	++
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	+
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	++
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	++
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	+
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	+

E.II RATES OF EDUCATOR 2

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	-
1.2 There is a lack of deadlines for defining the capacity of the residency program.	+
1.3 There is a lack of communication with the peripheral hospitals.	-
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	+
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	+
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	+
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	+
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	-
3.4 There is no definition of educational capacity of the sub-specialties.	++
3.5 There is a lack of an optimal equipped planner for the residency program.	+
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	-
4.2 There are no defined milestones for the planning and control of the residency program.	+
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	-
5.2 There is a lack of an automatic planning and control system for the residency program.	-
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	-
5.4 There is a lack of an optimal equipped planner for the patient care services.	++
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	+
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	+
6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	+
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	+/-
7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	+

7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	+
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	-
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	-
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	+
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	+
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	++
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	++
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	+
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	+
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	++
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	+

E.II RATES OF EDUCATOR 3

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	-
1.2 There is a lack of deadlines for defining the capacity of the residency program.	+/-
1.3 There is a lack of communication with the peripheral hospitals.	--
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	-
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	-
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	-
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	-
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	--
3.4 There is no definition of educational capacity of the sub-specialties.	+
3.5 There is a lack of an optimal equipped planner for the residency program.	-
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	+/-
4.2 There are no defined milestones for the planning and control of the residency program.	--
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	+
5.2 There is a lack of an automatic planning and control system for the residency program.	++
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	-
5.4 There is a lack of an optimal equipped planner for the patient care services.	+
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	+/-
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	++
6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	-
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	+/-
7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	+

7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	+/-
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	-
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	-
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	-
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	+
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	++
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	+
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	+
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	++
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	++
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	++

E.III RATES OF PROGRAM COORDINATOR

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	+/-
1.2 There is a lack of deadlines for defining the capacity of the residency program.	+/-
1.3 There is a lack of communication with the peripheral hospitals.	--
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	+/-
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	+/-
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	++
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	+/-
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	--
3.4 There is no definition of educational capacity of the sub-specialties.	+/-
3.5 There is a lack of an optimal equipped planner for the residency program.	+/-
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	+
4.2 There are no defined milestones for the planning and control of the residency program.	-
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	+/-
5.2 There is a lack of an automatic planning and control system for the residency program.	+
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	--
5.4 There is a lack of an optimal equipped planner for the patient care services.	+/-
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	+/-
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	+
6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	+/-
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	+/-
7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	-

7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	+
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	++
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	++
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	--
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	-
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	++
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	+
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	++
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	-
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	+
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	+/-

E.IV RATES OF STAFF MEMBER

Causes	Rating importance
1. Defining capacity of residency program	
1.1 There is a lack of standard procedures for defining the capacity of the residency program.	+/-
1.2 There is a lack of deadlines for defining the capacity of the residency program.	+
1.3 There is a lack of communication with the peripheral hospitals.	+/-
2. Defining capacity of patient care services	
2.1 There is a lack of standard procedures for the definition of capacity of the patient care services.	+/-
2.2 There is a lack of deadlines for the definition of capacity of the patient care services	+/-
3. Structuring internship schedule	
3.1 There is no defined planning horizon for the schedule of the residency program.	+
3.2 The internships of the residency program schedule are based on short-term planning and control instead of long-term planning and control	+
3.3 There is no defined number of consecutive weeks of internships in the schedule of the residency program.	+
3.4 There is no definition of educational capacity of the sub-specialties.	++
3.5 There is a lack of an optimal equipped planner for the residency program.	+
4. Defining remaining capacity residents	
4.1 There is a lack of quality measurements for the planning and control of the residency program.	+/-
4.2 There are no defined milestones for the planning and control of the residency program.	++
5. Structuring patient care schedule	
5.1 There is no defined planning horizon for the schedule of the patient care services.	--
5.2 There is a lack of an automatic planning and control system for the residency program.	+
5.3 There are no frequent updates of the technology of the planning and control system of the residency program.	-
5.4 There is a lack of an optimal equipped planner for the patient care services.	+
6. Division of tasks of patient care services	
6.1 The culture of the department is classical, which influences the division of tasks and the capacity of patient care services.	+/-
6.2 There is no integration between availability of staff for supervision and the number of residents in the schedule of the residency program.	+
6.3 The division of tasks is based on short-term planning and control instead of long-term planning and control.	--
7. Day scheduling of residents	
7.1 There are no standard procedures for defining the schedule of the residents.	+
7.2 There is a lack of overview of all the tasks of the patient care services that need to be scheduled.	++

7.3 The wishes and requests of residents and staff are in the lead for the schedule of the patient care services.	--
7.4 The wishes and requests of residents are in the lead for the schedule of the residency program.	++
7.5 There are no deadlines for the delivery of wishes and requests for the residency program by residents.	+/-
7.6 There are no deadlines for the delivery of the evening, night and weekend shift schedule.	+
7.7 There is a lack of communication between the various stakeholders considering the planning and control of residents.	+/-
7.8 There is a lack of integration between the schedules of the residency program and the patient care services.	-
7.9 There is no definition of priority of interests between the schedules of the residency program and the patient care services.	+/-
7.10 The structure of the schedules (day, week) is different for the residency program and the patient care services.	+/-
7.11 The planning programs used for the planning and control are different for the residency program and the patient care services.	+
8. Online scheduling	
8.1 The department has a low boundary of calling sick, which influences the planning and control of patient care services.	+
8.2 It is not clear if all last-minute requests and wishes should be accepted in the schedule of the patient care services.	+/-

E.IV MEAN CAUSES RATES

Causes	Resident	Educator 1	Educator 2	Educator 3	Program coordinator	Chef de cliques	Mean
	1. Defining capacity of residency program						
1.1	+	+/-	-	-	+/-	+/-	+/-
1.2	++	+	+	+/-	+/-	+	++
1.3	+	--	-	--	--	+/-	--
	2. Defining capacity of patient care services						
2.1	-	-	+	-	+/-	+/-	+/-
2.2	-	-	+	-	+/-	+/-	+/-
	3. Structuring internship schedule						
3.1	+	--	+	-	++	+	+/-
3.2	-	-	+	-	+/-	+	+/-
3.3	++	-	-	--	--	+	--
3.4	+	+	++	+	+/-	++	++
3.5	+/-	--	+	-	+/-	+	-
	4. Defining remaining capacity residents						
4.1	-	-	-	+/-	+	+/-	+/-
4.2	+	--	+	--	-	++	+/-
	5. Structuring patient care schedule						
5.1	--	+	-	+	+/-	--	-
5.2	+/-	-	-	++	+	+	+/-
5.3	+/-	-	-	-	--	-	--
5.4	+/-	+	++	+	+/-	+	++
	6. Division of tasks of patient care services						
6.1	-	+	+	+/-	+/-	+/-	+
6.2	++	++	+	++	+	+	++
6.3	-	++	+	-	+/-	--	+/-
	7. Day scheduling of residents						
7.1	+/-	-	+/-	+/-	+/-	+	+/-
7.2	+/-	+	+	+	-	++	+
7.3	-	+	+	+/-	+	--	+/-
7.4	++	-	-	-	++	++	+
7.5	+/-	-	-	-	++	+/-	+/-
7.6	+	-	+	-	--	+	+/-
7.7	++	+	+	+	-	+/-	+
7.8	--	++	++	++	++	-	+
7.9	+	+	++	+	+	+/-	++
7.10	-	++	+	+	++	+/-	+
7.11	--	++	+	++	-	+	+
	8. Online scheduling						
8.1	+	+	++	++	+	+	++
8.2	+	+	+	++	+/-	+/-	++

Appendix F: Analyses other departments and hospitals

To generate solutions and to generalize the outcomes of the study, other hospitals and departments are analyzed. The departments are analyzed by conducting in-depth interviews with the persons that are performing the planning and control of residents. These interviews were semi-structured, thus pre-formulated questions combined with open questions and there was no strict order of the questions. The field notes are directly taken by showing the planning and control systems. The interviews were mostly individual interviews with the planners. The upcoming sections will discuss the analysis of the Radiology department of three other university medical centers and two other departments of the UMCG. Sections E.I, E.II and E.III will discuss the planning and control of residents at the Radiology departments of UMC Utrecht, AMC Amsterdam and Erasmus MC, respectively. Furthermore, section E.IV and section E.V will discuss the planning and control of residents at the Gastroenterology and Hepatology department and the Anesthesiology department of the UMCG.

F.I Radiology department UMC Utrecht

The first academic hospital that is analyzed is the University Medical Center (UMC) Utrecht. The UMC Utrecht is one of the eight academic hospitals in the Netherlands. The Radiology department of UMC Utrecht is comparable with the Radiology department of the UMCG. The UMC Utrecht has around 30 residents that follow the challenging Radiology residency program. The internships of UMC Utrecht are also divided among the various sub-specialties. However, they have divided the internships a level further. For instance, they divided the internship of Abdominal Radiology in Abdominal Radiology 1, Abdominal Radiology 2 and Abdominal Radiology 3. In this case, Abdominal Radiology 1 is making the MRI scans and Abdominal Radiology 2 is making CT scans etc. Furthermore, the residents of the UMC Utrecht have an extra internship on the Central Military Hospital. The Central Military Hospital is part of the Ministry of Defense of the Netherlands and is located in Utrecht.

Current performance

At the UMC Utrecht they are quite satisfied with the current planning and control of residents. However, they do not have a clear overview of the number of weeks residents are attending their internships. At the UMC Utrecht they have a month schedule, but they do not have an overview of the total amount of weeks residents are spending at the internships. They are more working conform the EPA perspective. If a resident does not gain the required competences during an internship, he should attend the internship for a second time. However, this responsibility lays with the resident themselves. If the resident feels that he/she has not the required competences yet and wants to attend an extra internship, he/she can give this information to the planner. Furthermore, the UMC Utrecht has problems with the hours of evening, night and weekend shifts residents are taking. These hours are much higher than the norm for evening, night and weekend shifts. The final problem of the UMC Utrecht is that they acknowledge the fragmentation of the internships. Sometimes residents are only spending a few days of the week at their internships, due to performing specific tasks for the patient care services. The current performance of the UMC Utrecht is summarized in Table 45.

- At the UMC Utrecht, they are quite satisfied with the current planning and control of residents. However, they do not have a clear overview of the number of weeks residents are attending their internships.
- The UMC Utrecht has problems with the high number of hours of evening, night and weekend shifts that residents are taking.
- The UMC Utrecht acknowledges the fragmentation of the internships, due to performing specific tasks for the patient care services.

Table 45: Current performance - UMC Utrecht

Structural planning and control

The UMC Utrecht has around 30 residents at the Radiology department. Besides residents and staff members, they have three fellows for the provision of patient care services. These fellows are mostly performing the ultrasounds. Most of the staff members are not willing to perform these ultrasounds, which is why residents, technicians and fellows are performing them.

The UMC Utrecht has no strict inflow moments of new residents. The resident can start the residency program when they are ready, for instance after they finished a project. Currently, two residents are coming in February and one resident in May. When these residents have started the residency program, they will search for new residents. The culture of the department is stated by the residents and staff members as very good. The supervisors are always open for answering questions and the residents are not afraid to ask them those questions.

The residency program of the UMC Utrecht is divided differently with the peripheral hospitals than the UMCG. At the UMC Utrecht a resident is starting either at the UMC Utrecht for two years or at a peripheral hospital for two years. These two years are followed by either two years in the peripheral

hospital or at the UMC Utrecht, respectively. The final year is either spend at the UMC Utrecht or in a peripheral hospital. Thus, instead of one year in a regional hospital, this residency program focuses on two years in a regional hospital. The UMC Utrecht works together with Gelre ziekenhuizen in Apeldoorn and Meander Medisch Centrum in Amersfoort. The problem that arises with these peripheral hospitals is that they have different sub-specialties. For instance, Gelre ziekehuizen has Pediatric- and Neuroradiology combined in one internship, whereas the UMC Utrecht has divided these two internships. This difference in sub-specialties makes the overview of the weeks spent at an internship unclear. Furthermore, the UMC Utrecht does not know which internships the residents have followed in the other hospitals. The structural planning and control of the UMC Utrecht is summarized in Table 46.

- The UMC Utrecht has around 30 residents.
- There are no strict inflow moments of residents.
- Instead of one year in a regional hospital, this residency program focuses on two years in a peripheral hospital.
- Besides residents and staff members, the UMC Utrecht has three fellows. These follows decrease the tasks of the residents.
- The staff members are always open for providing supervision.

Table 46: Structural planning and control - UMC Utrecht

Tactical planning and control

The schedule of the internships of the residents at the UMC Utrecht is a month schedule. The new internship starts at the Monday of the first full week of the month. Thus, if a week starts at a Wednesday, the internships are starting at the next Monday. The planning of the internships is composed for a whole year, whereas the evening, night and weekend shifts are scheduled for three months. The program that is used for the planning of internships of residents is Microsoft Excel. Furthermore, the planning of the evening, night and weekend shifts and the planning of the staff are also performed in Microsoft Excel. In addition, the UMC Utrecht makes use of Microsoft Access for databases of the residents and staff members. Furthermore, they use Monaco for the calculation of the residents' hours. The UMC Utrecht is looking for a new planning and control program called MedSpace. This program is already used by Gelre ziekehuizen in Apeldoorn and Zutphen.

The planning and control of the residents is performed by a member of the secretary. Furthermore, there are two residents that can adjust the schedule of the residents. This means that if a resident wants to make an adjustment in evening, night and weekend shifts or any other task in the provision of patient care, they need to contact the member of the secretary or one of the two responsible residents. These two residents are working closely together with the member of the secretary, to make sure the schedule is sufficient.

The residents of the UMC Utrecht perform the same tasks in the provision of patient care services as the residents of the UMCG. For instance, they are performing the ultrasound and fulfilling the evening, night and weekend shifts. Furthermore, they are performing the ATLS and the extra internship on the Central Military Hospital. The residents of the UMC Utrecht are fulfilling the evening, night and weekend shifts from the 10th month of their residency program. These first months they are only performing a shift from 13-18h, together with another resident. In this way, they are prepared for taking the evening, night and weekend shifts on their own. The tactical planning and control of the UMC Utrecht is summarized in Table 47.

- The UMC Utrecht has a month schedule and they are more working conform the EPA perspective.
- The program that is used for the planning of internships is Microsoft Excel. Furthermore, also the planning of the evening, night and weekend shifts and the planning and control of staff are performed in Microsoft Excel. In addition, they use Monaco for the calculation of the residents' hours.
- The composition of the schedules is done by a member of the secretary, in combination with two residents.
- The UMC Utrecht is looking for a new planning and control program called MedSpace.

Table 47: Tactical planning and control - UMC Utrecht

Offline and online operational planning

The allocation of residents to patient care services and internships is done by a member of the secretary. However, the decisions on of who is attending which internship or when a resident starts his program, all lay with the educator. Thus, the educator makes the final decision. The residents can give their preferences and it is tried to take them into account. The staff has the opportunity to fill in their schedule at a weekly staff meeting. This schedule is in the lead for the rest of the planning and control process. The offline and online operational planning and control of the UMC Utrecht are summarized in Table 48.

- The educator makes the final decision on the internship schedule.
- Preferences are filed in once a week and they are tried to be considered.

Table 48: Offline operational planning and control - UMC Utrecht

Conclusion

The Radiology department of UMC Utrecht is comparable with the department of the UMCG. The UMC Utrecht has around 30 residents that follow the challenging Radiology residency program. The difference with internships of the UMC Utrecht is that the internships are divided a step further. For instance, they divided the internship of Abdominal Radiology in Abdominal Radiology 1, Abdominal Radiology 2 and Abdominal Radiology 3. In this case, Abdominal Radiology 1 is making the MRI scans and Abdominal Radiology 2 is making CT scans etc. At the UMC Utrecht, they are quite satisfied with the current planning and control of residents. However, they have no clear overview of the amount of weeks residents are attending their internships. Furthermore, the hours of evening, night and weekend shifts of residents are too high and they acknowledge fragmentation of internships due to tasks for the provision of patient care services. The UMC Utrecht has a month schedule that is composed by a member of the secretary. Besides this member of the secretary, two residents are responsible for the internship schedule. For the planning and control of residents, the UMC Utrecht uses Microsoft Excel in combination with Microsoft Monaco. The final responsibility of the internship schedule lays with the educator.

F.II Radiology department AMC Amsterdam

The second hospital that is analyzed on the planning and control of residents is the Academic Medical Center (AMC) in Amsterdam. The structure of AMC Amsterdam is comparable with the UMCG; the residents follow the themes of Radiology defined in the national residency program. However, the difference with AMC Amsterdam is that the ATLS internships are divided together with the themes of Radiology. For instance, two weeks of internships of Musculoskeletal Radiology is translated into two weeks of ATLS internship. This division can be made because there are many Musculoskeletal cases at the ATLS, for instance many broken bones. Furthermore, AMC Amsterdam has evening, night and weekend shift blocks of a month. This causes less fragmentation of the internships during the week, however the residents are still fulfilling too many evening, night and weekend shift blocks during their residency program.

Current performance

At AMC Amsterdam, they state that they have a good functioning schedule. They do not have many residents that are ill or tasks of patient care services that need to be taken over from residents due to personal circumstances. The only problem that they still experience is problems with residents from other hospitals. For instance, residents from UMC Utrecht want to follow their Musculoskeletal Radiology internship at AMC Amsterdam, which causes fluctuations in the number of residents at the internships. The planners know the visits of the external residents too late to take them into account in the long-term planning. These problems also arise with the peripheral hospitals. Furthermore, AMC Amsterdam experiences problems with a high amount of evening, night and weekend shifts. The current amounts of shifts are 4.5 months of the total 12 months, which is 37% of shifts in a year of their residency program. This percentage is way higher than the maximum number of 25%. The current performance of the AMC Amsterdam is summarized in Table 49.

- The AMC states that they have a good functioning schedule for the residents.
- The AMC only experiences problems with residents from other hospitals.
- The AMC experiences problems with a high amount of evening, night and weekend shifts.

Table 49: Current performance - AMC Amsterdam

Structural planning and control

There are around 25 residents following the Radiology residency program at AMC Amsterdam. Furthermore, residents from other specialties are following internships at the Radiology department, such as residents from Radiotherapy. The supervision of the residents is sufficient; there are enough supervisors available and they are open for questions. The culture of the department is also stated as very good. Residents and staff members are helping each other and taking over evening, night and weekend shifts were possible. At AMC Amsterdam, they have 4 fellows who are taking part in the evening, night and weekend shifts and who are fulfilling tasks at the Radiology department. For instance, they have a fellow for the ultrasounds of Abdominal Radiology and a fellow for the Musculoskeletal Radiology to provide supervision. A significant difference with the UMCG is that AMC Amsterdam has evening, night and weekend shift blocks of a month. They have one week day shifts, one week evening shifts, one week night shifts and one week compensation of the shifts. These evening, night and weekend shift blocks are causing less fragmentation of the internships during the weeks of their internships. However, the residents have many shift blocks, which still fragments the total days of residents attending their internship during a year.

AMC Amsterdam works together on regional level with Onze Lieve Vrouwe Gasthuis in Amsterdam and Kennemer Gasthuis in Haarlem. Once in two months there is a meeting with these regional hospitals. The inflow moments and the type of internships spent at the AMC Amsterdam are not strict. Therefore, the inflow of these peripheral residents sometimes causes fluctuations in the number of

residents at the sub-specialties. The structural planning and control of the AMC Amsterdam is summarized in Table 50.

- The AMC has around 25 residents.
- Besides residents and staff, the AMC has 4 fellows who are taking part in the evening, night and weekend shifts and who are fulfilling tasks at the Radiology department.
- The AMC has shift blocks of a month: one week day shifts, one week evening shifts, one week night shifts and one week compensation.
- The inflow moments of the peripheral residents are not strict and cause fluctuations in the number of residents at the sub-specialties.

Table 50: Structural planning and control - AMC Amsterdam

Tactical planning and control

At AMC Amsterdam, the planning and control of residents is performed by the residents themselves. There are six residents performing the planning and control of residents: two residents for the common trunk, two residents for the differentiations and two residents for the evening, night and weekend shifts. There are always residents available who want to perform the planning and control. At the AMC Amsterdam, this is a task of the residents and everyone is glad that there are residents who want to perform this task. Furthermore, the residents know exactly what is and what is not possible for the internships. The schedules of the common trunk and the differentiation composed by the residents are sent to the educator. The educator checks the schedules and sends the final versions to the planning department. The evening, night and weekend shift blocks are send directly to the planning department. The planning department finalizes both schedules and communicates them with the residents and staff. The schedules are composed for around 4 months in advance. The only improvement for this scheduling process is that the schedules are composed separate from each other. The number of residents for the common trunk is not integrated with the number of residents for the differentiations.

The structure of the schedule of the common trunk and the differentiations is comparable with the structure of the UMCG. The internships of the residents are divided per week and it is tried to have as many consecutive weeks as possible for the common trunk. For instance, they try to have eight consecutive weeks of internships for the common trunk. The planning and control of the common trunk, the differentiation and the evening, night and weekend shift blocks are performed in Microsoft Excel. Furthermore, they use Rostar Flex for the calculation of the total hours. On the 1st of February, they are getting Matrickx, a new planning and control program.

The total number of weeks of the internships of residents is adjusted to the competences they have gathered. Thus, for instance, if a resident does not have the required competences yet, he or she might have to attend the internship for a second time. As at the UMC Utrecht, the AMC Amsterdam also follows a structure that is more conform the EPA perspective. The tactical planning and control of the AMC is summarized in Table 51.

- At the AMC, residents are performing the planning of the internships.
- The educator checks the schedules and sends the final versions to the planning department.
- The schedules are composed for around 4 months in advance.
- The internships of the residents are divided per week and it is tried to have as many consecutive weeks as possible for the common trunk.
- The planning and control is performed using Microsoft Excel. Furthermore, they use Rostar Flex for the calculation of the total hours.

Table 51: Tactical planning and control - AMC Amsterdam

Offline and online operational planning

The allocation of residents to tasks of the patient care services is done by the planning department. Furthermore, the allocation of internships is done by the residents. In performing this allocation, it is tried to satisfy the wishes and requests of the residents as much as possible. However, sometimes it is not possible to satisfy all the wishes and requests. When the schedule is executed, the residents responsible for the planning and control of the internships check whether the residents did attend the correct internship. In this way, the weeks spent at the internships are checked.

The offline and online operational planning and control of the AMC are summarized in Table 52.

- It is tried to satisfy the wishes and requests of the residents as much as possible. However, sometimes it is not possible to satisfy all the wishes and requests.
- It is checked whether the residents did attend the correct internship. In this way, the weeks spent at the internships are controlled.

Table 52: Offline operational planning and control - AMC Amsterdam

Conclusion

The second hospital that is analyzed on the planning and control of residents is the AMC in Amsterdam. The structure of the AMC is comparable with the UMCG; the residents follow the themes of Radiology defined in the national residency program. However, the difference with the AMC is that the ATLS internships are divided differently. The ATLS internships are divided together with the themes of Radiology. For instance, two weeks of internships of Musculoskeletal Radiology is translated into two weeks of ATLS internship. Furthermore, the AMC has evening, night and weekend shift blocks of a month. This causes less fragmentation of the internships; however, the residents are still taking too many evening, night and weekend shifts during their residency program. Furthermore, the planning and control of the internships is performed by the residents themselves. There are six residents performing the planning and control: two residents for the common trunk, two residents for the differentiations and two residents for the evening, night and weekend shift blocks. In addition to the staff and residents, there are 4 fellows working at the Radiology department, who are fulfilling for instance the evening, night and weekend shifts and other tasks at the Radiology department. Furthermore, these follows are providing supervision to the residents. On the 1st of February, the AMC is getting Matrickx, a new planning and control program.

F.III Radiology department Erasmus MC

The third and final Radiology department that is elaborated is of the Erasmus Medical Center (MC) in Rotterdam. The Radiology department of Erasmus MC is comparable with the department of the UMCG; the schedule is also constructed by using the eight specialties. The Erasmus MC has around 30 residents that follow the challenging Radiology residency program. The main difference with the UMCG is that Erasmus MC has two chief residents, which construct all the schedules for the residents. These two chief residents are fifth-year residents who have experience with scheduling residents at the Radiology department. They construct both the internship schedule and the schedule for the provision of patient care. Another remarkable difference is that at the Erasmus MC the residents have many teaching tasks. Almost every afternoon they have to give a lecture to medical students or give a tour to medical students at the Radiology department.

Current performance

At the Erasmus MC, they have no problems with capacity of internships or high fluctuations of residents at the internships. Overall, the internships are going well and the residents, staff and educators are satisfied with the current situation. However, there are always things to improve. First, residents at the Erasmus MS do have many other tasks to fulfill for the provision of patient care services, which fragmentizes the internships. The residents fill many gaps at the Radiology department at for instance the ultrasound or the ATLS. Another problem at Erasmus MC is the teaching tasks of the residents. Almost every afternoon one resident has to give a lecture or teach medical students at the Radiology department. This also causes fragmentation of the internships. The current performance of the UMC Utrecht is summarized in Table 53.

- The Erasmus MC states that the internships are going well and the residents, staff and educators are satisfied with the current situation.
- However, residents at the Erasmus MS do have many other tasks to fulfill for the provision of patient care services, which fragmentizes the internships.

Table 53: Current performance - Erasmus MC

Structural planning and control

As comparable with the UMCG, the residents have to fulfill many tasks in the provision of patient care. These tasks include the evening, night and weekend shifts, the shifts at the ATLS and the ultrasounds. Furthermore, as stated before, they have to perform many teaching tasks, as giving lectures to medical students. It is tried to have an equal division of these tasks among the residents. Besides residents and staff members, the Erasmus MC has around 14 fellows at their Radiology department. These fellows are divided among the eight sub-specialties. The main advantage of these fellows is that they give more flexibility in the schedule. The fellows can perform any task that comes up at the department.

The Erasmus MC works together with the regional hospitals Maasstad Ziekenhuis in Rotterdam, Albert Schweitzer Ziekenhuis in Dordrecht and Elisabeth-TweeSteden Ziekenhuis in Tilburg. The residents of these peripheral hospitals and the residents of the Erasmus MC are exchanging in their third year of the residency program. The cooperation between the peripheral hospitals and the Erasmus MC is stated as sufficient. The Erasmus MC knows when the residents are visiting their hospital and which internships they have to attend. The structural planning and control of Erasmus MC is summarized in Table 54.

- The residents have to fulfill many tasks related to the provision of patient care services. These tasks include the evening, night and weekend shifts, the shifts at the ATLS and the ultrasounds.
- The Erasmus MC has around 14 fellows at their Radiology department. These fellows are divided among the eight sub-specialties

Table 54: Structural planning and control - Erasmus MC

Tactical planning and control

The schedule of the residents at the Erasmus MC is composed for a fixed 8 weeks; two blocks of 4 weeks. This schedule is composed each 8 weeks for the upcoming 8 weeks. The internships are scheduled in blocks of 4 weeks, since the number of internships can be divided by 4. The number of weeks of internships are conform the national residency program. The internships of the common trunk have a set sequence at the Erasmus MC, so each resident of the common trunk follows the same structure of internships. For instance, they first attend 4 weeks at the Abdominal Radiology, followed by 4 weeks at the Musculoskeletal Radiology etc. In this way, they all followed the required internships within 14 months to start the evening, night and weekend shifts.

The required months of internships before residents can attend evening, night and weekend shifts is 14 months at the Erasmus MC. The evening, night and weekend shifts are divided in blocks of three days. There are three shifts blocks: from Sunday until Tuesday, from Wednesday until Friday and a block for the weekends. These shift blocks exist for both the evening and night shifts.
At the Erasmus MC, there are no capacity requests from the sub-specialties. However, the sub-specialties do request a minimum number of residents at their specialty. For instance, the Pediatric Radiology suggests a minimum of two residents at their specialty. With the decreasing number of residents at the Radiology department, the sub-specialties know that this minimum number is harder to realize.

The internships schedule, the evening, night and weekend shifts schedule and even the day schedule are constructed by the chief residents. First, the evening, night and weekend shifts are constructed by the residents by filling in their wishes and requests. This evening, night and weekend shift schedule is send to the planning department which composes a day schedule and send this back to the chief residents. The chief residents fill in the gaps and make sure the schedule is correct and consistent with the wishes of the residents. Furthermore, the internship schedule is constructed by the chief residents in collaboration with the educators. The main advantage of the chiefs constructing the schedules is that they know what happens on the work floor and they know the wishes of the other residents. The chief residents divided the construction of the schedules: one chief constructs the internship schedule and one chief constructs the patient care services schedule.

Both the internship schedule and the patient care schedule are composed using Microsoft Excel. The construction of the schedule is done by many macros and functions of Microsoft Excel. Furthermore, the Erasmus MC uses HARMONY WebAccess for their day schedule. The tactical planning and control of the Erasmus MC is summarized in Table 55.

- The schedule of the residents at the Erasmus MC is composed for a fixed 8 weeks; two blocks of 4 weeks.
- The internships are scheduled in blocks of 4 weeks, since the number of internships can be divided by 4.
- The evening, night and weekend shifts are divided in blocks of three days.
- The internships schedule, the evening, night and weekend shifts schedule and the day schedule are constructed by the chief residents.
- Both the internship schedule and the patient care services schedule are composed using Microsoft Excel.

Table 55: Tactical planning and control - Erasmus MC

Offline and online operational planning

During the allocation of residents to tasks it is tried to divide the tasks equally among the residents. The chief residents use Microsoft Excel sheets to for instance calculate the number of evening, night and weekend shifts done by the residents. In this way, they can easily see which resident needs to attend more evening, night or weekend shifts. The residents can fill in their wishes and requests concerning the composition of the schedules. It is tried to satisfy these wishes and requests as much as possible. The statement of the Erasmus MC is that commonly the residency program is in the lead of the department.

The offline and online operational planning and control of the Erasmus MC are summarized in Table 56.

- It is tried to divide the tasks equally among the residents
- They use Microsoft Excel sheets to for instance calculate the number of evening, night and weekend shifts done by the residents.
- It is tried to satisfy these wishes and requests as much as possible.

Table 56: Offline operational planning and control - Erasmus MC

Conclusion

The third and final Radiology department that is analyzed is the department of the Erasmus Medical Center (MC) in Rotterdam. The Radiology department of Erasmus MC is comparable with the department of the UMCG; the schedule is also constructed by using the eight specialties. The main difference with the UMCG is that Erasmus MC has two chief residents, which construct all the schedules for the residents. These two chief residents are fifth-year residents who have experience with what works and what does not work at the Radiology department. They construct both the internship schedule and the schedule for providing the patient care services. Furthermore, the Erasmus MC has around 14 fellows at their Radiology department. These fellows are divided among the eight sub-specialties. The main advantage of these fellows is that they give more flexibility in the schedule. The schedule of the residents at the Erasmus MC is composed for a fixed 8 weeks; two blocks of 4 weeks. This schedule is composed each 8 weeks for the upcoming 8 weeks. In addition, the internships of the common trunk have a set sequence at the Erasmus MC. Thus, each resident of the common trunk follows the same structure of internships. Both the internship schedule and the patient care services schedule are composed using Microsoft Excel. The construction of the schedule is done by many macros and functions of Microsoft Excel. Furthermore, the Erasmus MC uses HARMONY WebAccess for their day schedule.

F.IV Gastroenterology and Hepatology department of the UMCG

Besides the three Radiology departments of other University Medical Centers in the Netherlands, two departments of the UMCG are analyzed. First, the Gastroenterology and Hepatology (GH) (in Dutch: Maag-, darm- en leverziekten) department of the UMCG. The GH department consists of approximately 15 residents that are following the challenging residency program. The department experiences no problems with scheduling the residents, since there are much less residents at this department. However, they do experience challenges with variables that influence the planning and control of residents, such as illnesses and pregnancies.

The residency program of the GH department differs in structure from the residency program of the Radiology department. The residency program of GH takes 6 years; 2 years Internal Medicine and 4 years Gastroenterology and Hepatology. The third year of the residency program takes place at a peripheral hospital, either at the Isala Klinieken in Zwolle or at the Medisch Spectrum Twente (MST) in Enschede. Most of the times, the residents are spending their fourth year in one of these peripheral hospitals as well. Year 5 and 6 of the residency program are spend at the UMCG again. For an overview of the length of the internships, see Table 57.

Year 1+2 internal medicine	Year 3+4 Isala or MST	Year 5+6 UMCG
Ward internship (12 months)	Ward internship (6 months)	Ward internship (4 months)
Intensive care (4 months)	Endoscopy (18 months)	IBD (inclusion body disease) internship
Oncology (4 months)		Hepatology internship
Nephrology (4 months)		Focus internship (12 months)

Table 57: Structure residency program - GH department

Current performance

The planning and control of residents of the GH department is experienced as sufficient for all the stakeholders. However, there are still challenges with the planning and control of residents at the GH department. For instance, they face problems with pregnancies and illnesses. Nevertheless, the problems occurring at the Radiology department with the planning and control of residents are much less at the GH department. The most underlying causes for this are the longer internships and the lower number of residents. This makes the planning and control of residents easier and more structured. The current performance of the GH department is summarized in Table 58.

- The planning and control of residents of the GH department is experienced as sufficient for all the stakeholders.
- However, there are still challenges with the planning and control of residents at the GH department, such as pregnancies and illnesses.
- The planning and control of residents is easier at the GH department, since there are less residents and the internships are longer.

Table 58: Current performance - GH department

Structural planning and control

The GH department has approximately 15 residents, together with 23.6 FTE of supervisors. At the GH department, the volume of patient care services is fixed for the five working days. The outpatient clinics, multidisciplinary meetings, ward visits and other compulsory tasks of the GH department are structured for the five working days. Besides these tasks, there are evening, night and weekend shifts.

The residency program of the GH department takes place in the same region as the residency program of Radiology, the OOR N&O. The only difference is that the GH residency program has a clear division of which internships are taken in which regional hospital. The first two years are spent at the UMCG and consist of the pre-education of Internal Medicine. The third year of the residency program takes place at a peripheral hospital, either at the Isala Klinieken in Zwolle or at the Medisch Spectrum

Twente in Enschede. Most of the times, the residents are spending year 4 as well in one of these peripheral hospitals. Year 5 and 6 of the residency program are spend at the UMCG again.

The culture of the GH department is very friendly. Residents and staff members are easily taking over shifts when there are illnesses. Furthermore, there is awareness among staff members and residents that a good planning and control is needed for the department. At first the staff members did not really care about the planning, they were more focused on the provision of patient care services. However, now they know that the planning and control is of one of the most important things in provide high quality patient care at the GH department. The structural planning and control of the GH department is summarized in Table 59.

- The GH department has around 15 residents, together with 23.6 FTE of the supervisors.
- At the GH department, the volume of patient care services is fixed for the five working days.
- The GH residency program has a clear division of which internships are taken in which regional hospital.
- There is awareness among staff members and residents that a good planning and control is needed for the department.

Table 59: Structural planning and control - GH department

Tactical planning and control

At the GH department, the planning of the residents is made together with the planning of the staff members. Thus, both schedules are composed by the same person, a member from the secretariat. The schedule is made in Microsoft Excel and shows a schedule for the whole week from day to day. The schedule shows which supervisors are available for which residents. This means that there are always enough supervisors available for the residents. Since the schedule is a day-schedule, it is always clear who is at which internship at which day.

Besides this staff and residents schedule, there is also a schedule that keeps track of the internships of the residents. This is, in contradiction to the schedule of the Radiology department, a month schedule. Thus, the internships are cut into pieces of a month and divided over the 12 months from January until February. The month schedule is clear and gives no problems. The only drawback from this month schedule is that it is not sure if the residents spend the total months at their internship. For instance, it could be the case that they are taking shifts for one week and miss one week of their internship. The member of the secretariat says that when a resident misses two weeks of their internship, it may be the case that they are doing another block of that internship at the end of their program. However, in most of the cases residents are just missing a maximum of one week, which should not cause problems for their internship schedule.

The planning horizon of the GH department is three months. This means that people know in advance if they have a day off or can take vacation etc. If staff members or residents want to change something, they can give notice to the planner 8 weeks in advance. Otherwise they need to find replacement themselves.

The schedule is made by a member of the secretariat and checked by an educator and a staff member. They discuss the schedule on a weekly basis. This gives rest for the planner, because if staff members complain they can go to the representative of the staff and complain there. Furthermore, all the three stakeholders are represented in this meeting, which is positive for the quality of the schedule. The evening, night and weekend shift schedule is composed by the residents themselves. Currently, the residents deliver the evening, night and weekend shifts planning on time for the staff planning. The late and night shifts are taken on a day basis. The tactical planning and control of the GH department is summarized in Table 60.

- The schedule is made in Microsoft Excel and shows a schedule for the whole week from day to day.
- The schedule shows which supervisors are available for which residents.
- This is, compared to the schedule of the Radiology department, a month schedule.
- This means that people know in advance if they have a day off or can take vacation etc. If staff members or residents want to change something, they can give notice to the planner 8 weeks in advance. Otherwise they need to find replacement themselves.
- The schedule is made by a member of the secretariat and checked by an educator and a staff member. They discuss the schedule on a weekly basis. This gives rest for the planner, because if staff members complain they can go to the representative of the staff and complain there.

Table 60: Tactical planning and control - GH department

Offline and online operational planning and control

The planning and control is done by the member of the secretariat. This planner has a priority list to make the planning. The bottlenecks of the planning and control are known and used to perform the planning and control. The offline and online operational planning and control of the GH department are summarized in Table 61.

- The bottlenecks of the planning and control are known and used to perform the planning and control.

Table 61: Offline operational planning and control - GH department

Conclusion

The residency program of the GH department differs in structure from the Radiology department. The internships are much longer and there are much less residents following the residency program. This makes that the planning and control of residents less complex. However, external variables are still influencing the schedule, such as illnesses and pregnancies. Besides these variables, the GH department states that they are succeeding in planning and control in a way that all the stakeholders are satisfied. The planning and control of residents is done together with the planning and control of staff members. They are integrated in one schedule and made by a member of the secretariat. There is a clear number of the FTE of supervision available for the residency program. In the schedule, the residents are coupled to one of the available supervisors. Furthermore, there is awareness among staff members and residents that a good planning and control is needed for the department.

F.V Anesthesiology department of the UMCG

The final department that is analyzed for this research is the Anesthesiology department. The Anesthesiology department of the UMCG is from the same sector as the Radiology department. This means that the two departments are comparable in managerial structure. However, there are many differences in the structure of the residency programs of both departments. The Anesthesiology department of the UMCG has around 70 residents, which is a high number of residents compared to the other residency programs. This high number of residents makes the planning and control of the residents even more complex.

The residency program of the Anesthesiology department is also defined by gaining competences in various themes of Anesthesiology. However, the residency program differs in structure from the residency program of the Radiology department. The structure of the Anesthesiology department is shown in Table 62.

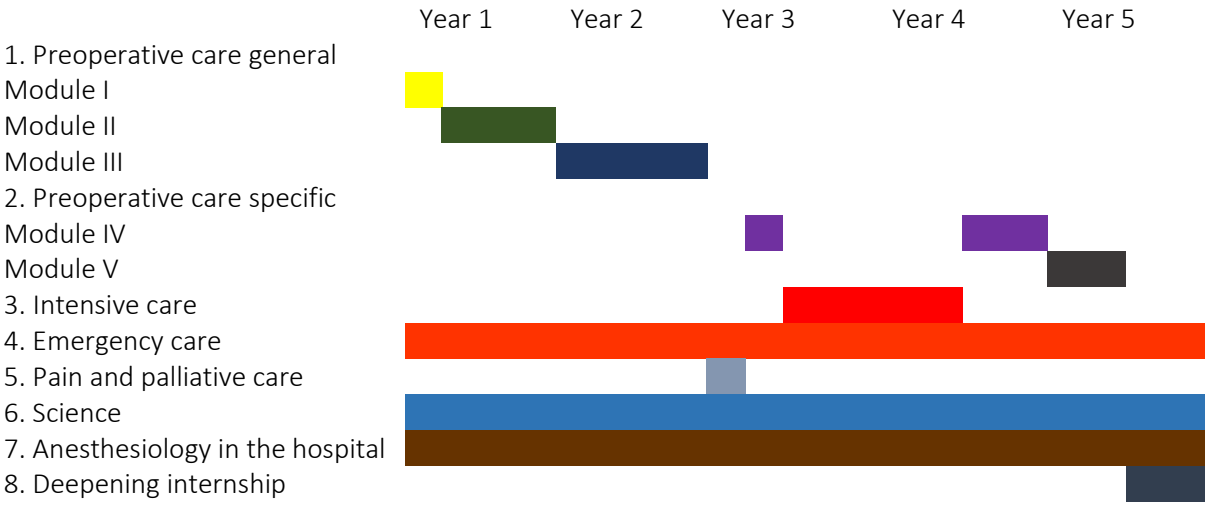

Table 62: Structure residency program - Anesthesiology department

Current performance

As stated before, the Anesthesiology department of the UMCG has around 70 residents. This is a very high number of residents and makes the planning and control of the residents rather complex. Many of the residents of the Anesthesiology department are women. This results in many pregnancies and part-time workers. Furthermore, the Anesthesiology department has also problems with fragmentation of the internships. Part-time workers, evening, night and weekend shifts and other tasks in the provision of patient care services are resulting in less days spent at the internships.

- Many of the residents of the Anesthesiology department are women. This results in many pregnancies and part-time workers.
- The Anesthesiology department has also problems with fragmentation of the internships, due to tasks in for the provision of patient care services.

Table 63: Current performance - Anesthesiology department

Structural planning and control

The planning and control of the Anesthesiology department is based on a set volume of patient care services. These patient care services are tried to be fulfilled with the available staff and residents. The staff and residents can provide wishes and requests of the schedule before the planning and control is done. There is a certain set structure of the available staff and residents. For instance, staff member A always works on Mondays until Thursdays. At the Anesthesiology department, residents also fulfill tasks in the provision of patient care services, such as evening, night and weekend shifts and taking

care of the pager for the ATLS. However, these tasks are dependable on the staff members and what they want to perform.

The inflow moments of residents are strict in January and April. The moments are strict because there are many residents at the Anesthesiology department. The residents follow the introduction weeks together with two other residents. It is not desirable to have many single residents during the introduction week.

The Anesthesiology residents also follow a year of their program in a peripheral hospital. The difference for the Anesthesiology residency program is that every resident of the region always starts at the UMCG; it is not possible to start at another hospital of the region (yet). The peripheral internships take place in their second year of the residency program. The peripheral hospitals are Nij Smellinghe in Drachten, Medisch Centrum in Leeuwarden and Isala klinieken in Zwolle. The regional hospitals have two meetings per quarter of a year. The division of residents to the internships is also a bit different compared to the Radiology department. Here they have three places for three residents, and the residents need to divide the places among themselves. Thus, they have to decide themselves who goes to which peripheral hospital.

The structural planning and control of the Anesthesiology department is summarized in Table 64.

- The planning and control of the Anesthesiology department is based on a set volume of patient care services
- The inflow moments of residents are strict in January and April.
- During the Anesthesiology residency program, every resident of the region always starts at the UMCG; it is not possible to start at another hospital of the region.

Table 64: Structural planning and control - Anesthesiology department

Tactical planning and control

At the Anesthesiology department, there is one planner that is responsible for the planning and control of residents, as well as for the staff planning and control and the evening, night and weekend shifts. There is an educator involved in this process to ask questions, but the main responsibilities lie with the planner from the secretary. There are various schedules available: one for the residency internships, one for the residency tasks and one for the staff. These schedules are all integrated into one Microsoft Excel file with use of macros. They have a day planning for the residents and staff; however the internships are divided into months. The planning horizon of this department is around 8/10 weeks. The Anesthesiology department used other programs for the planning and control in the last couple of years, however none of them seemed sufficient. There are multiple layers and requirements on this planning and control, which is why the other programs did not work. They state that there is a lack of ICT support from the UMCG.

The Anesthesiology department has various evening, night and weekend shifts in multiple blocks with multiple staff. An important fact here is that the staff also takes these shifts and is in-house for supervision. There shifts are divided into three blocks. However, they are not satisfied with these three blocks and want to go back to a schedule with only two blocks of 16 hours. This would result in more people on the work floor the next day, which is both positive for the residency program as for the provision of patient care services. The evening, night and weekend shifts are taking together by a younger year residents and an older year residents. They have two pools of residents, one for the younger year residents and one for the older year residents.

The tactical planning and control of the Anesthesiology department is summarized in Table 65.

- At the Anesthesiology department, there is one planner that is responsible for the planning and control of residents, as well as for the staff planning and control and the evening, night and weekend shifts.
- There is an educator involved in the planning and control, but the main responsibilities lie with the planner from the secretary.
- The various schedules are all integrated into one Microsoft Excel file with use of macros.
- The Anesthesiology department has various evening, night and weekend shifts in multiple blocks with multiple staff. The staff also takes these shifts and is in-house for supervision.

Table 65: Tactical planning and control - Anesthesiology department

Offline and online operational planning and control

The allocation of residents to tasks and internships is done by using a certain set structure of the available staff and residents. First, this set structure is used to fulfill the patient care services by staff members. Then, the residents are coupled to the supervisors and internships. At the planning and control of the Anesthesiology department, the residents are coupled to the supervisors for a certain period. During the planning and control, the planner tries to satisfy the wishes and requests as much as possible. However, the planner has boundaries on the amount of accepting the wishes and requests.

The offline and online operational planning and control of the Anesthesiology department are summarized in Table 66.

- The allocation of residents to tasks and internships is done by using a certain set structure of the available staff and residents.
- At the Anesthesiology department, the residents are coupled to the supervisors for a certain period.

Table 66: Offline operational planning and control - Anesthesiology department

Conclusion

The Anesthesiology department of the UMCG has around 70 residents, which is a high number of residents compared to the other residency programs. This high number of residents makes the planning and control of the residents even more challenging. Furthermore, many of the residents of the Anesthesiology department are women. This results in many pregnancies and part-time workers. Therefore, the Anesthesiology department also has many problems with fragmentation of the internships. At the Anesthesiology department, there is one planner that is responsible for the planning and control of residents, as well as for the staff planning and control and the evening, night and weekend shifts. There is an educator involved in this planning and control, but the main responsibilities lie with the planner from the secretary. The schedules for both the staff and residents are integrated into one Microsoft Excel file with use of macros. Furthermore, the evening, night and weekend shifts are divided into three blocks. However, they are not satisfied with these three blocks and want to go back to a schedule with only two blocks of 16 hours. This would result in more people on the work floor the next day, which is both positive for the residency program as for the provision of patient care services. Finally, the residents of the Anesthesiology department are coupled to the supervisors for a certain period.

APPENDIX G: SURVEY

G.1 SURVEY PROCEDURE

Background

The questionnaire is about possible solutions for the problems around the planning and control of residents at the Radiology department of the UMCG. The questionnaire is made to test the support of the possible redesigns. The questionnaire is anonymous. It consists of five parts:

- The education of the resident
- The resident for patient care services
- The communication
- The resources
- The planning and control process

At the end of each part there is a text block to add comments about the answered questions. The questions are rated in Likert scale from 1-5, where 1 is strongly agree and 5 is strongly disagree. Furthermore, the option "No opinion" was available.

Introduction

Which of the following groups do you belong to?

- Residents
- Staff
- Educator
- Chef de Clinique
- Planners

The education of the resident

E1. Residents should have the possibility to compose their own residency program (for instance choosing a certain differentiation), irrespective of the educational capacity of the sub-specialties.
E2. The educational capacity of the sub-specialties should be adjusted to the expected number of residents for the upcoming residency year.
E3. It is acceptable to adjust work processes and/or staff schedules of the sub-specialties, such that the higher educational capacity of the residents can be met.
E4. The internships should be scheduled from the viewpoint of the educational capacity of the sub-specialties, not from the wishes and requests of residents. For instance, a numerus fixus could be applied to certain sub-specialties to meet the educational capacity.
E5. The staff members are sufficient available for supervision.
E6. I consider the education of residents as necessary evil.
E7. In the current situation, the residents have different supervisors for one internship. The supervision is dependable on the staff members that are present at a day. This change of supervisors for one internship has no negative influence on the residency program.
E8. To structure the supervision of residents, it is possible to couple the residents to one supervisor for each internship. It is acceptable to couple the resident to one staff member for supervision.
E9. The availability of staff for supervision should be adjusted to the number of residents in the upcoming residency year.
E.10 I am spending less time than expected from staff members on educating residents.
E11. Fourth- and fifth-year residents with the gained competences are allowed to provide supervision to the first and second year residents. This type of supervision should be used more broadly at the Radiology department
E12. The internships of the common trunk should be protected. Therefore, the internships of the common trunk should have priority in the planning of the internships compared to the internships of the differentiations.

E13. The fourth- and fifth-year residents should be seen as staff members and should take more tasks of the patient care services than younger year residents.

The resident for patient care services

P1. It is important that the residents are 80% of the time at their internships and these internships should not be fragmented by tasks from the patient care services.
P2. The department of Radiology would function better without residents.
P3. The daily staff schedule of the department of Radiology should be independent of residents. The patient care services should be able to be delivered without the attendance of residents.
P4. "For the continuity of the patient care services, the resident is coupled to a staff member. When the resident is absent, the staff member will take over the responsibilities of the coupled resident." I agree with this principle.
P5. There should be a reallocation of tasks and activities of the staff and residents, where the staff should take over tasks from the residents.
P6. Hiring fellows is a right method to create more space for the delivery of patient care services, for both the staff and residents.
P7. "If the resident takes over tasks of the patient care services from a staff member, this staff member will spend this time on supervision and/or other tasks for the residency program." I agree with this principle.
P8. With the reallocation of the tasks and activities of staff and residents, the staff could take evening, night and weekend shifts on voluntary basis.
P9. With the reallocation of tasks and activities of staff and residents, the staff should take compulsory evening, night and weekend shifts.

The communication

C1. The communication on the planning and scheduling of residents should be more clear. For instance, the bottlenecks with fulfilling the tasks of residents could be made more clear.
C2. This clearness could be created by a frequent appointment with a representative for each party. Thus, a frequent meeting with a resident, a staff member, an educator and a planner. I support this principle.
C3. Agreements between the stakeholders on the planning of the residents are always followed in the current situation.
C4. There should be strict deadlines for the delivery of wishes and requests of residents and staff, such as days off and holidays.
C5. If in the future the schedule would be composed for the next two months, it would acceptable that changes to this schedule only can be accepted if I arrange replacement myself and it has no negative consequences for the residency program.
C6. The changes in the internship schedule should be communicated clearly. It is wished that changes in the internship schedule are shown in an overview.

The resources

R1. In the current situation, the schedule of the residents is composed by three stakeholders. The internships schedule is composed by the program coordinator, the patient care services are scheduled by the planning department and the evening, night and weekend shifts are scheduled by the residents. I support this division.
R2. In certain academic hospitals, the residents are responsible for the composition of all the schedules of the residents. In this way, the responsibility lays with the residents themselves. The composition of the internship schedule by residents is also a good procedure for the UMCG.
R3. Another option is to both schedule the internships and the patient care services at the planning department. In this way, the two schedules could be integrated. Scheduling both the internships and the patient care services at the planning department is a decision I would support.

R4. These two options can also be combined. Thus, the internship schedule composed by the planning department together with residents made responsible for the schedules. This is a decision I would support.
R5. The planning of the internships and the planning of the staff would ideally be integrated into one planning program.
R6. A new planning program, such as Matrickx or MedSpace, would solve most of the planning problems of the Radiology department.

The planning and control processes
S1. The schedule of the internships should consist of a same order of internships for the common trunk. Thus, every resident should follow the same order of internships in the common trunk, for instance first 4 weeks Abdominal Radiology, then 4 weeks Musculoskeletal Radiology etc.
S2. The internship schedule should be divided in blocks of a strict number of weeks, such that the residents are switching from internship at the same moment.
S3. The internship schedule should show which residents are following their internships at which sub-specialty. Thus, the schedule should also show the residents per sub-specialty instead of only showing the schedule for each individual resident.
S4. The internship schedule should be composed at a specific day, for instance the first day of each month.
S5. It is acceptable to introduce strict deadlines for the delivery of the wishes and requests of the internships and differentiations.
S6. There could be shift blocks of 4 weeks, such that the structure of the evening, night and weekend shifts adjust better with the internship schedule.

G.II: SURVEY RESULTS

Q1 - Which of the following groups do you belong to?

	%	Count
Residents	42.31%	11
Staff	46.15%	12
Educators	3.85%	1
Chef de Clinique	3.85%	1
Planners	3.85%	1

E1. Residents should have the possibility to compose their own residency program (for instance choosing a certain differentiation), irrespective of the educational capacity of the sub-specialties.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	4	1	0	0	0
Agree	5	3	0	1	0
Somewhat agree	1	2	0	0	1
Disagree	0	5	1	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

E2. The educational capacity of the sub-specialties should be adjusted to the expected number of residents for the upcoming residency year.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	0	0	0	0
Agree	6	6	1	0	0
Somewhat agree	3	2	0	0	0
Disagree	0	3	0	0	1
Strongly disagree	0	0	0	1	0
No opinion	1	0	0	0	0

E3. It is acceptable to adjust work processes and/or staff schedules of the sub-specialties, such that the higher educational capacity of the residents can be met.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	1	0	0	0	0
Agree	7	1	0	0	0
Somewhat agree	1	6	1	0	1
Disagree	0	3	0	1	0
Strongly disagree	0	0	0	0	0
No opinion	1	1	0	0	0

E4. The internships should be scheduled from the viewpoint of the educational capacity of the sub-specialties, not from the wishes and requests of residents. For instance, a numerus fixus could be applied to certain sub-specialties to meet the educational capacity.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	2	1	0	0
Agree	0	6	0	1	0
Somewhat agree	2	1	0	0	1
Disagree	6	2	0	0	0
Strongly disagree	1	0	0	0	0
No opinion	1	0	0	0	0

E5. In the current situation, the residents have different supervisors for one internship. The supervision is dependable on the staff members that are present at a day. This change of supervisors for one internship has no negative influence on the residency program.

	Residents
Strongly agree	2
Agree	8
Somewhat agree	0
Disagree	0
Strongly disagree	0
No opinion	0

E6. I consider the education of residents as necessary evil.

	Staff	Chef de Clinique
Strongly agree	1	0
Agree	1	0
Somewhat agree	0	0
Disagree	5	0
Strongly disagree	4	1
No opinion	0	0

E7. In the current situation, the residents have different supervisors for one internship. The supervision is dependable on the staff members that are present at a day. This change of supervisors for one internship has no negative influence on the residency program.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	2	1	0	0
Agree	5	6	0	1	1
Somewhat agree	0	2	0	0	0
Disagree	2	0	0	0	0
Strongly disagree	1	1	0	0	0
No opinion	0	0	0	0	0

E8. To structure the supervision of residents, it is possible to couple the residents to one supervisor for each internship. It is acceptable to couple the resident to one staff member for supervision.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	0	0	0	0
Agree	1	0	0	0	0
Somewhat agree	1	1	0	0	0
Disagree	5	6	1	1	1
Strongly disagree	3	4	0	0	0
No opinion	0	0	0	0	0

E9. The availability of staff for supervision should be adjusted to the number of residents in the upcoming residency year.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	1	0	0	0	0
Agree	5	5	1	0	0
Somewhat agree	2	2	0	0	1
Disagree	2	4	0	0	0
Strongly disagree	0	0	0	1	0
No opinion	0	0	0	0	0

E10. I am spending less time than expected from staff members on educating residents.

	Staff	Chef de Clinique
Strongly agree	0	0
Agree	0	0
Somewhat agree	1	0
Disagree	5	1
Strongly disagree	3	0
No opinion	2	0

E11. Fourth- and fifth-year residents with the gained competences can provide supervision to the first- and second-year residents. This type of supervision should be used more broadly at the Radiology department

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	4	1	1	0
Agree	2	3	0	0	1
Somewhat agree	7	3	0	0	0
Disagree	1	1	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

E12. The internships of the common trunk should be protected. Therefore, the internships of the common trunk should have priority in the planning of the internships compared to the internships of the differentiations.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	0	0	1	1
Agree	3	4	0	0	0
Somewhat agree	3	4	0	0	0
Disagree	2	2	1	0	0
Strongly disagree	1	0	0	0	0
No opinion	1	1	0	0	0

E13. The fourth- and fifth-year residents should be seen as staff members and should take more tasks of the patient care services than younger year residents.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	3	0	1	0
Agree	2	4	0	0	0
Somewhat agree	5	3	1	0	0
Disagree	2	1	0	0	1
Strongly disagree	1	0	0	0	0
No opinion	0	0	0	0	0

P1: It is important that the residents are 80% of the time at their internships and these internships should not be fragmented by tasks from the patient care services.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	5	1	1	0	0
Agree	4	5	0	0	1
Somewhat agree	0	3	0	1	0
Disagree	1	2	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

P2: The department of Radiology would function better without residents.

	Staff	Chef de Clinique
Strongly agree	0	0
Agree	2	0
Somewhat agree	2	0
Disagree	6	0
Strongly disagree	0	0
No opinion	1	1

P3: The daily staff schedule of the department of Radiology should be independent of residents. The patient care services should be able to be delivered without the attendance of residents.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	3	0	0	0	0
Agree	4	2	1	0	1
Somewhat agree	3	1	0	0	0
Disagree	0	5	0	0	0
Strongly disagree	0	3	0	0	0
No opinion	0	0	0	1	0

P4: "For the continuity of the patient care services, the resident is coupled to a staff member. When the resident is absent, the staff member will take over the responsibilities of the coupled resident." I agree with this principle.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	0	1	0	0
Agree	5	3	0	0	0
Somewhat agree	3	0	0	0	0
Disagree	0	6	0	1	0
Strongly disagree	0	1	0	0	0
No opinion	0	1	0	0	1

P5: There should be a reallocation of tasks and activities of the staff and residents, where the staff should take over tasks from the residents.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	3	0	0	0	0
Agree	1	0	0	0	0
Somewhat agree	3	1	0	0	0
Disagree	2	10	0	0	1
Strongly disagree	0	0	0	1	0
No opinion	1	0	1	0	0

P6: Hiring fellows is a right method to create more space for the delivery of patient care services, for both the staff and residents.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	3	3	1	1	1
Agree	4	8	0	0	0
Somewhat agree	2	0	0	0	0
Disagree	1	0	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

P7: "If the resident takes over tasks of the patient care services from a staff member, this staff member will spend this time on supervision and/or other tasks for the residency program." I agree with this principle.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	1	0	0	0
Agree	4	4	1	0	0
Somewhat agree	4	2	0	0	0
Disagree	0	4	0	0	1
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	1	0

P8. With the reallocation of the tasks and activities of staff and residents, the staff could take evening, night and weekend shifts on voluntary basis.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	1	0	0	0	0
Agree	4	1	1	0	0
Somewhat agree	0	2	0	0	0
Disagree	4	4	0	0	1
Strongly disagree	0	3	0	0	0
No opinion	1	1	0	1	0

P9. With the reallocation of tasks and activities of staff and residents, the staff should take compulsory evening, night and weekend shifts.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	3	0	1	0	0
Agree	4	1	0	0	1
Somewhat agree	3	2	0	0	0
Disagree	0	3	0	0	0
Strongly disagree	0	4	0	1	0
No opinion	0	1	0	0	0

C1. The communication on the planning and scheduling of residents should be more clear. For instance, the bottlenecks with fulfilling the tasks of residents could be made more clear.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	4	3	1	0	0
Agree	5	6	0	0	1
Somewhat agree	0	1	0	1	0
Disagree	0	0	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	1	0	0	0

C2. This clearness could be created by a frequent appointment with a representative for each party. I support this principle.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	2	1	0	0
Agree	5	6	0	1	1
Somewhat agree	1	1	0	0	0
Disagree	1	2	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

C3. Agreements between the stakeholders on the planning of the residents are always followed in the current situation.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	0	0	0	0
Agree	0	1	0	0	0
Somewhat agree	2	2	0	1	1
Disagree	4	5	0	0	0
Strongly disagree	1	0	1	0	0
No opinion	2	3	0	0	0

C4. There should be strict deadlines for the delivery of wishes and requests of residents and staff, such as days off and holidays.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	2	1	0	1
Agree	4	5	0	1	0
Somewhat agree	2	1	0	0	0
Disagree	1	3	0	0	0
Strongly disagree	2	0	0	0	0
No opinion	0	0	0	0	0

C5. If in the future the schedule would be composed for the next two months, it would acceptable that changes to this schedule only can be accepted if I arrange replacement myself and it has no negative consequences for the residency program.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	0	1	0	1
Agree	3	5	0	1	0
Somewhat agree	0	4	0	0	0
Disagree	4	2	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

C6. The changes in the internship schedule should be communicated clearly. It is wished that changes in the internship schedule are shown in an overview.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	3	2	1	0	0
Agree	5	7	0	0	1
Somewhat agree	1	1	0	0	0
Disagree	0	1	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	1	0

R1. In the current situation, the schedule of the residents is composed by three stakeholders. The internships schedule is composed by the program coordinator, the patient care services are scheduled by the planning department and the evening, night and weekend shifts are scheduled by the residents. I support this division.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	1	0	0	0	0
Agree	4	2	0	0	0
Somewhat agree	1	3	1	0	0
Disagree	2	4	0	1	0
Strongly disagree	1	0	0	0	0
No opinion	0	2	0	0	1

R2. In certain academic hospitals, the residents are responsible for the composition of all the schedules of the residents. In this way, the responsibility lays with the residents themselves. The composition of the internship schedule by residents is also a good procedure for the UMCG.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	0	0	0	0
Agree	3	0	0	0	0
Somewhat agree	1	6	1	0	0
Disagree	4	4	0	1	1
Strongly disagree	0	0	0	0	0
No opinion	1	1	0	0	0

R3. Another option is to both schedule the internships and the patient care services at the planning department. In this way, the two schedules could be integrated. Scheduling both the internships and the patient care services at the planning department is a decision I would support.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	1	0	0	0
Agree	4	3	0	1	0
Somewhat agree	3	3	0	0	0
Disagree	2	3	0	0	0
Strongly disagree	0	0	1	0	1
No opinion	0	1	0	0	0

R4. These two options can also be combined. Thus, the internship schedule composed by the planning department together with residents made responsible for the schedules. This is a decision I would support.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	1	0	0	0
Agree	3	2	0	0	0
Somewhat agree	3	2	0	0	1
Disagree	1	4	0	1	0
Strongly disagree	0	0	1	0	0
No opinion	0	2	0	0	0

R5. The planning of the internships and the planning of the staff would ideally be integrated into one planning program.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	2	1	1	0
Agree	4	5	0	0	1
Somewhat agree	1	0	0	0	0
Disagree	0	1	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	2	3	0	0	0

R6. A new planning program, such as Matrickx or MedSpace, would solve most of the planning problems of the Radiology department.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	1	0	0	0	0
Agree	0	3	0	0	0
Somewhat agree	2	2	0	1	0
Disagree	0	0	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	6	6	1	0	1

S1. The schedule of the internships should consist of a same order of internships for the common trunk. Thus, every resident should follow the same order of internships in the common trunk, for instance first 4 weeks Abdominal Radiology, then 4 weeks Musculoskeletal Radiology etc.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	2	0	0	0
Agree	4	0	0	0	0
Somewhat agree	0	3	0	0	1
Disagree	1	4	1	1	0
Strongly disagree	1	0	0	0	0
No opinion	1	1	0	0	0

S2. The internship schedule should be divided in blocks of a strict number of weeks, such that the residents are switching from internship at the same moment.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	3	4	0	1	0
Agree	3	3	0	0	1
Somewhat agree	3	1	0	0	0
Disagree	0	1	1	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	1	0	0	0

S3. The internship schedule should show which residents are following their internships at which sub-specialty. Thus, the schedule should also show the residents per sub-specialty instead of only showing the schedule for each individual resident.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	3	1	1	0
Agree	6	6	0	0	1
Somewhat agree	0	1	0	0	0
Disagree	1	0	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

S4. The internship schedule should be composed at a specific day, for instance the first day of each month.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	1	0	0	0
Agree	5	4	0	0	0
Somewhat agree	3	1	0	0	1
Disagree	0	0	1	0	0
Strongly disagree	0	0	0	0	0
No opinion	1	4	0	1	0

S5. It is acceptable to introduce strict deadlines for the delivery of the wishes and requests of the internships and differentiations.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	2	0	0	0	1
Agree	6	0	1	0	0
Somewhat agree	1	0	0	0	0
Disagree	0	0	0	0	0
Strongly disagree	0	0	0	0	0
No opinion	0	0	0	0	0

S6. There could be shift blocks of 4 weeks, such that the structure of the evening, night and weekend shifts adjust better with the internship schedule.

	Residents	Staff	Educator	Chef de Clinique	Planner
Strongly agree	0	0	0	0	0
Agree	4	3	0	1	0
Somewhat agree	0	1	0	0	1
Disagree	1	2	1	0	0
Strongly disagree	2	0	0	0	0
No opinion	2	4	0	0	0