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Interventions to reduce patients length of stay in the emergency department of Isala Klinieken

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Management Summary

"More efficient, transparent and innovative hospitals can be achieved by introducing business and logistic perspectives in the health care sector" (TPG, 2004).

Motive

In Isala Klinieken, the emergency department (ED) observed an increasing demand for emergency care in 2007, resulted in long waiting times, a need for increasing capacity and dissatisfied patients in the emergency department. To cope with these changes, the patient length of stay (LOS; time from enter until departure in the ED) has to be improved. Since residents, ED-nurses and specialists in the hospital give various causes for a long patient length of stay, the management realised more quantitative insight is needed into the process and activities in the ED to be able to suggest length of stay improvements. This research focuses on patients of general surgery (including traumatology patients) and internal medicine, who together represent 91% of the total patient visits in 2008. These patient groups both have representatives of specialists and residents working in the ED.

Objective

Isala Klinieken wants to reduce the patient length of stay, hence the objective of this research is "***to suggest interventions to reduce patient length of stay in the emergency department by mapping all the processes assess the duration of separate processes and activities and analyse inefficiencies*".**

Research Questions

To accomplish the goal of this research, the research is split in the following parts: First we use a general system approach to analyse the main components of the ED: input, output, patient flow, resources, planning and control structure and current patient length of stay of the ED. Second, with input of manual measurements the research measures the duration of processes and activities. Third, part gives a conclusion of this quantitative analysis that explores inefficiencies in the process using lean management philosophy, capacity management and manufacturing theories. Finally, literature and analysis are combined to propose practical interventions to reduce patient length of stay.

Extensive Analysis

This research provides an extensive systematic analysis of the ED from a logistic perspective with a general system approach. This means that the ED is a black box that uncovers quantitative data of patient in- and outflow. When opening the black box, we follow patients who have their own process path in the ED. During this process they use resources, like staff and beds, until they leave the ED to home or to other departments of the hospital. Various steps in the process represent workstations or activities that add or do not add value to the patient in the process. This research gives an in-depth description of all these processes and activities. Measuring the duration of activities and time between these activities in the process leads to a quantitative and objective overview of the ED. The description is enlightened with an extensive analysis of the planning and control structure of the ED, available resources and the patients length of stay. Furthermore, the availability of staff in the ED is plotted to the demand of patients arriving for every hour of the day. Unbalance between capacity and demand is

revealed, together with the most inefficiencies from a logistic perspective with lean management and manufacturing theories.

Results

When combining the extensive analysis into conclusions with a logistic background, we conclude the following: The ED is a complex process with unplanned patient arrivals and unknown care paths through the ED. When a patient enters the ED, all the steps of care are unknown because decisions about these steps (care path) are taken by staff later in the process. Depending on the needs and results (of diagnostics), the care path of a patient changes within the process. The decision about this path is postponed to the time a resident has these results. Therefore important processes start after each other (e.g. steps before a patient is admitted), instead of parallel towards each other. Not only the decision is postponed, but also the needs of the patient are postponed to the time the resident is available. When a patient enters the ED the main goal is to get a consult of a resident. In general, the demands of the patients do not determine the process in the ED. Currently, they cannot be segmented by their needs in the process, and they are segmented by their urgency. Every patient follows the same (unstructured) process in the ED, where they enter separate queues with an unspecified waiting time.

Staff in the ED (especially residents) work on many patients at the same time, since they are scarce they divide their time over all patients in the ED. This staff only performs work on one patient at the time, while the other patients are waiting and no activities are performed for them. These issues imply a high work in process. An increase in work in process leads to an increase in patient length of stay. Another problem with the unavailability of staff is that the working schedules of residents unfit arriving patient demand. The number of patients arriving in the ED changes every hour. In the analysis, time-slots of high patient demand were found where fewer residents were available than in hours of low patient demand. Also the capacity of the radiology modalities and capacity of nurses in the nursing departments does not fit the demand of emergency patients.

These conclusions result in four main areas of inefficiency in the ED for which this research describes practical interventions. The practical interventions focus on improvements of early decision making and information availability, parallel processes, reducing number of patients in process, fit capacity to demand and a process oriented approach where the needs of the patients determine the process.

Recommendations

We recommend to benchmark the performance of the current situation of the ED three-monthly with new statistics and performance figures to check the following parameters: length of stay (departure, admission patients), number of patients per time-slot of the day, number of admissions, hours of admission, triage times, time to residents' anamnesis, time from anamnesis to departure. The current data-warehouse system is able to present and measure these parameters. For other parameters the current system is unable to present useful measures: recording request time of diagnostics and time of results available. We recommend extending the electronic patient record in such a way that it stores data and numbers of these performed diagnostics result times. With that the ED can extra measures the queues a patient enters and waste time between result and further action. With every performance check, the ED finds inefficiencies and can compare these with earlier performance and patients in- and outflow. This benchmark should be routine for the management to control the performance and

problems of the ED. A further step is to implement a performance board for ED-nurses and residents to keep track of their work and involve them in performance, problems and decision making.

Further research

This research provides an extensive analysis with quantitative and qualitative data of patient flow in the ED. The ED can use this analysis to carry out a simulation study to measure the impact of future developments (exploding self-referrals, the impact of emergency residents in the ED and merge of two emergency departments into one) on the performance. With a model of the ED, the (expected) arrival of patients, utilisation of staff and rooms, various waiting times (e.g. from enter to anamnesis) and length of stay, the management of the ED is able to make decisions how to cope with this future changes in the organisation of the ED.

Preface

In September 2008 I had an accident in Enschede that forced me to have my first acquaintance with an emergency department from the inside. Only two weeks later I entered an emergency department again, but this time it was for another reason: I did not need help, but they needed help. It was the start of my graduation project in the emergency department of Isala Klinieken in Zwolle.

Although the physical start of my research was not what I thought it would be, the welcoming of the colleagues in Isala Klinieken was great! The staff of the emergency department was eager to show me around and make me familiar with the ED. There were some very special contacts that helped me from the beginning to end of this research. From start to end, my supervisors guided me through the process. It felt comfortable that both were only a phone call away. Erwin Hans set me free to perform my own research, but helped me with the structure and important steps in the research. His motivation to improve health care easily passes over to me. Remco Rosmulder, working on his PhD project in an emergency department, provided me with interesting ideas and helped me look further than I first could. In conversations with him, he always gave a lot of advice. The third person I thank is Hermien ten Bolscher who guided me through the wilderness of the emergency department and provided me with a critical view on my work and improvement ideas. She always relied on my capabilities and outcomes of the research and supported me. I think it is great that the ED has such an ambitious manager! With Annemarie de Kleine I held a lot of brainstorms sessions, especially on manufacturing literature. Her interest in logistics made our brainstorm sessions always interesting and they always ended with a lot of new ideas that made us both enthusiastic.

Many people contributed to the completion of this thesis. I thank them all. Some I'd like to thank in particular. Alies Lula, a very involved and enthusiastic nurse of the emergency department who always inspired and supported me in my research and during the workshops. My interest in processes always triggered her to learn and to apply it to her own situation and her enthusiasm helped me keep going. I also thank the nurses and residents who participated in the workshops: Diderik Knol, Gijs Landman and Anna Prent, thanks for always making time in your busy schedules to participate and help improving the emergency department. For 4 months they've been my inspiration to continue! I thank Sabine Diepeveen for her scarce spare time on Wednesdays that she spent with me and thinking through the improvement possibilities and hearing my ideas. It is good to have an internist so closely connected with the emergency department. I thank Erwin Booy for his help and comments on the data of the electronic patient record. I mention all my colleagues of the office I worked, especially Wouter and Mirjam for their youthful conversations during lunch breaks and to fill the air with some jokes or laughs during a hard day's work.

Finally I thank my boyfriend, parents and friends for all their help and support.

Enjoy reading!

Jeanine van de Grootevheen
Zwolle, 2009

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1 Introduction

"More efficient, transparent and innovative hospitals can be achieved by introducing business and logistic perspectives in the health care sector" (TPG, 2004). This research applies this perspective to improve an emergency department in a Dutch hospital.

This first chapter starts with the research background (1.1) and gives information about *Isala Klinieken* and the associated emergency departments (1.2). In paragraph 1.3 the problem definition clarifies the direction of the research and paragraph 1.4 clarifies the objective and structure of the report.

1.1 Background

A research of TPG (a Dutch mail order firm) in 2003, tasked by the government, claimed that improvements in (logistic) processes of patients can lead to a more efficient, transparent, and innovative hospitals while maintaining the same level of quality (TPG, 2004). According to TPG this focus is needed, since diseases are getting more complex and the number of patients are increasing, which has a negative effect on waiting times and the length of stay for patients.

The emergency department in a hospital functions as a gateway for patients to get all kinds of acute or minor medical help. It is one of the departments in a hospital where the length of stay of a patient is quickly noticed by providers. An expansion of the number of patients and self-referrals, and the broadening of skill mix in emergency departments leads to difficult professional health care. This reflects in problems with management and control, growth of staff and full waiting rooms.

One of the strategic objectives in 2008 of Isala Klinieken in Zwolle is to map and improve the health care pathway of patients and to reduce the waiting times (Isala Klinieken, 2007). According to this aim, the emergency department started a project in 2007 to improve the length of stay of internal medicine patients. The patient length of stay is the total time, from enter until departure, the patient spends in the emergency department. After interventions of the project, the length of stay remained almost the same. One of the reasons was that involved staff did not see the benefits of the suggested improvements.

This research focuses on all involved processes of the emergency department (hereafter ED) of Isala Klinieken in order to improve the length of stay (hereafter LOS) of emergency patients.

1.2 Context

Isala Klinieken is a hospital in Zwolle that delivers health care on two different hospital locations (Sophia and Weezenlanden) and in an outpatient clinic in Kampen. The mission of the hospital is to "provide basic health care for the region of Zwolle (367.000 inhabitants) and top clinical speciality health care for the population in the region between the three academic hospitals Groningen, Utrecht and Nijmegen."

With 3.896 FTE personnel and 1100 beds, Isala Klinieken is the largest non-academic hospital in the Netherlands (Isala Klinieken 2007). Aside from providing top-clinical health care, the hospital

provides medical training to nurses, technicians, residents and co-assistants. In 2006, a total of 189.832 patients came for a first outpatient clinic visit and 42.339 patients were admitted (excluding day-care admissions).

The emergency department of Isala is one of the ten trauma centres in the Netherlands and together with hospitals in Apeldoorn, Deventer, Zutphen, Hardenberg, Meppel, Hoogeveen and Hardewijk, Isala is gathered into *trauma region Zwolle* (± 1,2 million inhabitants) (Figure 1).

Figure 1: Region for basic health care (inner circle) and trauma region Zwolle (outer circle)

This research focuses on the emergency department of Isala Klinieken, situated on location Sophia in Zwolle. The ED is part of the speciality general surgery, but delivers health care to emergency patients with all kinds of complaints and diagnoses. Hermien ten Bolscher controls the ED of Sophia and is supervisor of this research. The heart and lung specialty delivers their health care in location Weezenlanden so the emergency patients for this specialty are immediately transferred to that location.

In the last three years, the number of patient visits in the ED (location *Sophia* only) has increased from 20.455 in 2006 to 25.551 patients in 2008 (increase of almost 25% in two years) (*Eridanos,* 2009) (Table 1).

	2006	2007	2008
Number of patients	20455	24453	25551
Average a day	56	67	70

Table 1: Number of patient visits in the ED for 2006, 2007 and 2008 (source: *Eridanos*, 2009)

The ED divides its patient visits into specialties and care groups (same applies to the organisation in the entire hospital). The care groups general surgery and internal medicine contribute to the highest number of patient visits (91%) in the ED (Figure 2). Because of this high contribution and limited time frame of this study, further research will focus on these patients. Second, these care groups have both

representatives of specialists and residents working in the ED to give health care to their patients (residents of other care groups are on call). They are part of the process on the ED and one of the staff types that delivers health care. Further, the nursing departments of internal medicine receive most of their patients from the emergency department and general surgery is responsible for the intake of trauma patients. Regular patients in an emergency department are patients for the thorax, heart and lung and cardiology specialty. Isala Klinieken treats these patients in another location, so this care group is not in the scope of this research.

The framework and research problem are further defined in 1.3 regarding the patients visiting the ED for the care groups general surgery (incl. traumatology) and internal medicine.

We refer to Appendix A for an overview of all types of specialties and numbers of patient visits in 2008.

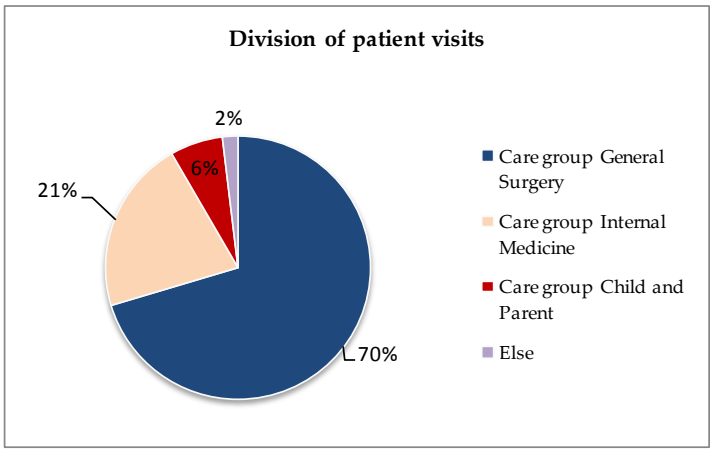


Figure 2: Division of patients over care groups in 2008 (n=25.551, *Eridanos*, 2009)

1.3 Problem definition

In 2007, Isala Klinieken noticed an increasing demand for emergency care (see also Table 1), together with an increase of waiting times for patients to enter the ED (pressure of environment that effects the internal performance). To be able to cope with these changes and to adapt to an expected increase of the number of patients in the future, the patient LOS (time from enter until departure in the ED) has to be improved. With a shorter LOS the ED expects to decrease waiting times, treat more patients with the same capacity and raise of patient satisfaction.

To encounter the increasing waiting times for patients the management decided in 2007 to start a project group. This project group analysed the LOS of internal medicine patients on the ED. The first results showed an average and median LOS which was too long with a high standard deviation (high peak up and down from the LOS).[1] The local standard of the LOS of internal patients was three hours.

[1] *Verbeteren doorstroom Spoedeisende hulp,* document Isala klinieken dd. 07-09-07

A number of interventions were done, but the variability and averages of these patients remained almost the same[2], due to the lack of insight into the benefits of the interventions of the involved staff.

Management realised more insight is needed into the activities performed on a patient, to be able to suggest length of stay improvements. The recorded data in the Hospital Information System (iZIS, 2008) was and will not provide explicit information or clarity on these activities.

Specialists, ED-nurses and residents of the ED approach the long LOS in various ways and they clarify this long LOS with various causes (shortage of residents or admittance problems).

This leads to the following problem statement:

The patients' length of stay is perceived by management as too long. There is a need of insight into the causes of these long length of stay

1.4 Research objective and approach

The objective of this research is:

"To suggest interventions to reduce patient length of stay in the emergency department by mapping all the processes, assess the duration of separate processes and activities and analyse inefficiencies"

To realise this objective, the research answers the following research questions:

1. **With which theories can the emergency department be analysed and which theories can we apply to suggest improvements?**

With a background of general business logistics, we use a system approach to structure the analysis of this research. Furthermore this research uses the management paradigm lean production, capacity management and manufacturing theories to introduce and evaluate the ED and to quantify the current situation. Lean management and capacity management are tools to analyse inefficiencies and with manufacturing theory we are able to suggest interventions. Chapter 2 explains the main concepts.

2. **How can the ED be described with a logistic perspective in terms of patient in- and outflow, resources, processes, activities and supporting processes, and what is the current patient LOS?**

Chapter 3 gives an analysis of the main components of the ED in a system approach. Paragraph 3.1 starts with a description of the input and output of patients in the ED and introduces the current

[2] *Verbeteren doorstroom Spoedeisende hulp,* document Isala klinieken dd. 15-05-08

patient LOS. Paragraph 3.2 reveals the resources and supporting processes as a second main component of a system. Finally, paragraph 3.3 gives the patient LOS and an in-depth description of the activities in the ED.

To analyse the ED and to get familiar with the processes and activities we follow the work of nurses, residents and receptionists. In addition we execute interviews with staff of departments linked with the ED to understand the patient flow (plaster room staff, ward personnel, outpatients department, admission office, radiology department and GP's diagnostic centre). A third method to discover the processes of the ED are process mapping workshops. According to the Department of Health, this is one of the most powerful ways for multi-disciplinary teams to understand the real problems from the patient's perspective (Department of Health, 2005). With the process mapping workshops we involve staff in the research and let them understand the patient's journey and each other's activities and work out the current process and activity steps in the ED.

For a quantitative analysis we use data from the electronic patient record (*Eridanos*, 2009) and data of our own manual measurements (*manual measurements*, 2008). With this data we are able to assess the durations of separate activities and the patient LOS to analyse inefficiencies in the process for the third research question.

3. **Which parts of the process indicate the most room for improvement to reduce patient length of stay?**

Paragraph 3.4 applies the theories of chapter 2 to reveal inefficiencies in the process. It explains the process or activities that have the most room for improvement

We use concepts from the literature to define waste activities and inefficiencies in the process (lean management, capacity management and manufacturing ideas). With the background of general business logistics, we evaluate the process of the ED and the system view.

Paragraph 3.5 gives a conclusion and summarises the answers on the second and third research questions. It structures the inefficiencies for which interventions are suggested.

4. **What interventions can be suggested to reduce patient length of stay in the emergency department?**

Chapter 4 proposes interventions to reduce the LOS. Paragraph 4.8 concludes with an overview of all suggestions and gives an indication of the time planning and impact of the interventions.

The interventions that we propose combine analysis and literature. For some ideas we use the output of process improvement workshops with the same staff as involved with the process mapping workshops. The guidelines of the Department of Health (2005) also handed methods to help effectively where to look for improvement ideas and to provide staff the opportunity to contribute to interventions and come up with brilliant ideas. The workshops focus on the problems from the process mapping and the waiting times and waste activities on the ED. With the philosophy of lean management and the elimination of this waste, the staff formulate practical inventions.

Chapter 5 gives a conclusion (5.1) and discusses the results of the research (5.2). After that we formulate practical recommendations for the ED and recommendations for further research (5.3)

2 Literature

The previous chapter introduces the initiatives to improve efficiency within the health care sector. Concepts and ideas of business logistics and manufacturing theories are increasingly being used to benchmark the health care sector (e.g. capacity, waiting list, staff shortages). It offers a different way of analysing this sector and we use this approach for the emergency department (ED). Instead of reducing the patient length of stay (LOS) with, for example, a focus on IT-solutions, this research focus on processes in the ED with ideas and perspectives from business logistics. This chapter introduces this ideas and perspectives that we need in this research.

The main goal of this research is to give suggestions to reduce the patient LOS in the ED. The first step is to reveal the current situation of the ED and to map all processes and activities. A general introduction to the system approach explains the approach we use to structure and analyse the current situation (paragraph 2.1). The second step is to quantify these processes and activities. Paragraph 2.2 describes lean management and capacity management that can give this quantification of the current situation of the ED and analyses inefficiencies. With manufacturing theories of paragraph 2.3 this research finally gives process improvement ideas and suggestions to improve the current situation and reduce patient LOS. The chapter ends with a conclusion (2.4).

2.1 System theory

A system by definition is composed by interrelated parts or elements. Every system has at least two elements which are interconnected. An organisation is an open system that reacts and intertwines with the environment (Boulding, 1956). It is a system in movement, with processes that occur between the input and output.

The system approach sees an organisation as an open system that reacts and intertwines with the environment. The first important elements of this system are the input and output. The input is the enter of products in the system, like raw materials, is a patient and output are the products, materials and patients that leave the system at the end. Between input and output the organisation transforms or processes the input, so it leaves in the correct form as output. In the following we refer to this transformation with processes. To be able to transform this input into output the organisation needs people, machinery, space, management, structure, information and so on. Concluding, an organisation is an open system that contains the following elements: input, output, processes (movement) and resources (staff and concrete things) that are interrelated. We explore these main concepts in chapter 3 and we add a structure to complete the analysis with a support structure that explains who or what plans the process.

A system view shows a company in its environment as a black box. Every step further down opens this black box and eventually describes the company on an activity level. The figures below give a structured example of systems, processes and activities. We compare the health care sector with a manufacturing company.

Figure 3 illustrates the in- and output of a manufacturing industry compared with the in- and output of a hospital. Raw material, as input for the first company, is processed into an end-product for the customer at the end. All companies or health care departments contribute their share to achieve this output. A patient enters with a health complaint and "leaves" as a healthy (treated) patient.

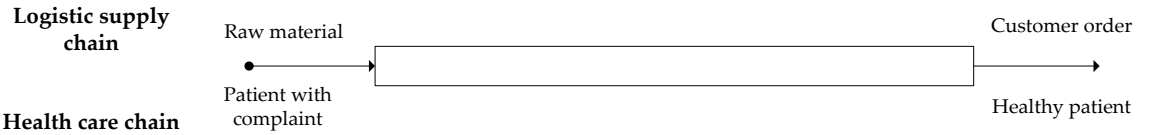


Figure 3: Highest level of system approach: the manufacturing industry compared with the health care sector

A first step to analyse input and output is to analyse the companies or service organisations from which the input is coming from and where the output is going. All organisations connected collaborate to bring and create the final product/service to the customer. Figure 4 shows these linkages. The work within a hospital remains uncovered as a black box.

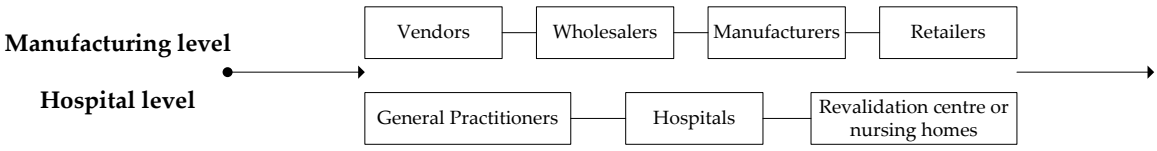


Figure 4: Partners in the manufacturing industrial supply chain compared with partners in the health care supply chain

If we open this black box the ED is one of the main departments in the hospital. Analogously with the manufacturer who receives "raw materials" from a wholesaler, the ED receives a patient as input. Both use processes to deliver their output: a consumer product or a diagnosed patient. In other words: with processes the manufacturer/ED is able to add value to deliver the wanted output. Figure 5 reveals a sequence of these processes.

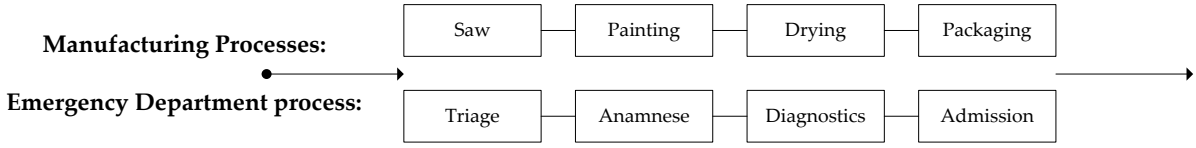


Figure 5: Various processes to transform input to output

To be able to add value, every process consists of one or more of activities. Activities are also in sequence and related to each other, just like processes, and link together steps to be done to achieve the appropriate output of a process (Figure 6).

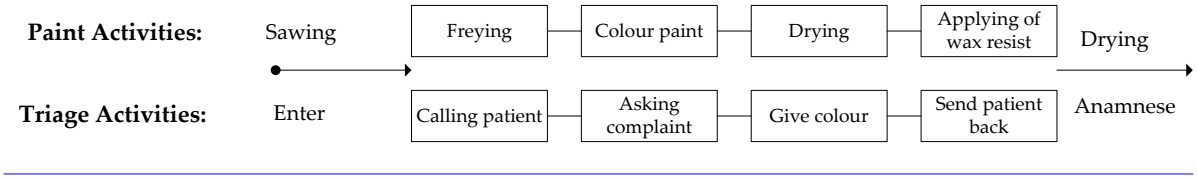


Figure 6: Activities with a process

2.2 Lean and Capacity Management

Chapter 3 uses lean management (2.2.1) and capacity management (2.2.2) to give a quantitative analysis of the current situation in the ED and its current inefficiencies. Both management theories also propose improvement for these inefficiencies.

2.2.1 Lean management

Since the beginning of manufacturing theory and common knowledge of supply chains and business logistics, various theories tried to propose process efficiencies and a reduction of costs of production by management paradigms. Lean management is one of these theories (others are total quality management (TQM), Six Sigma and theory of constraints) that combines varied operational methods into a new form of management philosophy. In this research we choose to use lean management, since it has practical ideas to involve staff within the process improvements.

Womack and Jones (2003) introduced lean management in 1990 with experience from a manufacturing company in the car-industry, Toyota Industries. Within this theory the general concept of a "lean production" is a process without waste or inefficiencies, defined as any action that does not add value to the customer. The philosophy proposes to use a step by step method of identifying and eliminating waste to increase the value for the end customer. Finally lean management can create interventions for improvement (Womack and Jones, 2003) by reducing this waste.

While the elimination of these types of waste may seem like a simple goal, waste remains a general concept of combined operational methods; a clear definition of waste is difficult. To overcome this problem, Toyota Industries (Liker, 2004) defined three types of waste in their production: *Mura*, *Muri* and *Muda*. While *Mura* and *Muri* focus on preparation and planning and fluctuations in scheduling, *Muda* focuses on processes on operational level. The seven original *Muda* are (Womack and Jones, 2003):

- Transportation (moving patients who are not actually required to perform health care)
- Inventory (all queues, work-in-progress and finished patients not being helped at that time)
- Motion (staff and patients or equipment moving or walking more than is required to perform the processing)
- Waiting (waiting for the next health care step)
- Overproduction (health care given that is not charged)
- Over Processing (diagnostics performed with no need for it)
- Defects (the effort involved in inspecting for and fixing wrong diagnosis's)

These seven *Muda* help defining waste, but it is difficult to distinguish waste in practical situations. It is convenient to distinguish activities between value-adding activity, non-value-adding activity and waste. Non-value adding activity is waste that cannot be avoided under the present work conditions.

As a management paradigm, lean management is adopted in health care (Hall, 2006), where added value to the customer refers to added value for a patient. A study of Dickson et al. (2007) used lean management in an emergency department to increase the content of service delivered, to add value for the patient and to eliminate avoidable waiting time. They mentioned involvement of all staff in process improvement ideas as a basic as an important method to eliminate waste (Dickson et al., 2007).

Both studies of Hall (2006) and Dickson et al. (2007) mention difficulties with distinguishing productive waiting (e.g. recovery) from unproductive waiting (waste, e.g. waiting for tests) and measuring value for the patients. They mention three reasons: the patient is typically unaware of the price of the product, the patient cannot fully quantify the quality of the service, and the expense that goes into delivering the service can be extremely difficult to measure (Hall, 2006 and Dickson et al., 2007).

According to Dickson et al. (2007), the adoption of lean principles improved the value of care delivered and allowed the ED to move significantly more patients. Other improvements were an increase of patient satisfaction and an improvement of the capacity in the ED. The results of the study showed some improvement ideas and redesigned processes to minimise waste (Dickson et. al (2007).

2.2.2 Capacity management and variability

This research uses capacity management to combine the number of patients (demand) with the number of staff and rooms in the ED (resources) and to be able to speak out if there is a fit between demand and capacity. Second, the research categories the current capacity planning over four hierarchical levels, explained below.

Capacity planning is the process of determining the production capacity needed by an organisation to meet changing demands for its products (Coyle et al., 2003). Capacity is the (maximum) ability of the ED to receive and help patients with an amount of resources e.g. an amount of patient rooms and staff personnel. The fit of demand and capacity is important, because too much resources can lead to over-capacity (high costs) and not enough capacity to help demand leads to waiting and queues of products/patients. This availability of appropriate resources influences the patient LOS and is therefore an important focus for the objective of this research in reducing the patient LOS.

The emergency system needs to be flexible enough to cope with the daily demand changes. It should also have the ability to make adjustments dependent on the type of patients entering the system. Many studies mention possible improvements on staff capacity in the emergency department to meet the demand/arrival of patients (Farrington et al., 1999; Hall, 2006 and Walley, 2006). According to Eklund (2008), capacity is almost exclusively limited by personnel resources, but the capacity of personnel is rarely sufficiently analysed. Once resource constraints have been identified and quantified, the means for increasing capacity of bottlenecks are subject to improvements of technical and/or allocative efficiency (Eklund, 2008).

Variability

Patients arrive with changing intervals during the day and on various days of the week. Chapter 4 elaborates on the variability of demand of patients and to effectively analyse this, we must be able to quantify it. Hopp and Spearman (2000) show the following formula to measure a relative variability:

Coefficient of variation (CV) = Standard deviation (σ) divided by the mean (t): (CV= σ/t)

The demand of patients has a low variability if its CV is less than 0.70, moderate variability if its CV is between 0.70 and 1.33 and high variability if the CV is greater than 1.33 (Coyle et al., 2003).

Fluctuations in demand, or high demand variability, degrade the performance of the system. Hopp and Spearman (2000) describes this in the variability law which explains that increasing variability in the system can have a negative impact on performance measures such as lead time, cycle time (length of stay), utilisation and quality (Hopp and Spearman, 2000). For example within companies with high demand variability, the utilisation of staff and rooms tend to be very low, because excess capacity is necessary to cover peaks in demand. Factors which influence variability are inventory, capacity and time of demand. Since both inventory and time of arrival of patients cannot be possible or predicted, the only opportunities for the ED is **to change capacity** in order to cope with variability (more capacity or assigning capacity in a different way).

Capacities of other departments related to the ED

Since we expect that patient demand for the ED is variable, we assume that the demand of diagnostics and admission inpatient beds is also variable. The capacity of e.g. radiology or wards has to be suitable and synchronised to this changing demand. The fit of capacity influences the LOS of patients in the ED because the patients remain in the ED until other departments are ready to help the patients. Hall (2006) already mentions that these complementary resource capacities are difficult to manage, this will be analysed further by match demand and (personnel) capacities of other departments in 3.2.

Framework for hospital planning and control

Van Houdenhoven et al. (2007) propose a generic hierarchical project planning and control framework that emphasise the interaction between the areas of interest and the various levels of control. Vertically the framework distinguishes four levels of managerial or planning activity levels and four horizontal categories of planning tasks (Figure 7). Since variability is inherent to the medical process, which implies dealing with unplanned events such as emergencies, the framework discern between offline and online operational planning.

In this research we use the framework, specifically the resource capacity planning, to distinguish the four hierarchical levels of resource capacity planning for the ED, to position the current planning methods and to propose interventions to improve this structure (paragraph 4.7).

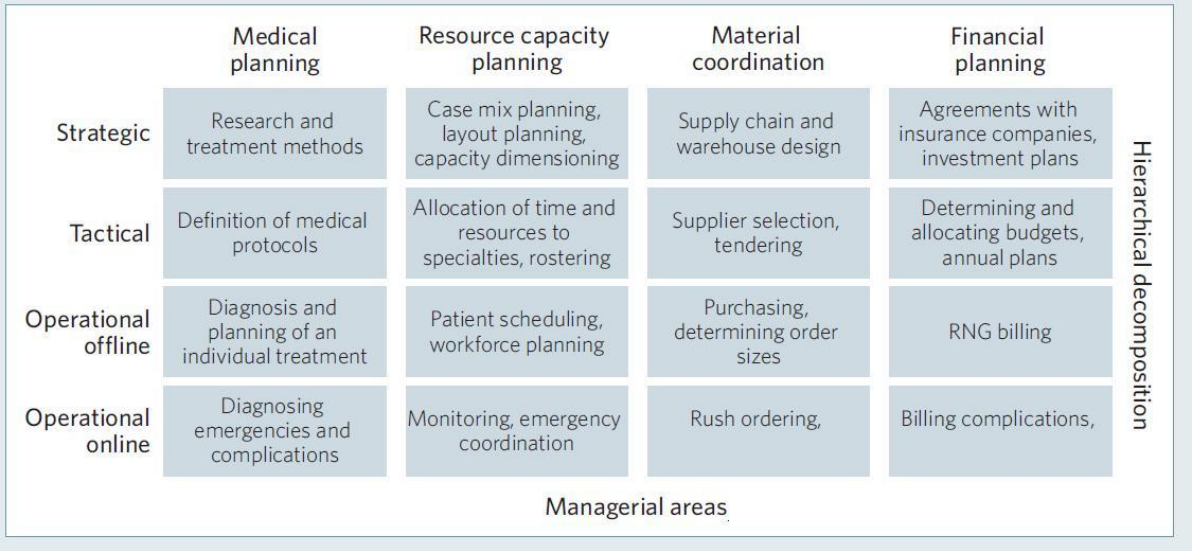


Figure 7: Framework for hospital planning and control; the content of the framework is an example (Van Houdenhoven et al. 2007)

Strategic planning for the ED addresses the formulation of long-term objectives, or mission statements of an organisation, and the determination of the investments needed to achieve these. These organisational objectives should be decomposed into consistent and concrete strategic objectives on all four areas of interest. Strategic planning should establish an ED that is capable to meet overall goals.

Tactical planning translates strategic objectives or choices into medium term objectives. As an example we mention resource allocation decisions by middle management (e.g. department managers). While strategic planning uses patient forecasts and/or historical information, tactical planning, like operational planning, deals with actual/ expected patients. As opposed to the operational planning, at the tactical level the longer planning horizon creates more flexibility in the dimensioning of the involved resources. While in operational planning the resource capacity is typically given, in tactical planning resource capacity can be temporarily expanded (e.g. overtime, temporary extra staff).

Operational offline planning deals with the in-advance day-to-day control of expected activities. It comprises the detailed coordination of the resources that were made available at the previous planning stage, to achieve the desired service levels. The adjective “offline” refers to the fact that operational offline planning concerns operational planning in advance. Operational offline decisions are typically delegated to lower management or clinicians. Examples are diagnosing, department scheduling and inventory replenishment ordering.

Operational online planning involves all control mechanisms that deal with monitoring the process and reacting to unforeseen or unanticipated events. Examples are: planning in case of the arrival of an emergency patient and patient rescheduling due to temporary resource unavailability (for instance echo or residents).

2.3 Manufacturing theory

Although there are many differences between health-care organisations and manufacturing companies, many operational management principles for analysing processes, inventory management and production planning can be used for both sectors. Many of the challenges facing health care providers are similar to those in manufacturing (Eklund, 2008). This paragraph gives suggestions for process improvements from a manufacturing perspective based on Hopp and Spearman (2000).

2.3.1 Work in Process

Manufacturing processes use Little's law to relate the cycle time of a process to the throughput of a machine and the amount of work/products in progress with the following formula:

Cycle time (CT) = work in process (WIP) divided by throughput (TH)

Throughput is the average output of a production process (machine, workstation, line, plant) per unit time (e.g. parts per hour). To reduce the CT of a process, the WIP has to decrease, assuming that the TH remains constant. Indicators for a high WIP are large queues and batched products. Both indicate opportunities for reducing cycle time, as well as WIP (Hopp and Spearman, 2000). In the ED the cycle time in the process is the length of stay of the patient from enter until departure.

A constraining activity in a production system or process is called a bottleneck. This bottleneck has the lowest throughput of the entire system so it eventually determines the total cycle time. An increase in the capacity of the bottleneck resource of a system has positive effects on the throughput and therefore on the cycle time of the whole system (Little's law). Schuring and Van Der Wiel (2005) suggest to continuously assign resources to the slowest obstacle (bottleneck) of the process or system, with flexible resources (mainly staff) as a prerequisite.

2.3.2 Time based strategies (reducing cycle time)

Little's law is a strict mathematical formula that offers theoretical ideas to reduce cycle times. Less strict ideas are given by Coyle et al. (2003). According to them reductions in cycle time (CT) are based upon three factors: processes, information and decision-making. If the health care on the ED is seen as a series of processes, then those processes being performed faster will reduce the CT, so the patient LOS (or the time between these processes) can be reduced.

Secondly, a faster provision of information offers another important opportunity to reduce cycle time. The utilisation of faster, more efficient forms of order transmission – the internet for example – can significantly reduce the time needed to complete the transaction. Timely, accurate information about sales, orders, transportation service and so on, leads to shorter cycle times and also reduces uncertainty about what is happening (Coyle et al., 2003).

The final opportunity in reducing cycle time is decision making. Empowered individuals make decisions relevant to their areas of expertise and responsibility. While this can lead to, for example costs of wrong decision-making, some companies suggest that the risk is justified in terms of the time that is saved and the improvement that often takes place with respect to customer responsiveness.

If we translate this idea to the emergency department, it suggests reductions in the patients LOS by faster performance of time between process steps in the ED (the duration of the process itself is the time of health care delivered, which is not the focus of this study), faster provision of information and early decision making about for example; early diagnostic test for patients or early decision of admission. Reducing time between processes fits with the ideas of lean management to eliminate all waste in the process (2.3.1).

2.3.3 Process variety

In manufacturing theory, the level of demand variability and the numbers of in- and output make a considerable difference to the organisation of the process and the utilisation of resources (machines, personnel). The processes within a manufacturing company are often categorised into five main design process choices, corresponding to these variable numbers and variability's (Figure 8). Each process choice represents a different flow of work (Walley, 2006).

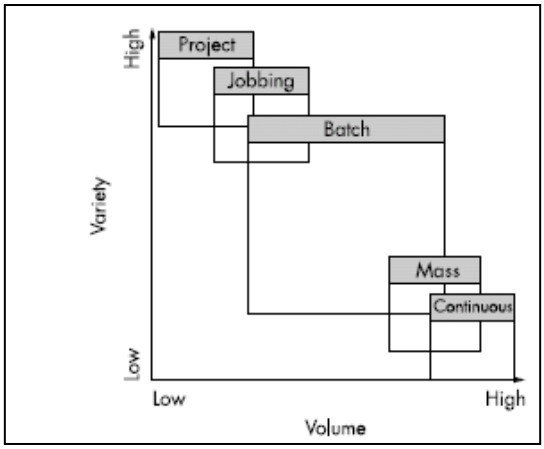


Figure 8: Manufacturing process choice related to volume and variety (Walley, 2006)

Walley (2006) concludes that the emergency department segments patients according to their complaints and symptoms. This contradicts with the manufacturing approach explained above and he suggests splitting patient arrivals into segments of process-based flows with similar process sequences. The flows combines for example patients who need two diagnostic test (e.g. a lab and echo) in one 'process' group and patients who need ongoing examination, fast diagnosis and admission in another 'process' group. Just as in manufacturing theory, the configuration of resources, like residents and patient rooms, have to be adjusted to these process sequences.

Another segmentation method Walley (2006) mentions is to divide the product range into smaller groups and produces these in "cellular" operations. Cellular operations are small scale factories, concentrating on narrower ranges of product, where the process can be designed specifically for smaller product range (e.g. the fast track patients in the ED). The difficulty with cellular operations is a good balance between the achieved performance gains of better process design and the loss of efficiency caused by ring fenced resources.

2.3.4 Track and tracing

Another way to improve and control the process flow of products in a factory is to always track the product (Hopp and Spearman, 2000). This stipulates the necessity for firms to develop the ability to know the location of all products at any point in time. For the emergency department this means that information should be available on the position of patients in the system to control the flow of patients and to react immediately on problems (e.g. large queues, many admission patients; Hopp and Spearman, 2000). A study of Hall (2006) confirms the idea of constant system monitoring in health care. This study tries to minimise patient queuing and mentions monitoring (e.g. tracking number of

patients, diagnostic grouping) linked to immediate actions as a solution to reduce delays in patient queuing.

2.4 Conclusion

This chapter explains the literature to use when analysing and suggesting interventions for the ED. We answer the following question: *With which theories can the emergency department be analysed and which theories can we apply to suggest improvements?*

We decide to use a logistic perspective to realise the defined objective (chapter 1). This approach provides us with the following theories to analyse the ED and suggest interventions.

A general system approach is a structured analysis tool that uncovers the main components of a system (in this case a department) step by step. It structures the analysis of the ED.

Lean management and capacity management are quantitative tools that discover inefficiencies in processes. Lean management is a management paradigm that categories waste that should be eliminated to improve the performance of the system. Capacity management relates the incoming patient demand to the available capacity of resources (staff and beds to help this demand.

Manufacturing theory shows many ideas to attack inefficiencies in processes and improvement possibilities to reduce the patient LOS in the process on the ED. For this research we use *Little's Law*, theory of reducing cycle times, theory of process choices related to volume and variety and track and trace possibilities.

Concluding, the decision to realize the objective from a logistic perspectives provides us applicable literature.

3 Analysis of the emergency department

The research objective is to give suggestions to improve the patient length of stay (LOS). This patient length of stay is a quantitative measure to determine the performance of the emergency department (ED). To know which interventions reduce the patient LOS, we need a quantitative analysis of the current situation of the ED, next to a descriptive analysis. This chapter answers research questions two and three and uses concepts, introduced in chapter 2, to give the appropriate analysis and explore problems in the patient flow.

From the previous chapter we know that a system consists of inflow, outflow, main processes, managing and supporting processes and people and resources. All these components can influence the performance of this system. Since we do not know at this moment what causes the long patient length of stay, we need to understand and analyse all these components of the ED (system) in this chapter.

First, paragraph 3.1 gives an overview of the ED as a system with number of patients' input and output, the main process remains covered as a black box. Second, paragraph 3.2 describes the managing and supporting processes and the people (nurses and residents) and resources (patient rooms) needed for the operations. The paragraph also makes a comparison of demand of patients versus capacity of staff.

After the first two components of the system, paragraph 3.3 finally gives an overview of process flows, patient LOS and an in-depth description of the main process and activities, which uncovers the operations in the ED in the black box. To understand the patient LOS in relation to the activities, the duration of every activity is measured. These first three paragraphs answer the second research question.

Even though we discussed the main components of the ED as a system in the first three paragraphs, we continue with a fourth paragraph. Paragraph 3.4 turns back to the system level again and further analyses the LOS in three time slots. The paragraph also examines every step of the patient and determines whether it adds value for the patient and where the patient enters a queue or a batch. The proposed literature from chapter 2 combined with the analysis, draws up a conclusion of the process and activities that contain the most improvement margin and answers the third research question.

Finally, paragraph 3.5 gives a summary of the chapter.

Chapter 3 contains many measurements which we extracted from an in-house developed electronic patient record (*Eridanos*). This record gives access to relevant patient data to all staff in the ED and collects data and information of the visit of the patient. Table 2 lists the measurement types of the EPR that we use in this research.

Type of date	**Measures**
Time Measurements	
Patient Enter	Date and Time
Patient Triage	Time
Start Resident anamnesis	Time
Patient Departure	Date and Time
Methods arrival and departure	
Patient referral method	Self-referred; specialist; GP (ambulance yes/no)
Patient departure method	Admission; discharge;
Day of the week	Days
Care Measurements	
Care Group	Internal medicine; General surgery
Colour of Urgency	Blue, green, yellow, orange, red
Patient room	1 until 12 and 13.1 until 13.4

Table 2: Data measurements (electronic patient record)

3.1 Inflow and outflow

3.1.1 Introduction

Paragraph 2.1 briefly discussed the system approach. The emergency department itself is a system within the health care sector. Various partners (e.g. GP and nursing departments) work together in an effort to deliver the right health care to a patient. The ED receives patients from general practitioners (51%), from an outpatient appointment of a specialist (12%) or patients who walk-in themselves (36%) (n=25.551 *Eridanos*, 2009). The residents in the emergency department examine this patient until diagnosis, which is the added value for the patient. After the diagnosis, patients leave the ED with a discharge (67%) or with an admission (33%) in one of the nursing departments (n=25.551, *Eridanos*, 2009). Figure 9 shows this position of the ED within the hospital and referrals.

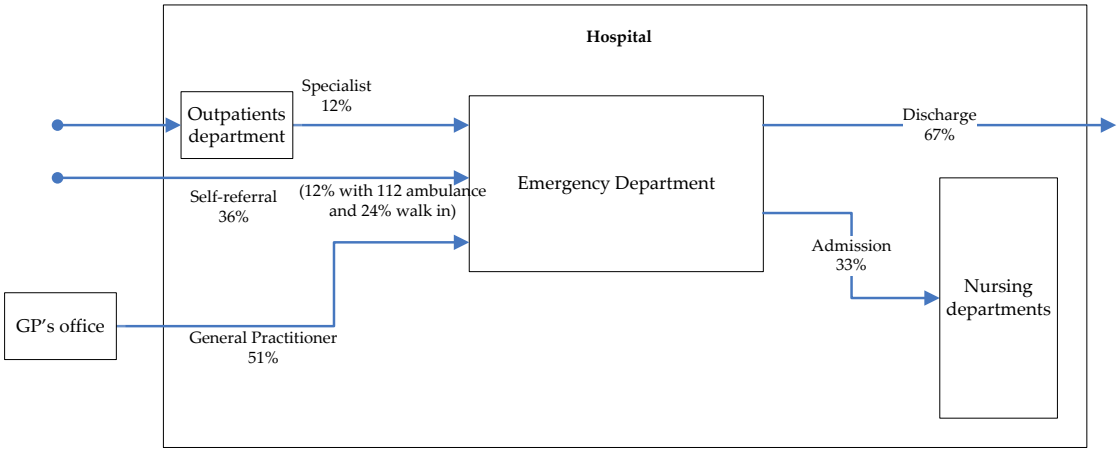


Figure 9: Overview of the patient flow in and out of the ED in 2008 (n= 25.551, *Eridanos*, 2009)

Approaching the ED from its position in the hospital is only one way to analyse the ED. If we look at the ED as a system (paragraph 2.1), it has an input (undiagnosed patients) and an output (diagnosed patients). The reminder of the paragraph explores these elements of the ED.

In 3.1.2 we specify the number of patients arriving (input) with a focus on arriving of patients every day, per weekday, per hour of the day and percentages with urgency-colours. In 3.1.3 we quantify the

output of discharge and admission patients. We further specify admission patients in average admissions per weekday and per hour of the day (Figure 10).

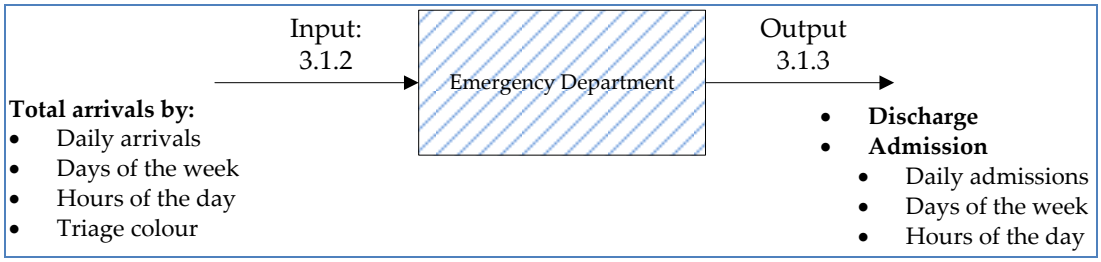


Figure 10: Overview of paragraph 3.1

3.1.2 Inflow of patients

This section shows the inflow of patients throughout the week, on every hour of the day and divided by urgency colours. As mentioned previously, the research focuses on the patients of care groups general surgery (including traumatology) and internal medicine (section 1.2).

First we give the results of the daily arrival analysis of all patients in 2008. On average 49 Surgery patients enter the ED every day and on 10-90% of the days between 37 and 61 patients arrived. The average for internal medicine patients is 15, with a 10-90% boundary of 9 to 21 arrival patients. The variability of both care groups is relatively low (*Eridanos,* 2009; Table 3).

	Total Patient Visits	
	G. Surgery	Internal M.
Inflow in 2008	17925	5404
Average arrivals a day	48,9	14,7
10-90% boundary	37 and 61	9 and 21
Standard deviation	9,5	4,7
Variability	0,20	0,32

Table 3: Arrivals of General Surgery and Internal Medicine patients in 2008 (n= 5404 Internal M. and n= 17925 G. Surgery) (*Eridanos,* 2009)

Second, we present the arrival analysis of patients on each day of the week. Table 4 shows the average, standard deviation and variability of the number of patients arriving on different days of the week. This variability is low. Figure 11 visualises Table 4 with the differences between the inflow of patients on different weekdays. On Saturday on average 2 more general surgery patients visit the ED than on normal weekdays. A higher arrival of fast track small surgery patients (sport incidents) explains this increase. The inflow of internal medicine patients is higher on Mondays and Fridays than on other days. This is a consequence of a high number of patients from the GPs before or immediately after the weekend. Although variability is low, for both specialties the Thursday is the weekday with the lowest number of patients and the Fridays are on average the busiest days of the week.

	Patient visits during the week					
	G. Surgery			Internal M.		
Inflow 2008	Average	St. Dev.	Variability	Average	St. Dev.	Variability
Monday	52,0	8,0	0,15	16,2	4,5	0,28
Tuesday	48,3	10,2	0,21	16,1	4,2	0,26
Wednesday	46,7	8,3	0,18	15,5	3,7	0,24
Thursday	46,3	8,9	0,19	14,1	4,0	0,28
Friday	51,6	10,9	0,21	18,1	4,7	0,26
Saturday	53,7	9,2	0,17	11,4	3,9	0,34
Sunday	44,6	9,7	0,22	11,7	4,2	0,36

Table 4: Number of patient visits during the week in 2008 (n= 5404 Internal M. and n= 17925 G. Surgery) (*Eridanos*, 2009)

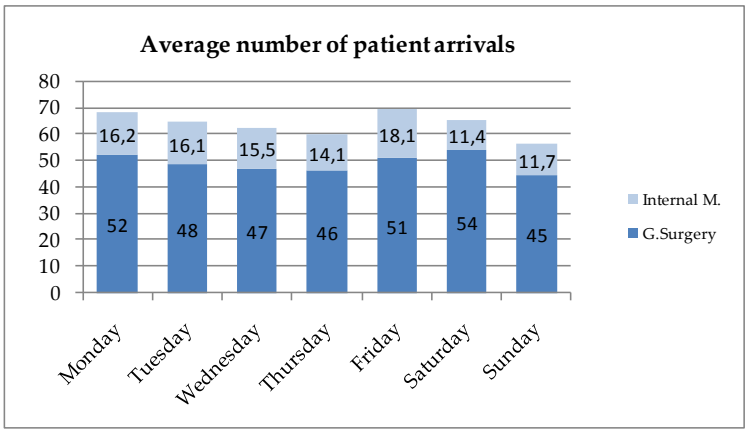


Figure 11: Average number of patient arrivals during the week in 2008 (n= 5404 Internal M. and n= 17925 G. Surgery) (*Eridanos*, 2009)

Third, we analyse the arrival rate for every hour of the day. On average 0,62 internal medicine patients per hour enter the ED (variability of 0,69) and 2,05 per hour of general surgery patients (variability of 0,73). The inflow of general surgery patients peaks at two hours of the day, at 11:00 and at 16:00 (Figure 12). The arrival of these patients starts a little bit earlier than patients for internal medicine, where arrival rates have a more smoothly arrival pattern during the day. The arrival of internal medicine patients shows a peak at 13:00 (Figure 13). We can explain this peak since most of the internal medicine patients enter the ED with a GP-referral. This means that between 9:00 and 10:00 patients start to come to the ED after an (emergency) consult of the GP between 8:00 and 9:00. Until 17:00 the number of arrivals remains high, which reflects the hours of consultations of the GP.

Looking at the 0-80% boundary we conclude that the arrivals per hour have a medium variability for patients of both care groups. Summarising, the variability of inflow of patients in the ED is low when we analyse the arrivals on a daily and weekly basis, but high when we analyse the inflow on various hours of the day.

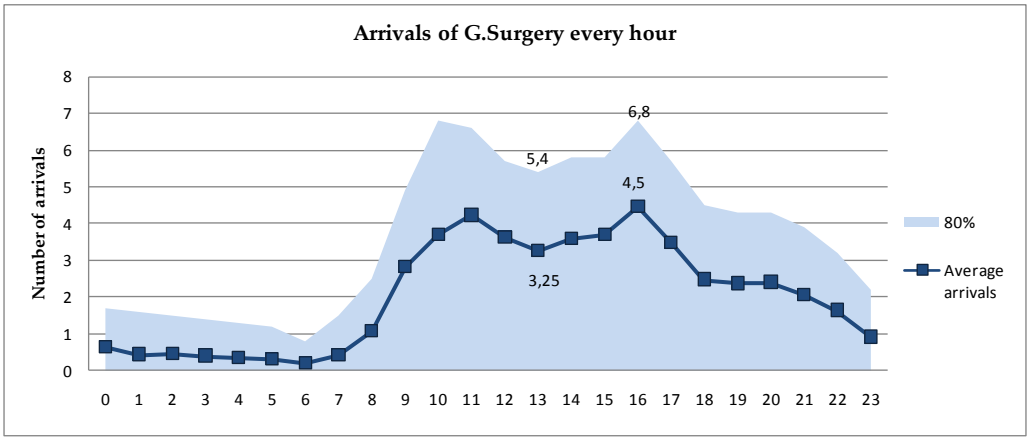


Figure 12: Boundary 0-80% of General Surgery patients on every hour of the day (n= 17.925, *Eridanos*, 2008)

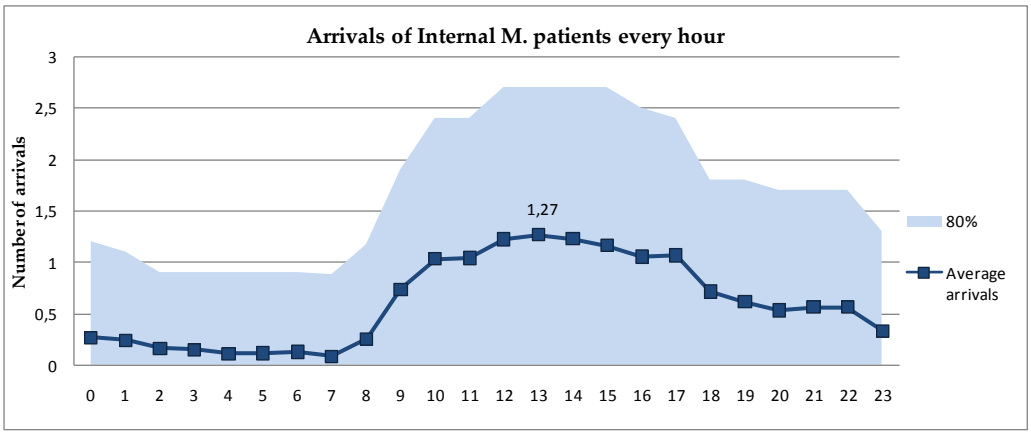


Figure 13: Boundary 0-80% of Internal Medicine patients on every hour of the day (n= 5404, *Eridanos*, 2008)

Fourth, aside from the division of the arrival of patients each day, every day of the week and for every hour of the day, urgency colour is also a categorisation that the ED uses to divide patients. After a patient arrives, the nurse gives the patient a colour, from blue, green, yellow, orange to red with increasing urgency of health care needs and decreasing time to wait for a resident (4.2.1 gives a further elaboration on triage). 50% of the patients have a green urgency (2 hours from triage to resident) and 43% have a yellow urgency (1 hour). The colour red (1% of the patients) represents high level trauma patients, who need immediate diagnostics and health care of an anaesthesiologist and trauma surgeon (*Eridanos*, 2009). Table 5 shows the percentages for both care groups.

	Number of patients	
Colour	**G. Surgery**	**Internal M.**
Blue	0,2%	0,1%
Green	59%	27%
Yellow	35%	62%
Orange	4%	9%
Red	0,5%	0,5%

Table 5: Percentages of total patients that receive triage colours (n= 23.329, *Eridanos*, 2009)

3.1.3 Outflow of patients

Patients leave the department in two different ways: admission to a nursing department in the hospital or discharge to home. We are especially interested in the admissions, since the wards of the hospital are partners of the ED in the supply chain. The outflow of patient to the wards is different for each specialty, due to varying seriousness and complaints of the patients. On average 10 patients of all internal medicine patients a day are admitted (n=3789 admissions in 2008) and also 10 general surgery patients a day (n= 3766 admissions in 2008). Figure 14 shows that the ED admits almost 70% of all internal medicine visits, but 'only' 21% of all general surgery patient visits. There is an 80% possibility that between 6 and 16 general surgery patients are admitted each day and between 6 and 15 internal medicine patients (10-90% boundary; Table 6; *Eridanos*, 2009).

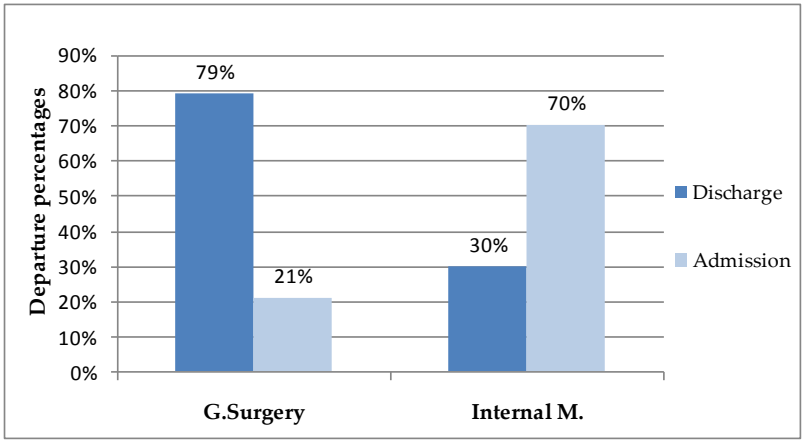


Figure 14: Average percentage of discharge and admission patients in 2008 (n= 23.329, *Eridanos*, 2009)

	Total Patient Visits	
Outflow in 2008	**G. Surgery**	**Internal M.**
Percentage admission	21%	70%
Average Admission a day	10,3	10,4
10-90% between	6 and 16	6 and 15

Table 6: Outflow of admissions from the ED to the wards in the hospital (n= 5404 Internal M. and n= 17.925 G. Surgery, *Eridanos*, 2009)

The admission rate of patients from the ED differs for each day of the week and on every hour of the week. Just as with the inflow of patients we analyse the admissions further by presenting admission on different weekdays and on different hours of the day.

First, Figure 15 shows the average admissions throughout the week. On average more patients are admitted on Friday than on other days. Second, Figure 16 shows the admission rate during the day, which reaches a peak between 18:00 and 19:00 for both specialties. At 17:30 and 17:45 both specialties have their carry-over session with specialists and other residents in the hospital. During this session less work is performed in the ED and afterwards residents change shift. The preceding patients are finished quickly. This can be an explanation for the high admission rate around 18-19 (after the carry-over). The carry over hour also explains the (small) gap in admissions between 17:30 and 18:30.

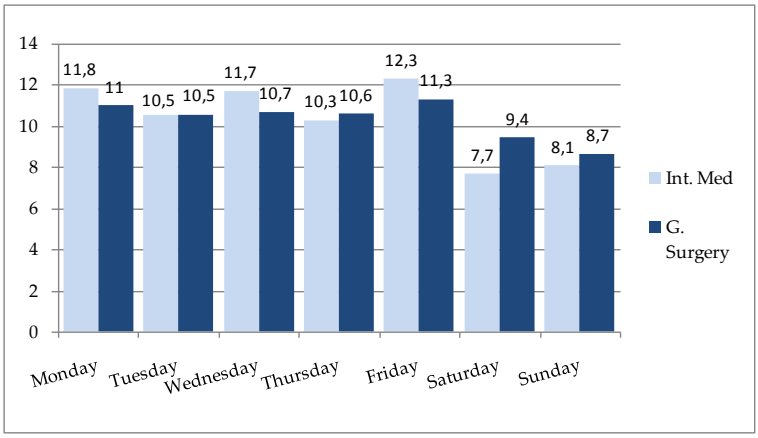


Figure 15: Number of patients admitted throughout the week in 2008 (n= 3766 G. Surgery; n=3789 Internal M., *Eridanos*, 2009)

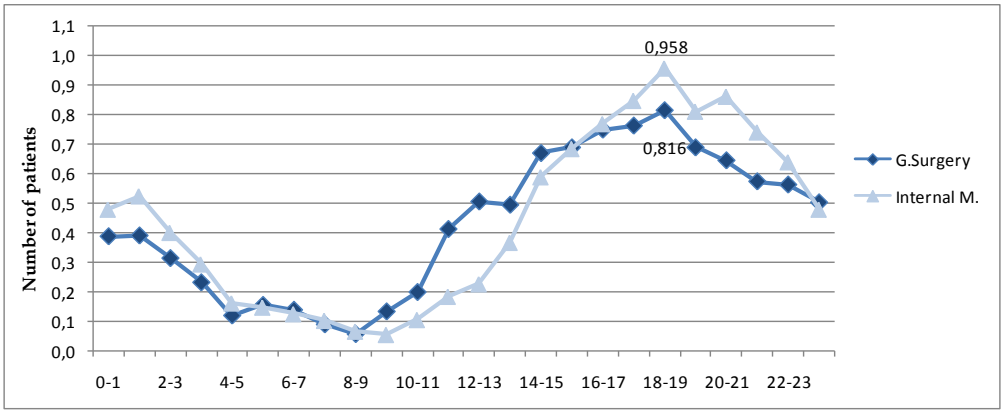


Figure 16: Number of patients admitted throughout the day in 2008 (Eridanos, 2009)

After analysing both input and output, we combine these numbers into one figure for both care groups. Figure 17 and Figure 18 present the average arrival-rate and departure-rate of patients for every hour of the day. Be aware that the two graphs have two different y-axis'; the averages of general surgery patients are higher than for internal medicine patients.

Both figures explain the increasing pressure on the resources of the ED during the day. From 7:00 until 17:00 the departure-rate is lower than the arrival rate. During these hours, the number of patients on the ED increases. For both specialties, more patients depart than arrive after 17:00 so only from then, the ED decreases in patient numbers.

For general surgery the departure rate is closer to the arrival rate than for internal medicine arrivals (at 15:00 almost more general surgery patients depart than arrive). This means that the actual number of internal medicine patients grows more rapidly than the total number of general surgery patients on the ED.

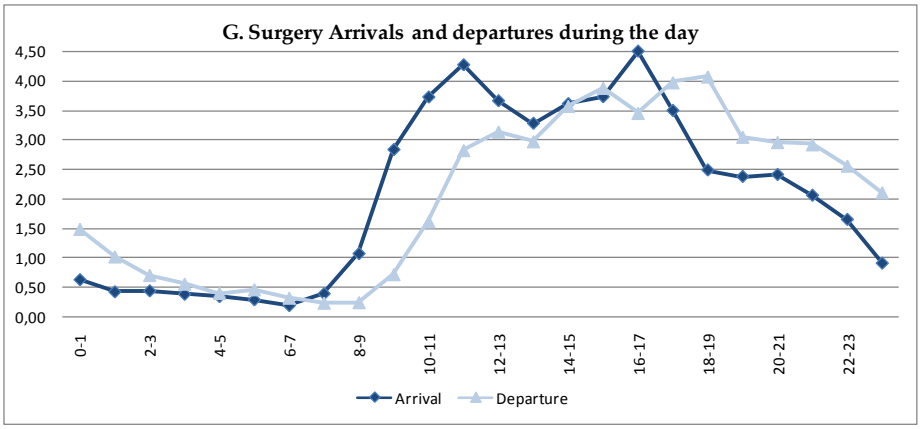


Figure 17: G. Surgery: Arrival/ Departure of average patients in the ED in 2008 (n =17925, *Eridanos*, 2009)

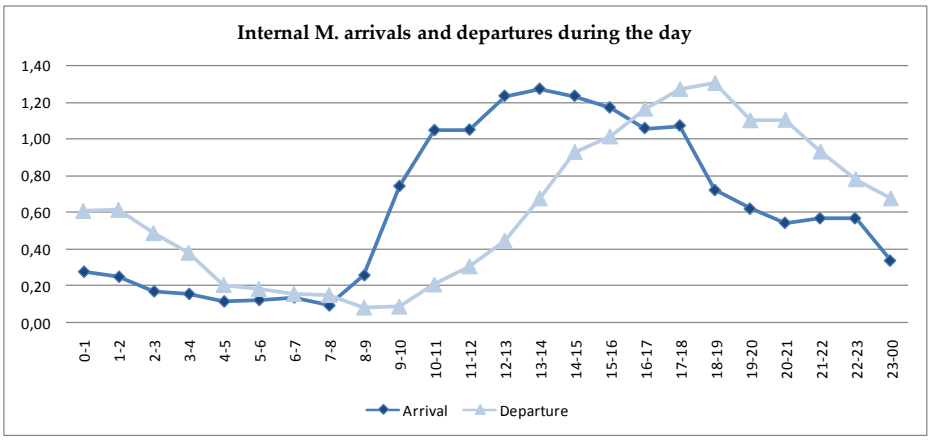


Figure 18: Internal Med: Arrival /Departure of average patients in the ED in 2008 (n= 5404, *Eridanos*, 2009)

3.2 Planning and resources

Previous paragraph revealed the ED as a system with an input and output. As a second component of the system, this paragraph presents the supporting processes and control of the ED and the resources that the ED uses to perform health care to patients.

First the paragraph gives an overview of the planning processes of resources (3.2.1). Then it gives an overview of the resources of the ED: working schedules of staff (3.2.2) and the patient rooms (3.2.3).

3.2.1 Planning and control structure

We explain the planning structure of the ED in this paragraph with the framework of Houdenhoven et al. (2007) introduced in paragraph 2.2.2. We enlighten the managerial area of resource capacity planning (Figure 19). What immediately attracts the attention in the structure of planning and decision making is the split of a hospital authority line and a medical authority line. When suggesting interventions for the problem of long LOS, we keep this framework in mind with the restrictions and possibilities of the split in authority.

Hospital authority line: Within the hospital authority line, the management of the ED plans the nurses, receptionists and departments assistants. The ED as a department is organised under the care group General Surgery. Every care group has its own (general) manager and the board of directors of the hospital has authority over this care group manager. The care unit manager controls the ED and is responsible for strategic and tactical decisions, while the operational executives (1,5 FTU) are in charge of the operational procedures. Three nurses of the ED have extra hours every week (0,2 FTE) to perform some extra tasks, one responsible for quality and one for education.

Medical authority line: Within the medical authority line, the partnerships of medical specialists are responsible for the resources and planning of the residents in the ED. The specialists work for the hospital, but because of their position as a partnership they have a lot of power. The specialists organise and supervise the residents working on the ED and they decide on the medical process of a patient (medical planning of the framework).

Figure 19 shows the strategic, tactical and operational planning's mechanisms for the two authority lines in the ED.

The split in authority is extra highlighted by the fact that the residents and specialist can give more specialised health care to a patient than the nurse can give. This increases the gap of work of two staff resources working on the ED and probably influences the way of work and communication lines between the two staff types.

The split of authority influences the work on the ED, for example if the ED is under high patient demand; the manager of the ED is not (formally) able to decide to add an extra residents or specialist. In addition, it complicates decision making about changing working structures of the implementation of new ideas.

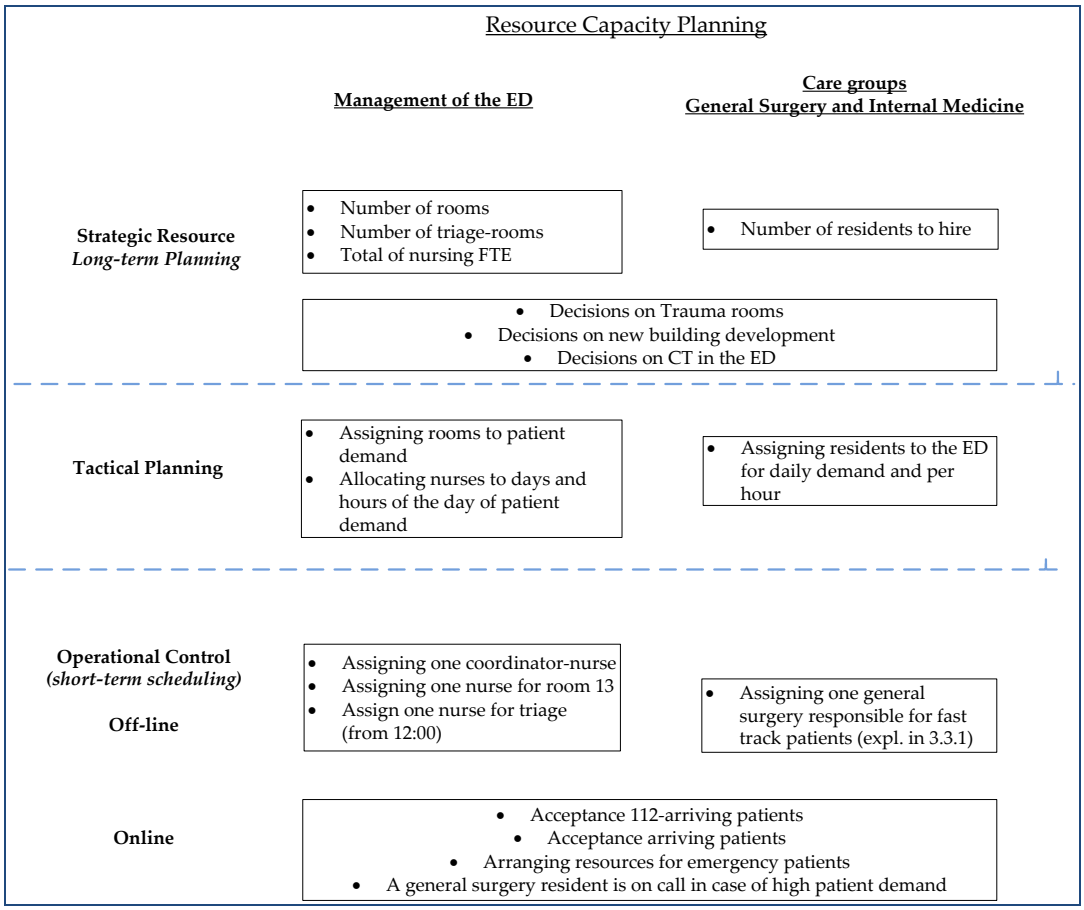


Figure 19: Framework for resource capacity planning for the ED (subtracted from Houdenhoven et. al., 2007)

3.2.2 Resources: Staff

Nurses, receptionists, department assistants, x-ray technicians, residents and specialists are all involved in the care of patients in the emergency department. This paragraph gives an overview of the schedules of nurses and residents and describes the work of other involved staff.

Nurses

Working Schedule ED-nurse	
Shifts	Total
7:30 - 15:30	3
9:00 - 17:00	1
10:00 - 18:00	1
12:00 - 20:00	1
14:00 - 22:00	2
15:30 - 23:30	4
23:15 - 07:45	3

Table 7: Number of nurses for every work shift in the ED

The working schedule of nurses starts at 7:30 with a day shift of 3 nurses. During the day this will increase to a maximum of 9 nurses at 15:30. After 17:00 the number of nurses will slowly decrease to 3 nurses' nightshift at 23.15 (Table 7).

In paragraph 2.2.6 we mentioned the urgency for the ED to be flexible enough to cope with daily demand changes. At this moment we can check if the available nurses in the ED match with the arrival of patients (demand every hour). Figure 20 plots the number of nurses to the actual number of patients on average on the ED through-out the day. We see that increasing and decreasing total number of patients correlates with an increase and decrease in number of ED-nurses.

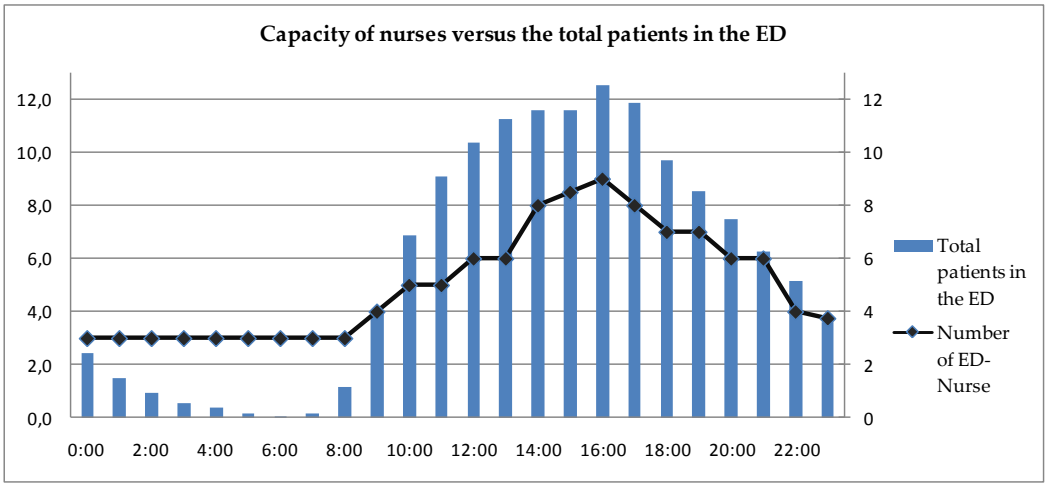


Figure 20: Number of working nurses against the actual number of patients in the ED in 2008 (Average number of patients Hour = av. Total hour-1 + av. ArrivalHour – av. departureHour; n=17.925 G. Surgery patients and n=5404 Internal Medince patients; *Eridanos*, 2009)

Before we can conclude if this demand of patients matches the capacity of nurses we have to check whether the results are consistent with the experience of the nurses. Around 20:00 and 21:00 6 nurses perform the work for (on average) 5-6 patients, while around 12:00 and 13:00 the same number of nurses work for 8-9 patients. This contradicts the experience of perceived workload of the nurses, with an expected higher workload around 20:00 than at 12:00.

To examine this difference in perceived workload Figure 21 plots **the sum** of patient arriving and departing in an hour. We assume that the nurses have the highest workload when a patient arrives or departs. This figure still cannot explain the higher workload of the nurses, but implicates a fit between nurse capacity and patients entering and departing. We are aware that workload of nurses depend on other factors than just work on patient (e.g. maybe the long admission LOS, see 3.3.1, influences the increasing pressure at 20:00)

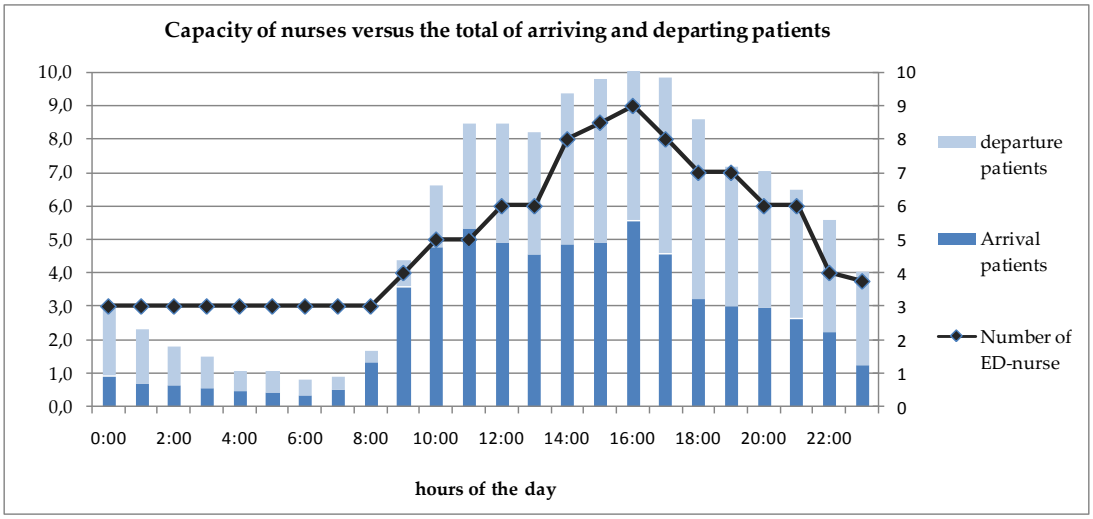


Figure 21: Number of working nurses against the SUM of patient arrivals and departures in 2008 (*Eridanos*, 2008)

Residents

Residents work for a specialty and are not part of the ED. The supervisors of these specialties schedule their residents, which mean that a lot of different residents work in the ED. Table 8 shows the schedule of the residents and Figure 22 and Figure 23 plot these work-schedules versus the total numbers of general surgery and internal medicine patients.

Working schedule residents			
General Surgery		Internal Medicine	
Shifts	Total	Shifts	Total
08:00 - 12:30	2/3	7:30 - 17:00	1
12:30 - 16:30	3/4	13:00 - 20:00	1
16:30-23:30	2	16:00 - 23:30	1
23:30-7:30	1	23:30 - 7:30	1
8:00 - 8:45 16:30 - 17:00	Carry-over	8:00-8:45 16:45-17:30	Carry-over

As we saw in 3.1.2, the highest amount of general surgery arrivals is at 11.00 and 16.00. As Figure 22 shows, the number of departure of patients is less, so total patients for general surgery increases from 11.00 and reaches a peak at 16.00. At both times, less residents work in the ED than in the times in between.

Table 8: Schedule for residents

The capacity of the general surgery residents does not optimally fit the demand of the patients throughout the day.

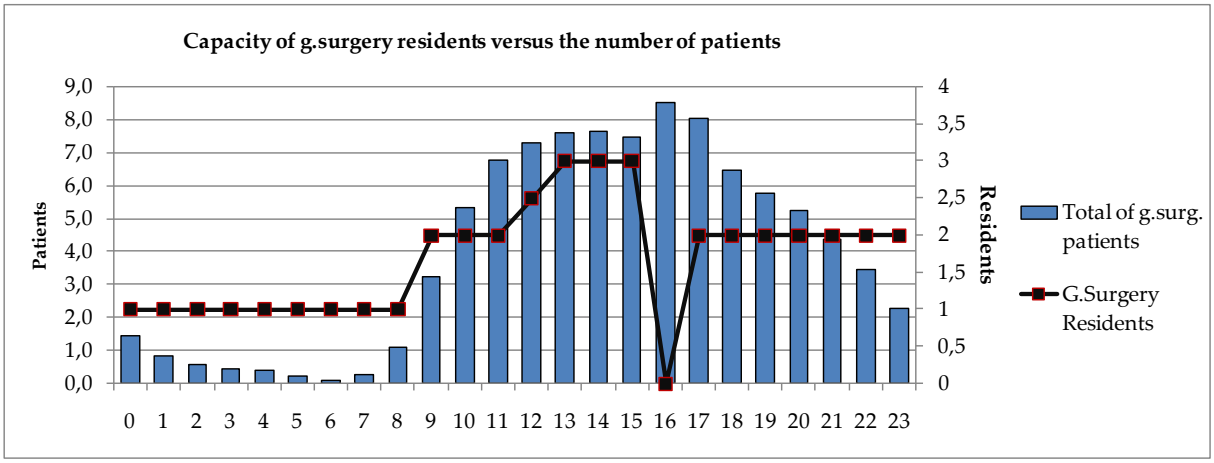


Figure 22: Number of residents working for general surgery against the actual number of patients on the ED in 2008 (Average number of patients Hour = av. Total hour-1 + av. ArrivalHour – av. departureHour) (n=17.925 G. Surgery patients, *Eridanos*, 2009)

The number of internal medicine patients increases rapidly from 10.00 in the morning. Only at 13.00 a second resident starts to work in the ED. At that moment, already a lot of patients are waiting to see a resident. The patients that enter the ED at 13.00 have to wait until the resident finishes the earlier patients. It is possible that the residents cannot catch up all these patients first, so they are lacking behind the whole day.

The gaps in both figures represent the carry over hour at 16.30. Most of the time all residents leave the ED although the general surgery patients reaches a peak at this hour and also a high amount of internal medicine patient are in the ED.

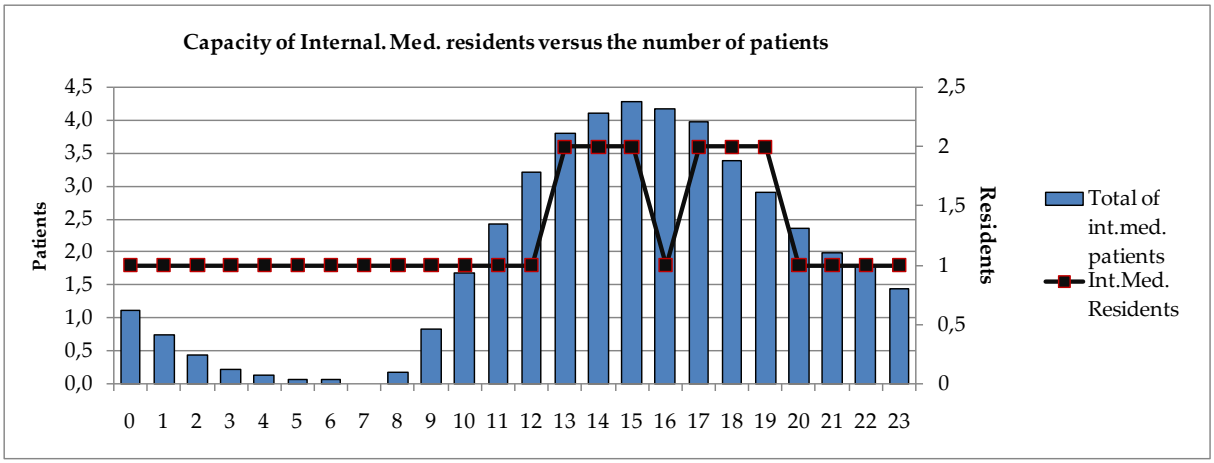


Figure 23: Number of residents working for internal medicine against the actual number of patients on the ED in 2008 (Average number of patients Hour = av. Total hour-1 + av. ArrivalHour – av. departureHour) (n=5404, *Eridanos*, 2009)

Overall we conclude that the residents working schedules does not completely fit the total demand of patients in the ED. This deteriorates the patient length of stay and probably increases the patients queue before and after anamnesis. Since the general surgery residents work with more flexible schedules in the ED than internal medicine residents, general surgery is better able to increase capacity of residents to cope with high demand of patients.

Receptionist and department assistant

When the referrer announces a patient, the receptionist prepares the papers (paper requests of laboratory and x-ray). When the patient arrives, the receptionist delivers the patient data to the triage nurse and inserts the patient on the digital board in the waiting room.

The receptionist monitors the patients in the waiting room and is also responsible for the registration of the patient in the patient record *Eridanos* and arrangements of (emergency) admissions in the hospital. Usually they do not work during the nights, but on Friday and Saturday an extra night-shift is planned to cope with the higher amount of arriving patient during the weekend-nights.

The department assistant takes care of the organisation of all kinds of stock (medicine, printing paper, needles), the cleaning of the department and the preparation of the rooms for new patients. During hours of high peak demand, they also escort patients through the hospital.

Inpatient wards

The nursing wards of the hospital are connected with the ED since they receive patients from the ED if they need further treatment or surgery. The number of admission patients from the ED is the actual demand for the inpatient wards. As said in 2.2.2 the capacity of partners of the ED should also be able to cope with demand.

The nurses in the wards (other than the ED) work with three shifts during the day. For example the short-stay department A1p works with three nurses during the day shift (07:30-15:30), but schedules for the evening shift only two nurses (15:30-23:15). The same applies to other nursing departments; the capacity of nurses reflects the number of inpatient beds available. Figure 24 plots the admission rate of

patients from the ED to the capacity of nurses available in the nursing departments. We see that most admissions take place during the evening shifts of the nursing departments. During these shifts fewer nurses are scheduled. We conclude that the capacity of the nursing departments is in contrast with the demand from the emergency department.

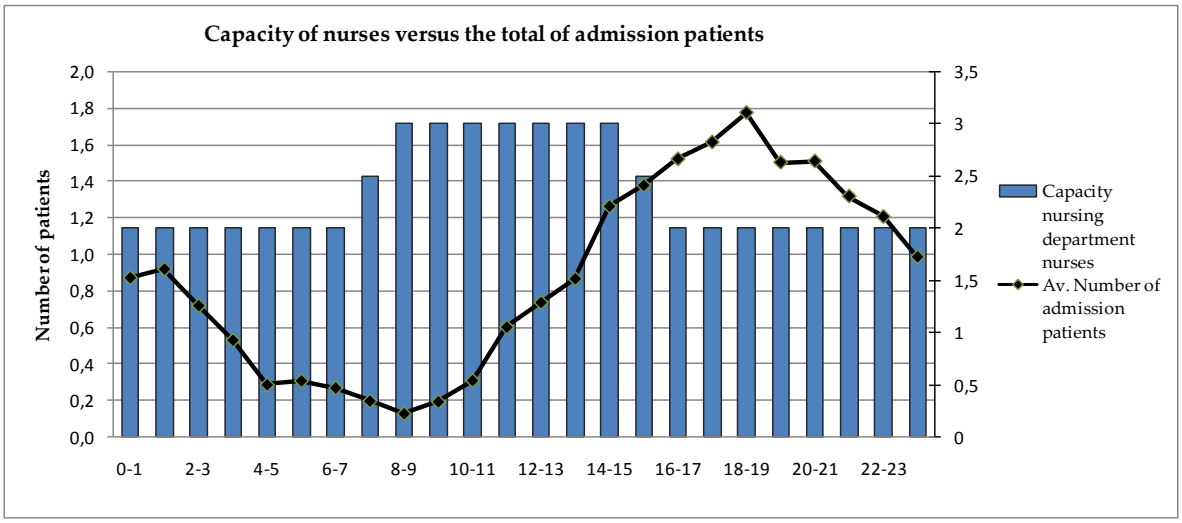


Figure 24: Admission of emergency patients most during evening shifts of nursing departments (*Eridanos*, 2008)

Radiology modalities

For the Bucky-room in the ED, two technicians are assigned to perform x-rays of patients in the waiting room, patient rooms and for the outpatient plaster room.

For an echo or CT the patient has to visit the radiology department where specialized technicians work on their normal (outpatients and inpatients) program. The management of the ED expects that the access times for an echo or CT for normal ED-patients are quiet high. The manual measurements show that patients wait for on average 46 minutes for an echo (n=21, manual measurements) and for 29 minutes for a CT (n=7, manual measurements). Note that the number of these measurements is very low, so the generality is restricted. Despite these uncertain numbers, we conclude that the capacity of the echo and CT does not fit with the patient demanding this radiology modality.

In case of an **emergency**, a technician with (mobile) echo-equipment is on call for the trauma room and present within 15 minutes. The access to the CT-scan for emergency trauma patients is 15 minutes. During the night, two technicians (one of echo, one for CT) are on duty at home and have to be present in 15 minutes.

3.2.3 Resources: rooms

The ED exists of ten general patient rooms (room numbers 1 to 10 on the floor-plan Figure 25). Room 1 is equipped with instruments for children and has a painted wall, while room 3 is extra equipped with ENT-instruments. Rooms 7 and 8 are close to the nurse station and are meant for patients who need extra monitoring or care. Room 11 and 12 are the trauma rooms and equipped with an x-ray facility. In room 13 there are three small beds with a plaster room for fast track surgery (trauma) patients. If needed, this room can be transformed into an extra trauma room. In every room the nurses and

residents have access to a computer with the electronic patient record. Room 13 has three computers and an extra monitor for x-rays.

In the middle of the ED there is a nurse station. This room is equipped with three computers and has a digital control board with overview of all the rooms and the waiting room. This board shows the patients in each patient room, their complaints, and the colour of triage and the indication of specialty. It also gives information of the patients in the waiting room. The residents of general surgery and internal medicine, working in the ED, have their own workspace.

The Bucky-room in the ED is used for all x-ray examinations of emergency patients. Also patients from the outpatient plaster room in the hospital are referred to this facility.

The triage room, next to the waiting room, is used to give patients their urgency colour. This room is usually equipped with one nurse who performs the triage of walk-in patients.

Figure 25: Floor-plan of the emergency department. Purple = general patient room, red = trauma room, green = x-ray facilities, blue = nurse workstation, yellow = residents workstation, orange = triage room.

3.3 Processes and Activities

Work in the ED, appears as a linked sequence of activities that 'changes' input (undiagnosed patients) into output (diagnosed patients). Paragraph 3.1 shows the various in and outflow of patients for the ED. Paragraph 3.2 describes the main elements of the ED: recourses (staff and rooms) and control structure. This paragraph describes the various steps to actually 'change' the patient from input into output, by uncovering the main process within the black box of the ED from paragraph 2.1, Figure 5. It explains the activities that result in the current patient LOS.

Since we only have a basic overview of the input and output, first, section 3.3.1 explores the patient LOS, or the time a patient spend in the ED between arrival and departure. Section 3.3.2 gives a generic overview of four patient flows (steps between arrival and departure) that represents patient groups that follow the same path through the ED or have similar process sequences. Supplementary 3.3.3 explains the content of the activities that exists in these process flows and is a more in-depth description of the how the ED and staff actual organises work in the ED.

This whole paragraph shows durations of the activities within the process flows on the ED to support the analysis. Since the current information systems lack data on this activity-duration, we measured the duration with a 4-day manual measurement series. The goal of the manual measurements was to collect data on all activities in the ED and on the (waiting) time between one activity and the next. On 4 days in november 2008 all staff working on the ED had the responsibility to fill out papers for every patient. In total 283 patients visited the ED in those 4 days of who 261 patients were tracked (92%) with a measurement form (149 'normal' patients and 112 fast track patients). Note that not every measurement form was filled out completely or correct. This resulted in low n numbers for some activities.

3.3.1 System performance: patient length of stay

The system approach showed patient in- and outflow. The time from this enter to the departure of the patient is the total time a patient spend in the ED, also the patient length of stay (LOS). Without explaining what exactly happens in the ED, we are able to compare time of input with time of output in which the ED 'operates' on the patients with various activities. The problem statement of this research mentions long patient LOS in the ED and the absence of causes of this long patient LOS. This paragraph measures the current patient LOS, to gain insight into the differences of LOS between types of patients and the causes of long patient LOS. We divide the measure in four 'sub-measures', aside from the normal average LOS in 2008. We present the differences in patient LOS:

1. between admission and discharge patients;
2. between patients arriving on different days of the week; and
3. between patients arriving on different hours of the day
4. between patients admitted before and after 17:00

For the measures, we use the following formula, calculated from *Eridanos* (2009):

$$\textit{Time DEPARTURE.ED} - \textit{Time ENTER.ED}$$

Average patient LOS

The total time a general surgery patient spends in the ED is on average 2 hours and 12 minutes. Internal medicine patients have an average LOS of 3 hours and 33 minutes (*Eridanos,* 2009). Table 9 shows that the LOS for both general surgery and internal medicine patients increased in 2008. The table also gives the median and the standard deviation. The standard deviation shows the hours and minutes that +/- 34% of the patients that have a LOS less or more than the average. Note that the LOS for general surgery patients is medium variable, which means that the LOS is spread out over a large range of values (variability is 0,80). The patient LOS for internal medicine patients is less variable (0,34), which means that most of the patients have a total LOS between 2 hours and 5 hours.

The variability of all LOS average measures from 1 to 3 presented below are (almost) the same as the variability of the whole year 2008 (medium variability for general surgery (0,8) and low variability (0,4) for internal medicine).

	Number of patients and Length of Stay			
	G.Surgery		Internal Med.	
	2007	*2008*	*2007*	*2008*
N	16361	17925	4904	5404
Av. N a day	45,0	48,7	13,5	14,7
Stdev.	9,7	9,5	4,4	4,8
Mean	1:50	2:12	3:30	3:33
Median	1:29	1:48	3:23	3:24
Stdev	1:32	1:46	1:31	1:32

Table 9: Average number of patient visits and the length of stay for general surgery and internal medicine patients in 2007 and 2008. Calculated with *time DEPARTURE.ED – time ENTER.ED* (*Eridanos*, 2009)

1. *Difference in LOS between admission and discharge patients*

Figure 26 shows that the length of stay for admission patients is higher than for patients who are discharged. The difference between admission and discharge for general surgery patients is 1 hour and 18 minutes. For internal medicine patients this difference is 47 minutes. We conclude that one of the causes of the long patient LOS could be the problems within the activities in the ED for the admission of patients (although the differences for general surgery are more visible than for internal medicine patients). To understand why this higher LOS appears, paragraph 3.4 describes the activities for admission in more detail.

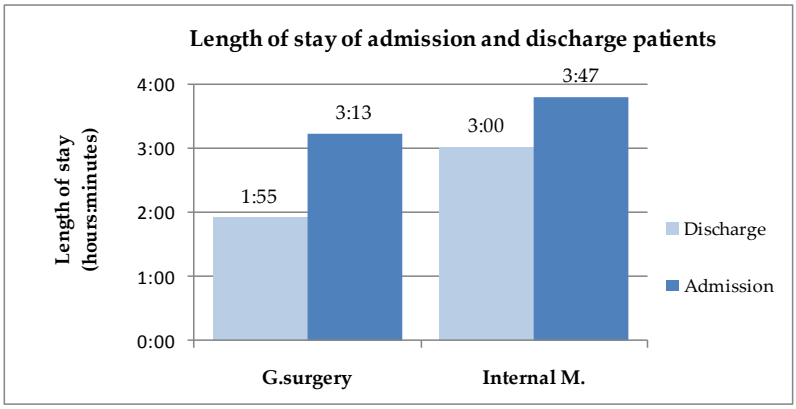


Figure 26: Length of stay for admission and discharge patients in the ED in 2008 (n=17925 for general surgery and n=5404 for internal medicine patients; Eridanos, 2009)

2. ***Difference in LOS between patients arriving on different days of the week***

Figure 27 and Figure 28 show the patient LOS for both care groups on different weekdays. A reason for a higher LOS on a weekday could be a higher number of patient visits. Therefore the figures compare the LOS with the number of patients.

On Thursday the patients for general surgery have a higher LOS than patients on other days, while the average number of patients is lower. An explanation for this could be the extensive surgery program on Thursday when most specialists (and older residents) are not available to discuss patients. For unknown reasons, the LOS for internal medicine patients is shorter on Tuesdays compared to other weekdays. More internal medicine patients visit the ED on a Friday than on a Monday, but still the LOS is higher on Monday. We cannot explain these differences, because as we show in 3.2 and 3.3 the activities and staff schedules in the ED are the same every day and there is no link between number of patients a day and LOS.

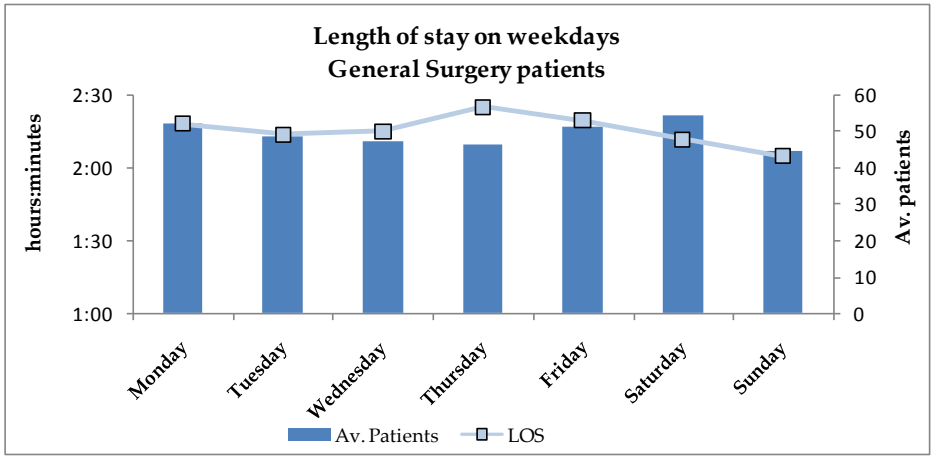


Figure 27: General Surgery patients: length of stay for every day of the week, 2008 (n=17925 for general surgery and n=5404 for internal medicine patients; Eridanos, 2009)

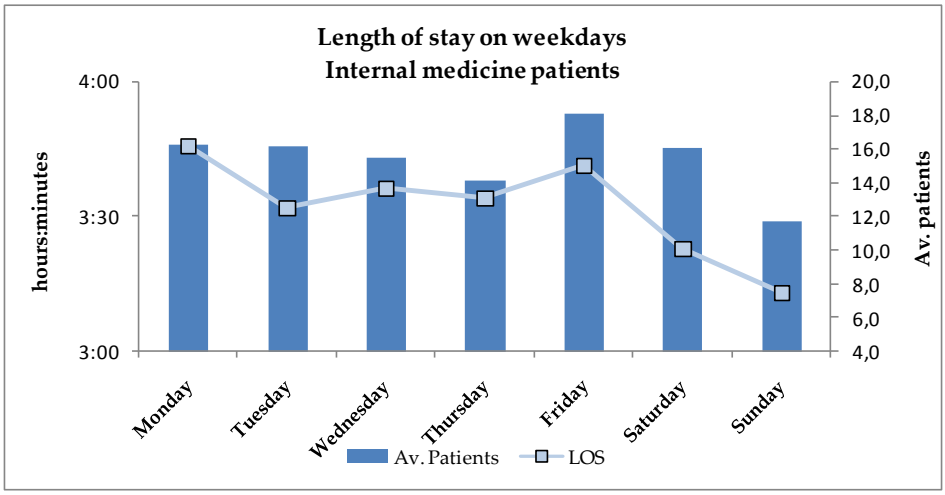


Figure 28: Internal medicine patients: length of stay for every day of the week, 2008 (n=17925 for general surgery and n=5404 for internal medicine patients; Eridanos, 2009)

3. *Differences in LOS between patients arriving on different hours of the day*

Figure 29 shows the length of stay between 8:00 and 22:00. The average length of stay of patients remains almost the same for every arrival hour.

The LOS of internal medicine patients between 00:00 and 06:00 is below the three hours. After 06:00 the LOS increases to an LOS of 3 hours and 40 minutes at 08:00. For general surgery the average LOS between 0:00 and 06:00 is also lower (1 hour and 50 minutes). A possible reason for (small) differences in LOS every hour is the influence of numbers of arrivals of patients in the ED. For hours with a high number of patient arrivals (13:00 for internal medicine) the LOS is the highest of the day, but we cannot generalise this statement, since the correlation between general surgery patients and residents is not visible. We assume that the average number of patients per hour is not the only factor that influences the patient LOS. Another possible explanation why LOS changes every hour is the number of residents on a shift. We present the staff schedules in paragraph 3.2 and combine the data in the conclusion.

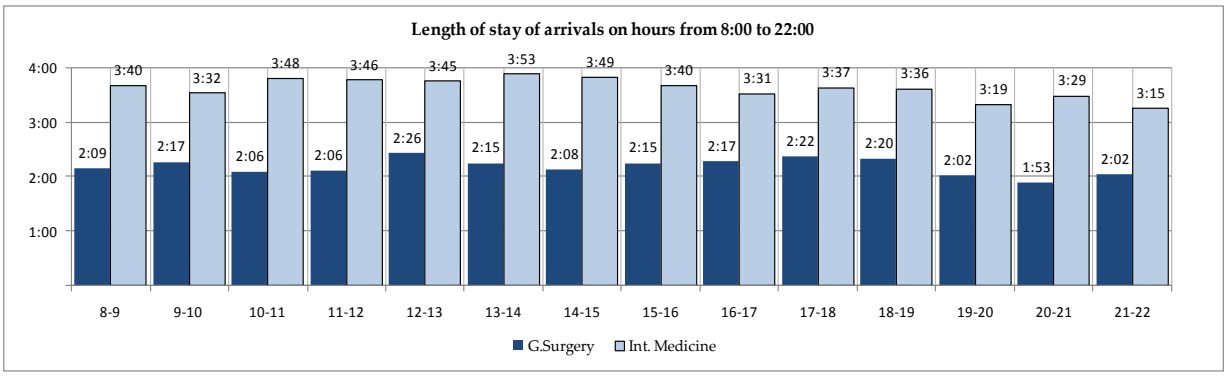


Figure 29: Length of stay for every hour of the day, 2008 (Eridanos, 2009)

4. *Difference in LOS between patients admitted before and after 17:00*

The arrivals of patients on every hour of the day did not show obvious differences in LOS. Since we showed in Figure 16 that most patients are admitted in the evening from 17:00 to late in the evening, we present the average LOS of these admission patients in this measure. Figure 30 shows that general

surgery patients admitted in the evening spend on average 31 minutes more time in the ED than patients admitted during the night and daytime. For internal medicine patients this is even 54 minutes more. When reducing the LOS of admission patients, it is possible to focus on the differences on the ED before and after 17:00.

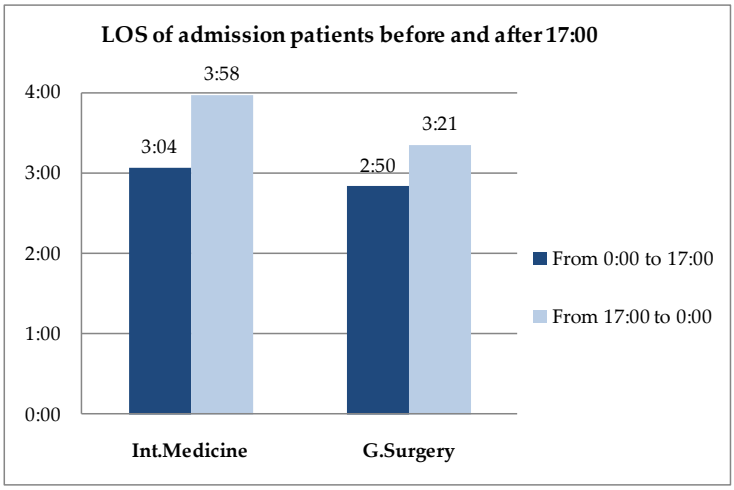


Figure 30: Length of stay in 2008 for patients admitted before and after 17:00 (n= 3789 admissions for general surgery and n=3766 admissions for internal medicine; Eridanos, 2009)

3.3.2 Process based patient flows

In the previous paragraph we discuss the patient LOS and this paragraph explores the activities that contribute to these LOS. If we follow incoming patients in the ED, we see that all patients somehow follow the same path through the ED. Figure 31 shows this path that describes the activities mainly from a patient's perspective.

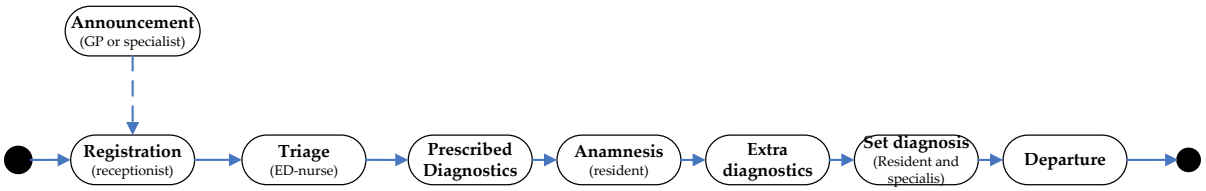


Figure 31: Process on the ED from a patient's perspective

Although these general activities apply for every patient, the steps between every activity and the time from one to the next differ, due to for example the decisions of the resident and/or specialist or the seriousness of the complaint of a patient. To get an overview of the variable routings of patients, we structure the many possible flows of a patient through the ED. We use the suggestion of Walley from paragraph 2.2.4 to split patients in groups with similar process sequence. Applied to the ED we define four process based flows with patients that have the same sequence and utilisation of activities. We present these four patient flows below, describe their path and accentuate the flow with figures.

The straight line in the figures connects activities of which the patient is aware of, while the dotted line represents the work of the resident or nurse of which the patient is not explicitly aware of, but is important within the explanation of the process. The minutes within the circular form are averages of

these activities. We elaborate on the variability's and explanation of these activities further down in 3.3.3.

First, the beginning is the same for all patients (if they are not entering the ED with an ambulance) (Figure 32). After registration, the patients take place in the waiting room and wait for a triage-nurse to perform triage. The coordinator-nurse places patients that arrive with an ambulance immediately in a patient room were another nurse performs triage on the patient.

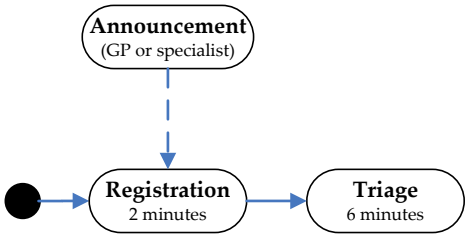


Figure 32: Beginning of the process in the ED (observations and manual measurements, 2008)

The following describe the four process based patient flows after triage until departure (discharge or admission).

1. *Patients receiving minor treatment (fast track)*:

These patients have a minor complaint (mostly fracture or scratches) and are helped in the ED in some kind of fast track circuit (62% of all general surgery patients). The receptionist recognises this patient as a fast track surgery patient and marks this by putting the patient in the waiting room for room 13 on the digital board. For most of these patients an x-ray is needed to confirm a fracture. Most of the time, the triage-nurse requests the first x-ray (on paper) and gives it to the x-ray technicians in the ED. The patient waits in the waiting room for an x-ray technician, who is ready to perform the x-ray. Afterwards, the patient returns to the waiting room. If there is a bed available in room 13 (total of three beds), the nurse assigned to this room calls the patient out of the waiting room. Preferable there is one or more general surgery residents assigned to this room. **The total patient LOS for these fast track patients is around 1 hour and 25 minutes and 1 hour and 33 minutes** (EPR, *Eridanos*, 2009 and manual measurements, 2008). Figure 33 and Figure 34 show the durations and process sequence of these types of patients. Note that, for example, the time from end of triage to enter room 13 is on average 21 minutes, but has a variability of 1,44. This means that also in many situations, patients wait for 50 minutes after triage before they enter the room (n= 66, manual measurements, 2008).

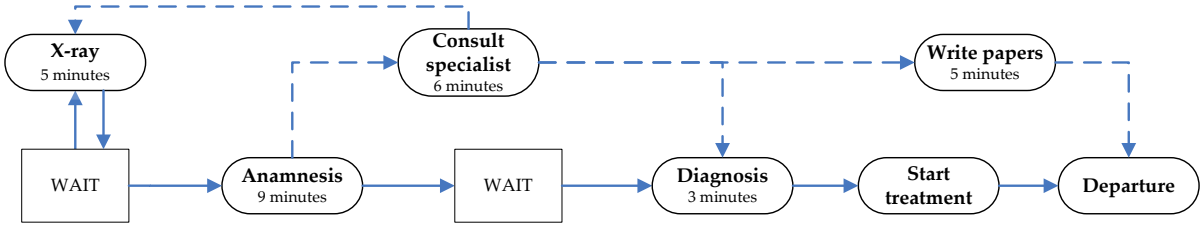


Figure 33: Process sequence for patients receiving minor treatment (observations and manual measurements, 2008)

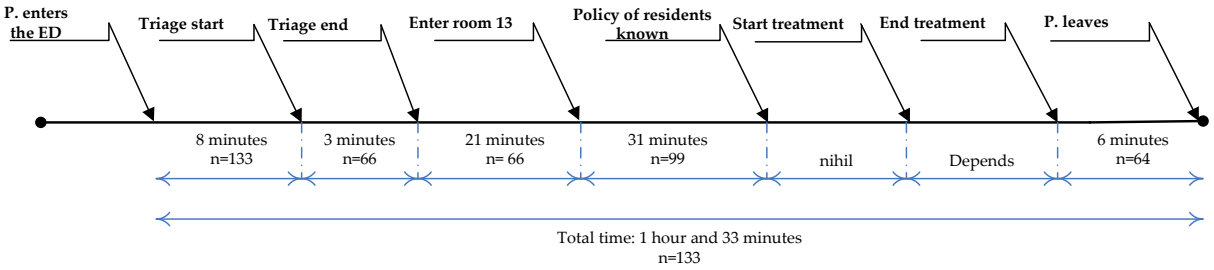


Figure 34: Time between separate actions within the process sequence of type 1 patients, entering room 13 for fast track surgery (manual measurements, 2008)

2. Patients with a familiar complaint: Rapid requests, assessment, and discharge:

These types of patients are referral patients or patients with common complaints for whom the triage-nurse starts all diagnostics. After residents' anamnesis no extra diagnostics are needed and most of the time the patient is discharged. The LOS of these patients in the ED is not available.

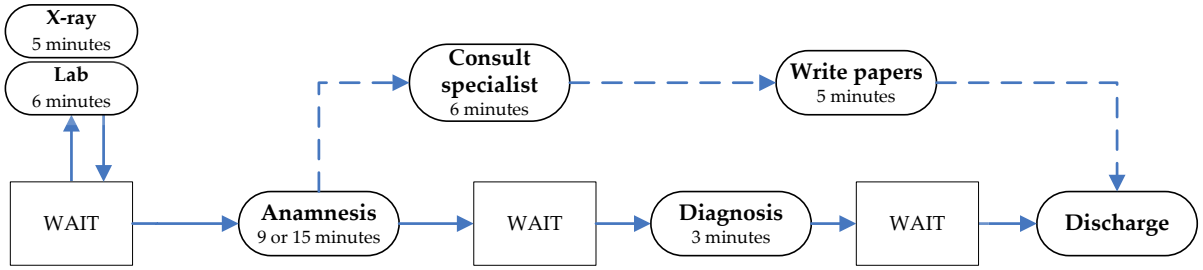


Figure 35: Process sequence: Rapid requests (observations and manual measurements, 2008)

3. Patients requiring multiple investigations (discharge or admission)

These patient types 3 have multiple complaints and when such a patient enters the ED, it is difficult to determine the process needs of these patients. After triage the nurse draws blood of a patient or receives faeces and/or requests an x-ray. The results of the tests and anamnesis of the resident determine if an extra diagnostic is needed. Most of the time these are complex patients where the resident has difficulties to set a diagnosis. For this patient the LOS in the ED is also not available.

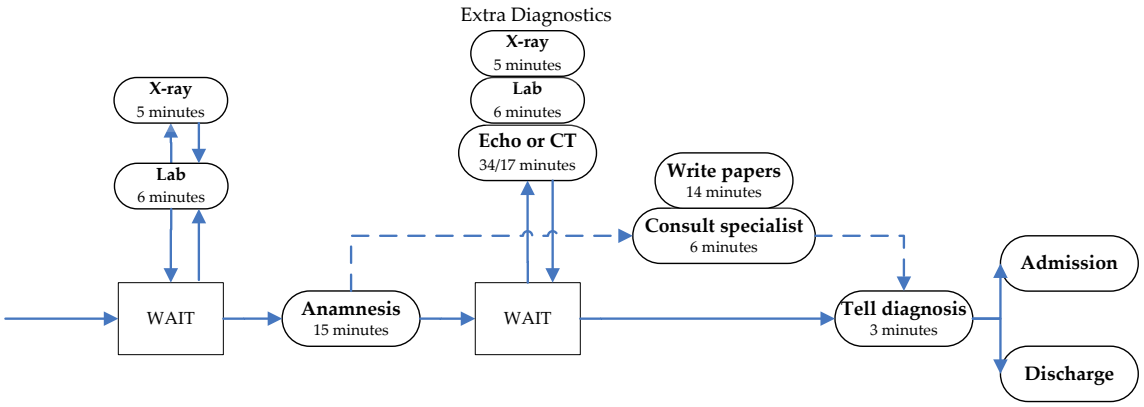


Figure 36: Process sequence for patients requiring multiple investigations (observations and manual measurements, 2008)

4. Emergency patients with major illness needing rapid admission, operation and/or intensive care bed
When the emergency office announces an acute emergency patient (1% of total patients), the resident of general surgery calls a traumatology surgeon and an anaesthesiologist. An emergency patient has immediate access to all facilities of the ED and specialists in the hospital. Nurses and residents perform triage and anamnesis at the same time. If it is needed, nurses take blood from the patient, an echo technician visits the patient immediately and an operation team is ready to operate the person. If the patient is stable the patient waits in the patient room of the ED to continue, else the patient leaves the ED immediately to go to an intensive care department or the operating room.

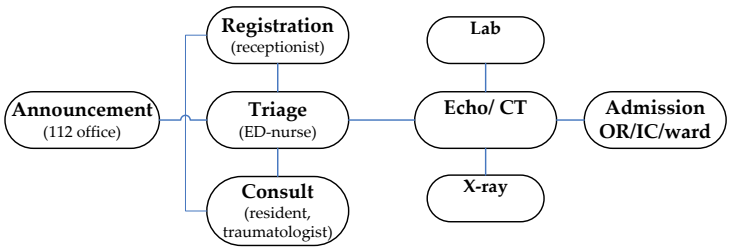
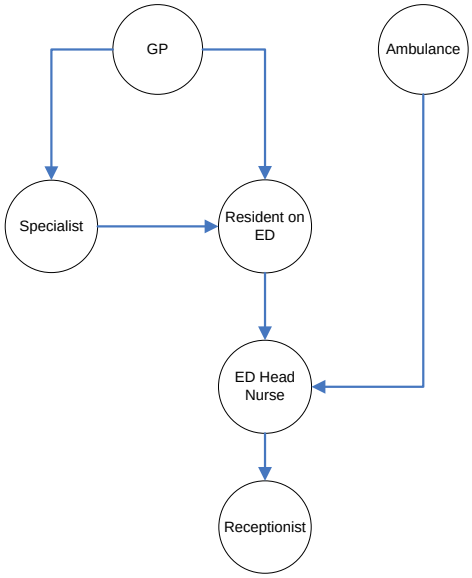


Figure 37: Process sequence for emergency patients (observations and manual measurements, 2008)

3.3.3 In-depth description of the activities

This paragraph further elaborates on the main activities on the patient's process and explains the duration of every activity of the process sequences. Figure 31 shows the structure of this paragraph with the steps from enter until departure. This paragraph discusses the following process steps and the associated activities including the durations of these steps. For an overview of a general activity sequence in the ED with the staff that performs these activities, we refer to Appendix B.

Announcement of a patient
Normally a patient with a GP or specialist referral or by ambulance is announced to the ED. This happens in three ways:



1. The GP calls the specialist (internal medicine or general surgery) were the patient already receives treatment. The specialist calls the resident on the ED with patient data and (diagnostic) requests.
2. The GP immediately calls the resident on the ED (patient had no previous hospital visit or specific specialist).
3. The emergency office of the ambulance announces an unexpected accident patient to a resident (emergency) or the coordinator nurse of the ED.

The staff that receives the phonecall with the announcement is also responsible for the correct communication, patient data, complaints and cause of

referral, of the patient to the coordinator nurse or receptionist.

Figure 38: Way of announcements of referral patients in the ED

Announcement papers are used to control the expected patients. On these papers the resident also prescribe any diagnostic request that can start during triage. Figure 38 shows the announcement structure.

Arrival registration

All patients, except for patients arriving with the ambulance, report at the reception desk. Walk-in patients register their name and birth date at the receptionist. The receptionist checks the patient data and papers, after which the patient takes place in the waiting room. If a patient arrives at the ED with the ambulance the nurse places this patient immediately in an available patient room. The receptionist enters the patient data in the triage system of the ED; onwards the digital board shows this patient in the waiting room for the ED.

Patients are diagnosed and treated by various specialties. When a patient is announced or reports at the desk, the receptionist attach this patient to the corresponding specialty on the digital board. The residents for general surgery and internal medicine work on the ED, but if patients needs medical help of another specialty (<9% of total arrivals, e.g. paediatrics and ENT medicine) the receptionist or coordinator-nurse calls the resident of that specialty.

Triage

Triage is the first activity performed on a patient. Triage is a process that involves a nurse who assesses a patient upon arrival in the ED and assigns the patient to a level of priority. With triage an ED-nurse is able to prioritise patients based on the severity of their condition. If the patient is in the waiting room, the triage nurse calls the patient to a special triage room, otherwise the nurse performs the triage in the patient room. During triage the nurse hears the complaints of the patients and follows a tree in the patient record to register the level of urgency. This urgency is determined on the pain level and severity of the complaints. There are five levels of urgency corresponding with different colours and times of waiting for a consult of the resident (red=immediately, orange = 10 minutes, yellow = 1 hour, green = 2 hours, blue = 4 hours). On average, the triage takes 6 minutes (n=133, manual measurements, 2008).

Prescribed diagnostics

After triage of the nurse, the patient returns to the waiting room or stays in the patient room. The following step in the process for the patient is to give blood or to visit the Bucky-room for an x-ray. Sometimes the nurse already takes blood during triage.

Notice that in normal hospital practice the first diagnostics starts after the visit of a resident. The reason that we mention the prescribed diagnostics in Figure 31 is that it corresponds to the actual work on the ED. For the GP and specialist referred patients, residents write down the first requests of diagnostics to carry out for the patient. These first diagnostics cover requests for laboratory or x-ray and sometimes an echo or CT. For walk-in patients (36% of all patients) the nurse is responsible for the

first contact and decides which diagnostics to request first, most of the time in consultation with a resident or requests no diagnostics.

The ED works with a standard laboratory form and the nurses are capable and have the experience to request this standard package for patients with a familiar complaint (most of them internal medicine patients). For patients with a visible fracture (20% of all patients are self referrals with fractures or minor injuries) in, for example the limb, the nurse has the knowledge to request an x-ray immediately, before the physical anamnesis of the resident. For other more difficult patients, the nurse sometimes calls a resident to ask which diagnostics to start. For the majority of the walk-in patients the first diagnostics start after the visit of a resident. In the ED no standard operating procedure exists for starting diagnostics during triage. The way the ED performs this kind of triage is more advanced than only assigning an urgency level to patients.

Laboratory

The ED works with a standard laboratory form that covers the most important tests. This 'one size fits all' package has a priority mark so laboratory technicians process these specimens of emergency patients prior to others from the hospital. The results (for blood and urine) should be available, digital in the patient record, between 40 and 60 minutes after receiving (standard procedures, Isala 2008). The triage nurse takes blood from the patient only when there are no other patients waiting, else blood is collected when a patient is assigned to a patient room in the ED or during his time in the waiting room. The collection of blood and sending to the lab have together an average duration of 6 minutes with a low variability (n= 32, manual measurements, 2008).

X-ray

The triage nurse gives the (paper) request for an x-ray immediately to the x-ray technicians. These technicians are assigned to the Bucky-room in the ED. Depending on the number of patients to help, the x-ray technicians call the patient from the waiting room. For these patients the x-ray process has an average duration of 4,2 minutes (n= 44, manual measurements, 2008). If the patient lies in a patient room the technicians come to take the patient (with bed) to the Bucky-room. This takes on average 8,9 minutes (n= 17 manual measurements, 2008). The duration also depends on the type of x-ray. After performing the x-ray, the picture is immediately visible in the electronic patient record (EPR).

Anamnesis and physical examination by the resident

When a resident visits the patient it depends on the type and arrival of the patient, if the results of previous diagnostics are available. The resident listens to the complaints and history of the patient and performs a physical and medical examination. This is called the anamnesis, which is the first actual contact of the patient with the resident. For some patients, the resident checks the patient record before the anamnesis in order to obtain some knowledge of the history and the performed diagnostics of a patient (if available). It is also possible that a co-assistant sees a patient first and reports the findings to the resident.

Residents of general surgery usually perform the anamnesis in 9 minutes (variability =0,65; n=57, manual measurements, 2008) and residents of internal medicine in 15 minutes (variability=0,43; n= 35, manual measurements, 2008). The variability of general surgery anamnesis is higher, probably

because of the different presentations of patients (small fractures versus appendicitis or hip fracture of elderly persons).

After anamnesis, the resident decides if extra diagnostics are needed for this patient or that a diagnosis can be made. It is also possible that a resident of another specialty needs to perform an anamnesis to attain an appropriate diagnosis.

Extra diagnostics

During anamnesis the resident can determine that more diagnostics are needed for an appropriate diagnosis. This can be requests for an echography (11% of the patients, 4-days of manual measurements, 2008), CT-scan (2,8% of the patients, manual measurements, 2008), ECG, an (extra) x-ray or a lab request. The nurse performs an ECG immediately, which takes no longer than 3 minutes. If the lab request is a supplementary of the standard lab form, no extra specimen is needed; otherwise the nurse collects a new specimen from the patient. For an x-ray, the technicians on the ED receive a request from the nurse and pick up the patient in the patient room. For an echo and CT the resident calls the radiology department and requests an examination for the patient. For these examinations the patient leaves the ED temporarily. This is on average 36 minutes (n=21, manual measurements) for an echo and 22 minutes for a CT (n=6, manual measurements). Since the walking distances of the radiology department is 5 minutes, the actual durations of both diagnostics is 10 minutes less (Table 10). Because of the limitation of the manual measurements, the n-value of the echo and CT examinations is low. This restricts the generality of the data and blurs the outcome of the percentages of the patients needing an echo and CT.

	Modality	
	Echo	CT
n	21	6
treatment duration	26 minutes	12 minutes

Table 10: Examination durations of CT and echo examinations (manual measurements, 2008)

Set diagnosis by resident and specialist

To determine the diagnosis of a patient, the resident needs the results of all tests and consults his specialist to get help or approval (average time of 6 minutes, n= 30 manual measurements). In case of discharge he writes the diagnosis in a letter for the GP. A different set of papers have to be filled out for admission patients, which usually takes more time. Admission papers take on average 14 minutes (n=39, manual measurements, 2008), while papers for discharge take only 5 minutes to finish (n= 28, manual measurements, 2008).

Departure

After the resident finishes the paperwork and communicates the policy to the nurse, the patient can either be sent home or admitted in the hospital. The resident visits the patient (average 3 minutes, n= 92, manual measurements) to tell this policy and in case of discharge gives the discharge papers for the GP immediately. The patient leaves the department or can make an appointment at the ED-desk for e.g. an outpatient clinic or the plaster room.

Admission activities

Since the patient LOS of admitted patients is higher than for discharge patients, this section gives a detailed description of the various activities of admission to actual transfer of the patient. The admission process starts with the decision of the resident and specialist to admit a patient. The resident communicates the decision to the nurse, who informs the receptionist with the patient data and admission diagnosis. He/she contacts the admission office to arrange a bed in a ward for this patient. The admission office arranges a bed in one of the wards and calls back to the receptionist, who informs the ED-nurse. If the patient is ready for transfer, the ED-nurse calls the ward, to come and get the patient. The total lead time of the admission process is on average 75 minutes (manual measurements, 2008). This average is the added sum of the individual averages and has a high variability, influenced by the various steps with variable durations.

Figure 39 shows the results of the manual measurements. Due to communication, it takes 10 minutes to call to the admission office to arrange a bed for a patient. After bed-assignment, the patients spends another 56 minutes (high variability) in the ED. The resident delivers the papers within this time and the nurse finishes the patient. We conclude that it takes longer to actually transfer the patient to the wards than from deciding to bed assignment.

To increase the validity of the measurements a seperate admission form had to be filled out by the nurses and receptionist so that they could maintain they normal work. The ED admitted 100 patients in 4 days of which 83 were tracked (83%).

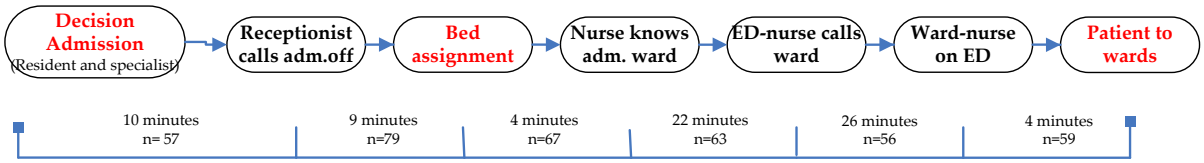


Figure 39: *Admission:* Start: resident determines diagnosis. End: Patient leaves the ED (*manual measurements* and *Eridanos*, 2008)

3.4 Evaluation of the ED

The first three paragraphs of this chapter analysed the ED with a system perspective, described inflow, outflow, the resources and control structures, the current patient LOS and the main process with the activities. They provide an extensive in-depth view of all the components and processes of the ED as a system. In this paragraph we make a giant step back and determine what actually happens. What is important for the patient? Do these activities add value for the patient and where do waiting lists appear?

In chapter 2 we introduced lean management, capacity management and the theory of Walley (2006) as tools to evaluate processes and explore inefficiencies in the process. In this paragraph we use this literature to explore the inefficiencies in the ED to be able to suggest interventions in the next chapter and answer the third research question. First paragraph 3.4.1 uses lean management to distinguish value and non-value added activities from a patient perspective. Paragraph 3.4.2 gives an analysis with the theory of capacity management. It explores the fit between capacity and demand in the ED and uses the variability of the inflow. Paragraph 3.4.3 overviews specifically the process in the ED with the theory of Wally (2006).

3.4.1 Analysis with lean management

If we approach the ED with lean management we need to discover value and non-value added activities (waste). To determine whether an activity adds value or not we keep the seven *Muda* of lean management in mind (transportation, inventory, motion, waiting, overproduction, over processing and defects). Exploring waste activities gives an indication where in the process is room for improvement that could be 'eliminated' to suggest interventions and reduce the patient LOS. This paragraph starts with a division of the patient LOS in three time slots, to be able to categorise the gaps of activities and waiting for a patient.

Time-slots

Figure 40 gives a first division of the averages of the patient length of stay for patients of both specialties. Aside from the time of enter and departure, the EPR measures only two moments in time of the patient's path in the ED that restricts the division in 'only' three time slots: the start-time of triage and the time of enter of the resident in a patient room (*Eridanos*, 2009).

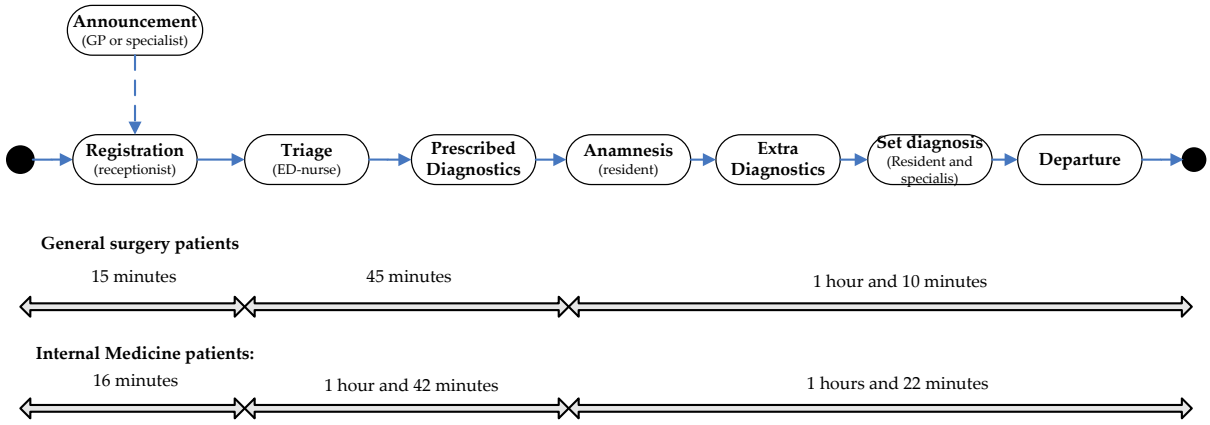


Figure 40: General division of Patient length of stay for both specialties (g. Surgery: n=9601; Internal M: n= 2988 Eridanos, 2009)

Looking at the time slots and the duration of the activities (paragraph 3.3) within these time-slots we conclude that the sum of all durations does not correspond with the high averages at the time slots. What happens between the activities? In addition we do not know if these activities add value for the patient. Since all three time-slots show more time spend than activities within the time slot, we discuss the waste activities in all three following categories:

- **Waiting for a resident**
- **The residents' process**
- **Triage activity and waiting**

We add a fourth category, admission, since admission is part of the last time slot and has higher LOS than discharge, 3.3.1)

- **Admission**

Waiting for a resident

The total time between triage and anamnesis is highly variable. In periods of low patient arrival and a low number of patients in the ED, the resident visits the patient more rapidly than in busy periods. Another factor that influences the time of resident anamnesis is the urgency colour; patients with colour orange expect to see a resident sooner than patients with colour green. On average the time between triage and anamnesis is **45 minutes for general surgery** patients and **1 hour and 42 minutes for internal medicine** patients (Figure 40). We consider the time of 1 hour and 42 minutes for internal medicine patients as extremely long, since most of the patients (urgency colour yellow, 62%) need to see a resident within 1 hour.

In all of the four introduced process based patient flows (3.3.2) the activities before the anamnesis are limited to only x-ray or lab requests. These possible value added activities have a duration of 3 and 6 minutes and are absolutely not related to the waiting time of 45 minutes and 102 minutes. This entire period the patient is waiting, which is a waste-activity.

The anamnesis itself is the most value added activity of the whole patient process. Patients enter the ED to see a doctor. In the current situation, internal medicine patients only see a resident after 2 hours!

Resident's process

The time from resident's anamnesis until the patient leaves the ED is 55% of the total time of a general surgery patient. Also it represents a long time-slot for internal medicine patients (41%). The variability of this time slot is really high (almost 1, 0 for both specialties). Every patient requires different health care, consults, diagnostics and admission or discharge. In this time-slot the resident works on the patients and a lot of activities are expected, but not all of them actually add value for the patient.

Indication of waste 1: result to action

The residents' anamnesis is the most important value added activity of the entire process of a patient in the ED. After this activity, the resident decides the next step for the patient, but this is variable per patient. The first actual waste visible in this process is the time between the result of a follow up diagnostic and the next decision for the patient. The manual measurements showed that residents work on another patient, so he/she is not able to immediately react on the result for a first patient. The time needed to come back to a (first) patients and decide for the next step, is difficult to quantify, but the manual measurements show some examples of which all times in between are waste (manual measurements, 2008):

- Laboratory result available at 16:55 and decision for an echo at 17:25
- Result of an echo at 21:00 and contact with specialist and resident at 21:25
- Laboratory result available at 12:05 and contact with specialist at 13:00
- X-ray available at 10:00 and request for extra lab at 11:00
- Contact specialist at 16:30 (diagnosis known!) and start finishing patient at 17:30

These times are indicated as a first waste indication within the resident's process. It increases the individual waiting times for patients.

Indication of waste 2: high number of patients

A reason for the resident that makes it difficult to return is that residents work for many patients at the same time. If we determine the work of the residents as one process, this has a cycle time (resp. 70 minutes and 82 minutes), a throughput (number of patients finished per hour) and a work in process level (total patients to work on). According to one of the seven *Muda*, all work-in-process and finished products are waste and reducing the WIP-level (with a same throughput) reduces the cycle time (Hopp & Spearman, 2000). Translated to the current situation in the ED, this means that the time a resident spends on activities of a first patient is waste for the second patient and should be reduced. A high WIP level is an indication for queuing of patients and is a second indication of waste within the residents' process. One of the reasons for this high WIP level is that it is difficult to keep track of patients to work on and the urge to first see a new patient instead of finishing an old one.

Indications of waste 3: difficulties for a resident

Aside from the first two indications of waste, the staff mentioned seven problems during the process mapping workshop why patients queuing times rises and long LOS after anamnesis happens:

- The resident waits for results of diagnostics
- The access times for echo or CT are relatively high, especially in the afternoon (manual measurements, 2008)
- Resident waits for anamnesis of a resident of other specialties
- Unavailable supervisors to discuss patients with
- Unexpected acute emergency patients
- Batching of patients to discuss with the supervisor

- Difficulties with communication between residents and nurses

All the above mentioned problems explore problems that contribute to a high patient LOS after the anamnesis. To give an example of one of these waste activities we quantify the problem of high access times for radiology modalities (2nd problem). The actual examination of Echo and CT are value added activities and the same holds for the other extra diagnostics possible (the x-ray and laboratory specimen). But noteworthy is the high access times between the request of an echo/CT and the actual begin of the examination (resp. 46 and 29 minutes, with n=21 and n=7). On average 21 minutes after the patient is back in the ED from an echo or CT, the resident receives a phone call of the radiologist with the results. The way to and from the radiology department is 'unnecessary' movement (motion) and is waste.
Concluded we state that still after the anamnesis of a resident the patient enters separate queues with an unspecified waiting time. Because a resident works with a high work in process and have difficulties to return to patients they started with, the individual patient LOS increases unnecessarily.

Triage
On average patients wait for 15 minutes until the nurse starts the triage. During the process mapping workshops, the following problems were mentioned that increases the patient queuing times before triage or of triage itself (process workshop, 2008):

- When more than *n* patients arrive in 30 minutes, the triage-nurse cannot perform triage within 5 minutes after arrival. This problem is confirmed by the manual measurements, where some patients have high access times of triage (15, 30 and 35 minutes, n=23).
- It is important to drain blood from a patient at an early stage, but this is not possible within the maximum time of triage. When and who has to drain blood? This sometimes increases waiting time of other patients.
- The triage-nurse is uncertain about which diagnostics to begin with, so the time of triage exceeds the maximum of 5 minutes.
- Triage nurses sometimes ask more information of the patient than only the needed information for a triage colour.
- The nurse waits for triage to start upon the receptionist has the papers ready.

Aside from the outcome of the process workshops about of the content of triage, Walley (2003) claims that current triage systems create additional problems in the ED and mentions three reasons why the ED should not segment patients according to their complaint and urgency. Two of these reasons are relevant for our triage discussion. First, the current triage systems uses valuable resources in what is a non-value adding task from a manufacturing perspective. With this he means that capacity (rooms and nurses) are needed during triage, while a resident asks all information of the patient again. This is a non-value added activity. Second, the allocation of priorities beyond a simple "urgent" and "non-urgent" categorisation disrupts the flow of minor patients through the system. According to Walley, triage systems are not effective in use and not to perform triage at all. In 3.1.2 we presented that on average 30 patients a day of general surgery patients received a colour green (60%) and 9 internal medicine patients (62%) has a yellow colour. How deals a resident with these high percentages and what does it add for the patients? And if a patient receives a colour green, what does this colour adds for this patient? There is almost always a patient with a more urgent colour in the ED and after delaying the anamnesis of the 'green' patient, the patient becomes urgent himself.

Currently the ED works with a standard laboratory package. After anamnesis the resident sometimes requests an additional test that is too specific to fit within the standard package (figures of the percentage of additional test for lab is not a reliable outcome of the manual measurements). This raises questions on the effectiveness of the standard laboratory package and the effectiveness of triage. How efficient is triage with standard lab packages if the initial requests do not cover all needs?

From these discussions we conclude that triage **only partly add value** for a patient. This gives room for improvements to make triage more effectively.

Admission

As we describe in paragraph 3.3.1, admission patients have an (extremely) higher patient LOS than discharge patients (78 minutes for general surgery patient and 47 minutes for internal medicine patients). One of the causes of this higher LOS is because of the LOS after 17:00; patients admitted after 17:00 spend 31 and 54 minutes more in the ED (resp. general surgery and internal medicine) than patients admitted between 0:00 to 17:00.

Paragraph 3.3.3 provided a closer look at the various steps within the ED to actually admit a patient. The decision to admit a patient is a decision of both specialist and resident and is taken after all the results and anamnesis. After the decision to admit a patient no actual value added activities are performed in the ED. The only effort the ED can make to improve the admission process is to reduce the time from decision to announcement at the admission office, which is 'only' 19 minutes on average (n= 57, manual measurements). The activity steps in the ED before or after 17:00 do not change, so we expect we can find a reason for this difference outside the ED.

We conclude that the decision to admit a patient is taken almost at the end of the process, which is late. After this decision, there are various steps that nurses and residents do and all of these steps are waste activities, since it are mainly administrative actions (waiting for the patient) or movements. The only value added activity within this process is the finalisation of the admission papers and the preparation of the patient for the admission in the hospital. Sometimes the nurse already starts the beginning of the treatment (medicines) (process mapping, 2008)

Concluded we say that a long patient LOS is caused and influenced by the late decision to admit a patient, partly because it depends on the late decision of the residents and partly the long LOS is influenced by problems after bed-assignment. Focussing on admission we conclude that the most room for improvement in the process is after bed assignment. We noticed that the capacity of ward-nurses does not correspond to the admission of patients (demand for the wards).

Conclusion lean management

Approaching the ED with lean management we define four waste activities that signify improvement possibilities. With these waste activities we define suggestions for improvement in the next chapter.

The ideas of lean management are also used in the process mapping workshops and helped to identify problems that deteriorates the length of stay of the patients. These problems led to a number of improvement projects that specifically try to eliminate waste, explained in paragraph 4.7.

3.4.2 Analysis with capacity management

Capacity management mentioned that variability in demand degrades the performance of a system (LOS in the ED) and the use of capacity to cope with this variability. In the ED, the inflow of variability is low when we analyse the arrivals on a daily and weekly basis, but medium when we analyse the inflow on various hours of the day. This higher variability can be tackled with the mobilisation of resources (staff) on various hours of the ED. The ED uses the same schedules for all days of the week and differ the numbers of nurses and residents throughout the day, which corresponds with the variability theory.

To check if these staff are correctly available during the day, the available capacity in the ED should fit patient demand in order to prevent queuing of patients (increase of LOS) or overcapacity (e.g. expensive costs for staff) (paragraph 2.2.2). According to the working schedules and inflow of patients, we conclude the following:

- The availability of nurses seems to fit the arrival and departure of patients, assuming that nurses have the highest workload in begin and end of the patient's process.
- The capacity of the residents of both care groups does not correspond with the demand of incoming patients:
    - The residents of both care groups leave the ED for their carry over hour around 16:30. This chapter shows that the demand of patients at that time is highest of the day. For general surgery this is even worse, since the peak of arriving patients a day is between 16:00 and 17:00.
    - The arrival of internal medicine patients increases rapidly from 0,2 to 3,8 patients between 10:00 and 13:00. A second internal medicine resident is only added to the ED at 13:00 when this resident first should catch up with the patients arriving between 10:00 and 13:00 before he/she can start seeing patients of 13:00.
    - The capacity of the nurses in the wards does not correspond with the demand of admission patients from the ED. Most patients are admitted between 18:00 and 19:00, so there is a high demand during the evening shift of the ward-nurses and a low demand during the day-shift.
    - The availability of the echo and CT does not fit with the demand from the ED, with exception for severe emergency patients.

3.4.3 Analysis with a system and process oriented approach

Analysis of the system

If we approach the ED with the system view, introduced in paragraph 2.1, then we notice a relatively high percentage of specialist referrals and a high percentage of admission patients for the internal medicine specialty. Second, we notice a split of authority with a medical line and a hospital management line.

Specialist referrals account for 12% of all patients, who enter the hospital with an outpatient appointment or are under medical attention of a specialist. Also patients who have complaints but just left the hospital after surgery or had an overnight stay are specialist referrals. These outpatient patients end up in the ED were they follow the same path as others (start with triage et cetera) and finish in the queue on the ED, which increases the work for the residents and the waiting times of all

patients. The residents perform an anamnesis (just as the specialist) and requests diagnostics afterwards, while the specialist has the knowledge and treatment history of this patient. A lot of this history and treatment gets lost between specialist and the ED (resident). We do not consider the specialist referral patients as destined for the ED. These patients use capacity (beds, residents, nurses) of the ED which is not necessary and they are referred because the hospital is unable to manage in a different way with these patients. The high admission rate of admission of internal medicine patients could be a consequence of these (most of the time) severe emergency patients.

The split in authority on the ED implicates a possibility of conflict when decisions about the ED need to be made. The nurses are part of the ED, while the residents work for other departments of the hospital, although the residents make the most important decisions on the patient's medical process flow in the ED. When suggesting interventions for the problem of long LOS, we keep this framework in mind with its restrictions and possibilities.

Analysis of the process

Walley (2006) concludes with an idea to segment patients according to their process flow, instead to segment on urgency. The process flow implicates a manufacturing perspective of the activities in the ED. Paragraph 3.3.2 describes four possible flows, although the ED does not explicitly work with these flows. Looking at these flows, we conclude the following:

- The process of type 4 patients (severe emergency patients) is a line-organisation in which the resources of the ED immediately react on the demands of the patient.
- In contrast to type 4 patients, the flow through the process of the patients of type 2 and 3 heavily depends on the availability of the resources of the ED. There is no typical method how to deal with these patients (like with type 1 patients) and the demands of the patient are postponed to the time when staff is ready. These patients experience high waiting times in front of every activity (e.g. before a residents anamnesis or before admitted in the wards)
- Type 1 patients (all general surgery patients) are separated from other patients. The ED reserves a nurse and three beds. The LOS of these patients is shorter than other general surgery patients; they spend on average 1 hour and 30 minutes in the ED. According to this we conclude that well defined groups of patient with the same process needs (only an x-ray and short resident's anamnesis) could lead to improvements in patient LOS. The focus of both nurses and residents is on the needs of the patient and on the output (quick departure) of the process.

From this current analysis of the process based flows we conclude that, first; the ED does not work with these process flows, but with urgency colours. In spite of this structure, no organisation of the residents or nurses exists to divide them over these urgencies (e.g. the nurses can help patients of all colours). A consequence is that during periods of high peak demand and a full ED, nurses and residents can't find each other to transfer information. A second conclusion on work segments is that the work of nurses and residents cannot intertwine with each other; both work on 'their own island'; for their own part of the health care and for their own department.

A third conclusion is that the current work for patients of type 2 and 3 depends on the availability of rooms, nurses and residents they are being pushed through the process on the ED. Because the available staff is not able to help the needs of all patients at the same time and there is **no focus on the**

process outcomes, queues exist. After every activity in the ED, the patient joins a queue of a new activity with unspecified waiting time determined by the total number of patients demanding the activity and the available resources.

We conclude that according to Walley (2006) the ED contradicts a manufacturing approach and does not work from a process view. The focus on process outcomes instead of for example on urgency colours could be a possible improvement to improve the patient LOS for especially the minor patients.

3.5 Summary

We decided to look at the ED as a system, with input, output, resources, supporting structures and main processes and activities. Currently we presented a lot of insight analysis' and data to give a description of the ED. This paragraph presents the main conclusions from literature and analysis and answers the second research question: *How can the ED be described with a logistic perspective in terms of patient in- and outflow, resources, processes, activities and supporting processes, and what is the current patient LOS?*

Second, this paragraph summarises the information and concludes with an answer on the third research question: *Which parts of the process indicate the most room for improvement to reduce patient length of stay?* In the following chapter we suggest interventions that help to reduce the patient LOS.

- Figure 41 summarises the in and outflow of patients in the ED in 2008:

Total Patient Visits					
	General Surgery	Internal Medicine		General Surgery	Internal Medicine
Inflow in 2008			**Outflow in 2008**		
Referral method			**Average outflow**		
Specialist referral	12%		Percentage departure	79%	30%
Self referral	36%		Percentage admission	21%	70%
GP referral	51%		*Average Admission a day*	10,3	10,4
Average inflow			*10-90% between*	6 and 16	6 and 15
Average arrivals a day	48,9	14,7	**Admission on weekday and daily hour**		
10-90% boundary	37 and 61	9 and 21	Weekday with highest admission	Friday	Friday
Variability	0,20	0,32	*admission-rate*	11,3	12,3
Inflow on weekday and daily hour			Hour with highest admission	18:00 - 19:00	18:00 - 19:00
Weekday with highest arrival-rate	Saturday	Friday	*admission-rate*	0,96	0,82
arrival-rate	54	18			
Hour with highest arrival-rate	16:00 - 17:00	13:00 - 14:00			
arrival-rate	4,5	1,27			
Highest % of urgency colour	Green: 59%	Yellow: 62%			

Figure 41: The inflow and outflow of the ED

- The variability of inflow differs when we change the scope of the moment of arrival: The variability is low when we analyse the arrivals on a daily and weekly basis, but medium when we analyse the inflow on various hours of the day.
- During day-time, from 7:00 to 17:00, more patients (of both care groups) enter the ED than depart from the ED. This reflects in a pressure of increasing patient numbers with highest expected patient population at 16:00.

Planning and control structure and resources

- The resources of the ED are staff and patient rooms. Nurses and residents work in the ED to give various specialised health care to the incoming patients. Every day they work with the same schedules, but during the day the total number of these staff varies. Other resources connected with the ED receiving ED-patients are the radiology department and nursing wards.
- The planning and control structure that the ED uses to control the resources, process and activities is split in a hospital and medical authority line that makes decisions on separate

resources on the ED. When suggesting interventions for the problem of long patient LOS, we keep this framework in mind with its restrictions and possibilities.

Current patient LOS

- The length of stay for general surgery patients is on average 2 hours and 12 minutes with a medium variability of 0,80. For internal medicine patients the average LOS is 3 hours and 33 minutes with a lower variability of 0,34.
- Patients who need to be admitted in the hospital stay on average 1 hour and 18 minutes (general surgery) or 47 minutes (internal medicine) longer in the ED than discharge patients.
- When these patients are admitted after 17:00 they spend on average resp. 31 and 54 minutes more in the ED than patients admitted between 0:00 and 17:00.
- For general surgery the daily patient LOS during the day varies with only 9 minutes and the LOS for internal medicine patients varies with 22 minutes, with a peak of 3 hours and 53 minutes for patients that enter between 13:00 and 14:00.
- We cannot demonstrate that a higher number of patients results in a longer patient LOS. The Thursdays have on average fewer patients than Mondays, but the LOS is longer on a Thursday. We cannot explain the differences in LOS on the 7 weekdays.

Processes and Activities

- Undiagnosed patients enter the ED and diagnosed patients leave the ED. In between the ED executes activities on this patient: *arrival registration*, *triage*, *prescribed diagnostics*, *anamnesis*, *extra diagnostics*, *diagnosis* and *departure* (discharge or admission):

Figure 42: General sequence of process activities in the ED

- Although every patient follows the same activities, the sequence or routing of the patients and time between the steps are highly variable. Walley (2006) suggest to split patient arrivals into groups with similar process sequence. For the ED we defined four process based patient flows: *Patients receiving minor treatment (fast track)*; *2. Patients with a familiar complaint: Rapid requests, assessment, and discharge; 3. Patients requiring multiple investigations; 4. Emergency patients with major illness needing rapid admission, operation and/or intensive care bed*.

The following activities in the ED indicate the most room for improvement (research question 3, section 1.4):

The most inefficiency in the process is indicated in two places: first, in front of the resident or the resident's work and second, the long LOS and activities of admission patients. These are the two major causes of a long patient LOS in the ED and indicate the most room for improvement. Moreover, the capacity of residents does not fit the demand of their patients, and from a manufacturing perspective; triage does only partly add value for the patients and the processes contradict the manufacturing approach. These current practises influence the patient LOS negatively.

This leads to the overall conclusions for which chapter 4 describes suggestions for improvement:

1. The main reason for patients to visit the ED is that they want to see a resident or specialist. Currently general surgery patients spend on average 60 minutes and internal medicine patients 118 minutes in the ED before they see a resident, which is an indication for a large queue. This waiting adds no value for the patient in the current situation, since real value added activities before the anamnesis are only an x-ray or lab request. The residents do not only perform an anamnesis but also work on extra requests, writing papers, waiting for results that are **not** directly performed after each other. This leads to more 'waste' after the anamnesis. One reason is that residents work on many patients at the same time, so their work in process level is high. This deteriorates the patient LOS and the flow of patients through the process. The resident is the main bottleneck in the process and the throughput of residents determines the 'speed of the processes. **The intervention in paragraph 4.2 gives suggestions how to reduce the WIP level of residents to reduce the patient LOS after residents' anamnesis.** Various (small) improvement ideas to attack the problems within this process are carried out in the process improvement workshops and described in the intervention in **paragraph 4.7**.

The availability of residents (bottleneck) of both specialties does not match the demand of arrival patients in the ED. As a result waiting times of patients before an anamnesis increases rapidly. Capacity management stretches the idea that capacity should fit demand and Schuring and Van Der Wiel (2005) suggest to continuously assigning resources to the slowest obstacle (bottleneck) of the process or system. **In our suggestion in paragraph 4.2 we also give ideas how to optimally fit the demand of patients to reduce patient LOS.**

2. We see that admission patients have a higher LOS than discharge patients. After the admission decision, the patients spend on average (with high variability) another 70 minutes in the ED (manual measurements, 2008). All the extra activities for admission patients are waste-activities. Although there is a higher LOS for patients admitted after 17:00, the sequence of these waste activities is similar. If we look at the capacity of the nurses in the wards we see that the schedules do not correspond with the demand of admission patients from the ED. Most patients are admitted between 18:00 and 19:00, so there is a high demand during the evening shift of the ward-nurses and a low demand during the day-shift. This could influence the high LOS after 17:00. **The intervention in paragraph 4.3 gives suggestions to reduce admission patient LOS focuses on interventions to improve the bed- and nurse- capacity of inpatient wards and an earlier diagnosis of admission.**

3. The current triage systems uses valuable resources in what is a non-value adding task non-value added activity. The content of triage is unclear and the residents ask the same information during anamnesis as the nurse during triage. The urgency colours only disrupt the flow of minor patients through the ED, they have long LOS but receive e.g. less additional tests. **The intervention in paragraph 4.4 gives suggestions how to change triage in order that it adds more value for the patients (instead of only first analysis of acuteness).**

Aside from the main inefficiencies in the process, we see that the general process and way of working on the ED contradicts the manufacturing approach of dividing patients into process based flows. This deteriorates the patient LOS of minor patients and staff is not focussed on the demands of the patients

and the process outcomes. **Paragraph 4.5 starts with a small practical idea how to focus on process outcomes.**

From the philosophy to eliminate all waste in the process, the outcomes of the process workshops concluded that a lot of wasteful activities are presently taking place in the ED. **Paragraph 4.7 suggests improvement ideas to decrease waste. These are worked out in project plans following from the workshops.**

The access times for an echo or CT are high, but in 3.3.3 we explained that only 10% of all patients need an echo and only 3,8% a CT. We conclude that the access times for an echo or CT are high, but these radiology modalities are not the main bottleneck and cause for a long patient LOS, since only small patient numbers need an echo or CT. **However, we recommend to further analyse the opportunities for improving the access times of radiology in paragraph 6.2.**

- Figure 43 summarises the interventions that follow from the analysis of this chapter:

Category	Interventions	Paragraph
Residents	1. Reduce WIP level Improve track and tracing	4.2
Admission	Early announcement	4.3
Capacity	1. Change capacity residents 2. Capacity fits demand of admissions (beds and ward-nurses)	4.2 4.3
Triage	1. Advanced triage and improvement of announcement 2. Change nurse anamnesis	4.4
Process	Resident and nurse perform triage	4.5
Workshops	Improvement projects	4.6

Figure 43: Structure of chapter 4 according to the conclusion of the analysis in this chapter

4 Suggestions for improvement

4.1 Introduction

The previous chapter explored the structure and processes and activities of the ED. It analysed inefficiencies and concludes with the parts of the process that have room for improvement. In the chapter we suggest interventions to reduce patient LOS by attacking these inefficiencies. Figure 44 shows the inefficiency areas and gives the structure of this chapter. Aside from the four inefficiency areas, paragraph 4.7 gives interventions defined in the process improvement workshops. Every paragraph ends with a conclusion of the interventions within a timeframe and the organisational impact. We conclude in 4.8 with an overview of all suggested interventions gives two categorisation possibilities.

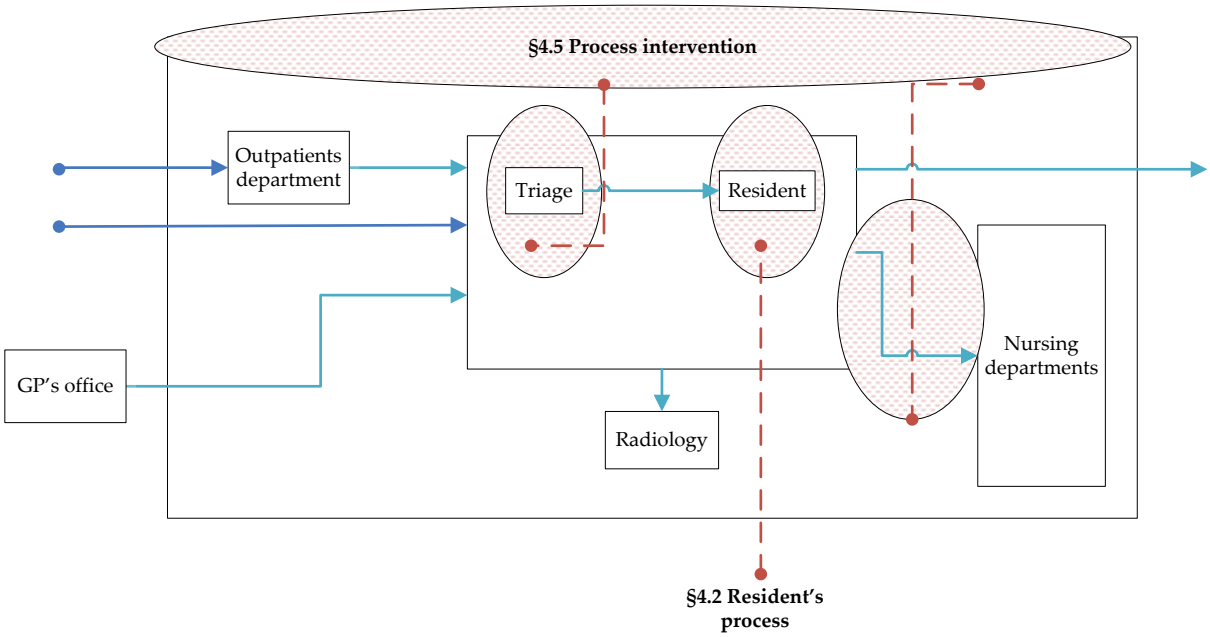


Figure 44: Overview of chapter 4 with the paragraphs that contain interventions to improve the main inefficiencies in the ED

4.2 Interventions for the resident's process

In chapter 3 we defined the work of the residents as a process with the most inefficiencies. This has three main reasons. First, residents work on many patients at the same time (high WIP) that leads to an increase in waiting time because the resident is not able to react immediately on incoming results. Second, on average patients wait 60 and 118 minutes (resp. general surgery and internal medicine) from entrance until they see a resident, which is too long. Third, the number of residents working in the ED during the day does not correspond with the demand of patients.

The first intervention (4.2.1) suggest to use Little's law (from 2.3.1) to reduce the patient LOS, explicitly for the part after resident anamnesis. The second intervention gives suggestions to change the schedule of residents to fit the patient demand in order to decrease the waiting time of a patient from enter to anamnesis (4.2.2).

4.2.1 Intervention A: Reduce patient in process

The resident's process has a cycle time, a throughput time and a work in process level. The resident's cycle time is the patient LOS after anamnesis (CT = WIP/TH). We suggest reducing the work in process level of residents, so reducing the number of patients that residents of one specialty work on. According to Little's law, a reduction of WIP results in a reduction of patient LOS. Since we determined that this process is the bottleneck process of the ED we know that reducing the length of stay of this process gives an overall reduction of the patient length of stay in the ED.

This intervention focuses especially on general surgery residents, since they have a high average number of patients a day. The internal medicine residents could follow the same example but it will probably result in less improvement.

Awareness of working method

For a translation of Little's law to our situation in the ED, we define the physical examination as a starting point and the determination of the diagnosis as the end of the process. The work in process is the total number of patients between the start and end points. If a resident examines five patients in a row, a total of five patients are work in process until the resident determines the diagnosis of one patient. If the resident first consults patient 1, then patient 2 and then patient 3, three patients are work in process. The resident can decide to start with patient 4, which increases the work in process to 4, but can also choose to first finish patient 1 before he start with the examination of patient 4. In this case, the work in process remains three patients (patient 2, 3 and 4) (Rosmulder, 2008).

The example above is an easy example, which can be applied to residents working in the fast track room 13. For these patients the LOS is on average 1 hour and 30 minutes (paragraph 3.3). The manual measurements show on average that 31 minutes after entrance the patient is in room 13 (n= 66, manual measurements, 2008). The resident works for a little less than 60 minutes on this patient, before this patient leaves the ED. We define this as the cycle time of the resident's process. It is difficult to determine the throughput of a resident, since it is not sure how many residents work on patients in room 13. During periods of high peak demand an extra resident helps in the room, while sometimes all residents work on other patients and room 13 is unmanned. We assume that every 15 minutes a patient leaves room 13 (manual measurements, 2008) and that on average one resident is assigned to the room. The TH is 4 per hour (CT= 1 hour and WIP = TH/CT) and we calculate the WIP as 4 patients.

Table 11 shows the expected current working method with a WIP level of 4. It shows an expected average waiting time of 35 minutes (also waste) and shows that 37% of all activities add value for the patient. Table 12 shows an improved working method which results in a reduction of the cycle- and waiting time of all patients. The waiting time of Patient 1 and Patient 2 reduces with 30 and 25 minutes. Moreover, the percentage of waste reduces for each individual patient. Also notice that the resident of method two only uses two beds, instead of four, so an improvement in the use of resources of 50%.

Current WIP level					
Time	**Patient 1**	**Patient 2**	**Patient 3**	**Patient 4**	
0-5	Anamn.	X	X	X	
5-10	Rontgen	Anamn.	X	X	
10-15	X	Rontgen	Anamn.	X	
15-20	X	X	Rontgen	Anamn.	
20-25	Besluit gips	X	X	Rontgen	
25-30	X	Besluit gips	X	X	
30-35	X	X	Besluit gips	X	
35-40	X	X	X	Besluit Ok	
40-45	X	X	X	Aanmelding OK	
45-50	Papieren	X	X	X	
50-55		Papieren	X	X	
55-60			Papieren	X	
60-65				Papieren	*Average*
Cycle Times	50 min.	55 min.	60 min.	65 min.	**57,5**
Waiting time	30 min.	35 min.	40 min.	40 min.	**37,5**
Value added activities	40%	36%	33%	38%	**37%**
					35%

Table 11: Possible current working method of residents

The process sequence through the ED for all fast-track patients is almost identical, so this reduced WIP method is easy to apply in theory; most of the time the patients only require one x-ray and a decision that can be made quickly. In the examples we use a standard of 5 minutes for every activity, but the actual duration changes during the day and depend on the specialist and resident. Although we simplified the work in room 13, we assume that changing the sequence to help patients offers opportunities to reduce the patient LOS.

WIP level decrease with 2 patients					
Time	**Patient 1**	**Patient 2**	**Patient 3**	**Patient 4**	
0-5	Anamn.	X	X	X	
5-10	Rontgen	Anamn.	X	X	
10-15	Besluit gips	Rontgen	X	X	
15-20	Papieren	X	X	X	
20-25		Besluit gips	X	X	
25-30		Papieren	X	X	
30-35			Anamn.	X	
35-40			Rontgen	Anamn.	
40-45			Besluit gips	Rontgen	
45-50			X	Besluit OK	
50-55			X	Aanmelding OK	
55-60			Papieren	X	
60-65				Papieren	*Average*
Cycle Times	20 min.	30 min.	60 min.	65 min.	**43,8**
Waiting time	0 min.	10 min.	40 min.	40 min.	**22,5**
Value added activities	100%	67%	33%	38%	**60%**
					49%

Table 12: Changed working method with WIP decrease

To summarise, the resident should first finish a patient, if possible, instead of starting anamnesis of a new patient. The work in process of the resident decreases and we expect a shorter LOS after anamnesis of a resident.

Reason for high WIP-levels

Before we describe the practical interventions to decrease the patient in process level and decrease length of stay, we first have to understand why residents work with a high WIP level. During the

process mapping workshops the staff gave aspects that influence the number of work-in-process of residents:

- Work on only one patient is inefficient, since results after diagnostics (e.g. lab requests) are not immediately at hand.
- The number of arrival patients is higher than the number of residents that help them.
- Working with a triage system encourage residents to assess new, non-urgent patients before they discharge patients who have been diagnosed and are waiting to go home (Walley, 2003). The residents feel the urge to continue to see new patients instead of finishing old patients.
- There are not enough incentives for the residents to decide to return to a patient when this is possible (they have to check if results are available or if a patient returned from an echo).
- Residents batch their patients in order to discuss with the supervisor (especially internal medicine residents). Supervisors discourage residents to discuss one patient at the time. Batches indicate a high number of patients that wait for a diagnosis (high WIP).
- Within the residents 'process' a lot of queues exist. Possible waiting queues are waiting for an echo, lab results and a consult of another specialty. Queues are an indication of high WIP.

Practical interventions to reduce patients in process

We suggest introducing this method by organising a lecture and a practical workshop. During this workshop the management can simulate a normal day with arriving patients at predefined times. The residents make decisions on which patients to help when and the workshop leaders show how the varied choices impact a patient's journey through the ED and the waiting time of others.

An implementation of the suggestion is difficult and mainly depends on the way of working and experience of the resident, but the ED can stimulate the method of working for residents:

- Currently the resident lacks overview in high demand periods so is unknown of results available. Implement a track and trace system that shows the patient's position in the process of the ED (as introduced by Hall, 2006). This digital board can show results that are available for patients, which is an incentive for the resident to return to patient. It could encourage the coordinator nurse to stimulate the resident to finish a patient.
- Prevent batching of patients, by making specialists aware of the negative impact on patient LOS. A prerequisite is a blame free culture.
- During the day, coordinate the release of patients to the ED. When a resident finishes one patient, another is able to enter a patient room. Another possibility for the coordinator nurse is to monitor the number of requests for diagnostics and the available results and accepts patients in a patient room if these are available. In this way, the coordinating nurse in the ED prevents the WIP level to exceed a predetermined quantity and stimulates the resident to first finish patients. The challenge is to achieve a WIP reduction without a loss in throughput (number of patients per hour) (Hopp and Spearman, 2000).
- Intensify the work protocol of the coordinating nurse. Divide nurses and maintain overview of processes (see also 4.7).
- Educate residents in this working method and the advantages (set up contacts with Amsterdam Medical Centre where they also want to teach residents).

4.2.2 Intervention B: Change residents' schedule

In chapter 3 we explain the gap in capacity of residents for certain hours of the day. We suggest to change the work schedule of residents to fit patient demand. The capacity interventions presented in this paragraph do not immediately involve the (internal) process in the ED, but can indirectly change the influence the performance of the ED. We expect that a better fit of residents reduces the time from enter to anamnesis.

Following Eklund (2008, 2.2.2) we can say that increasing the throughput of residents or the capacity (numbers) of residents decreases patient length of stay (Little's law, 2.3.1), by temporarily assign an extra resident. We use this idea to improve the fit between capacity and arrival numbers for every hour of the day. The residents work according to the schedules in paragraph 4.2.2, were Figure 22and Figure 23 showed some hours with room for improvement because the total capacity does not fit the number of patients in the ED. We suggest the following interventions:

- For internal medicine we suggest to assign a second resident to the ED already before 13:00. From 10:00 until 13:00 the arriving patients increases rapidly (from 0,2 to 3,8 patients on average). Paragraph 3.3.3 also shows that the patient LOS increases from an average patient LOS of 3 hours and 32 minutes for patients that enter between 8:00 and 9:00 in the morning, until 3 hours and 53 minutes for patients that enter between 13:00 and 14:00.
- The capacity of general surgery residents decreases at 16:00 while this is the hour when the most patients for this specialty are in the ED. This is also reflected in a longer patient LOS of general surgery patients that enter between 17:00 and 18:00 (2 hours and 22). We suggest maintaining one resident in the ED during the carry over and only decreasing the number of residents after 18:00. Another possibility is to assign a fourth resident to the ED around 14:00 or 15:00. The total numbers of patients in the ED decreases quicker with 4 than with 3 residents.
- We suggest to maintain flexibility of available residents. It is convenient to have a resident or specialist on call. In the current situation, only general surgery has residents on call. The flexibility of internal medicine residents is low. Internal medicine should increase its options to call an extra resident or specialist if the resident on the ED suffers of high patient demand.

4.2.3 Organisational impact

Both interventions impact the work of the residents in the ED the most (see Figure 45). We expect that improvements in patient LOS take place after residents' anamnesis.

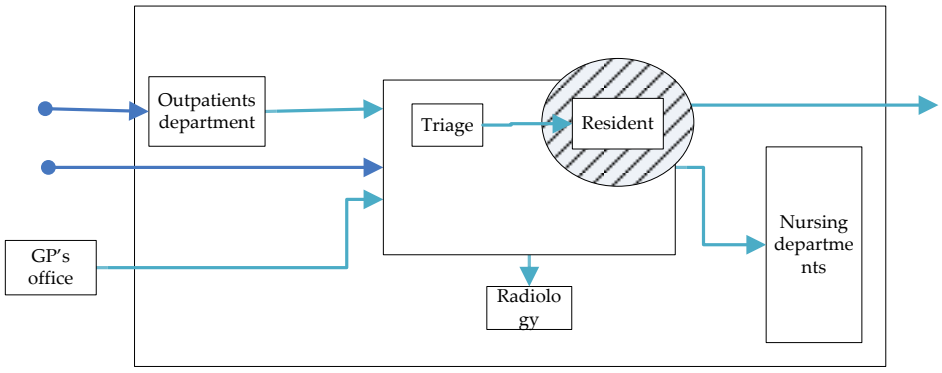


Figure 45: Area of organisational impact of the interventions in the ED

4.3 Admission process interventions

The longer LOS for admission patients is a second indication of inefficiency of the process in the ED. In chapter 3 we concluded that admission patients have a longer LOS in the ED than patients who are discharged; the activity steps of admission take place after the decision to admit, at the end of the process. We also concluded that patients admitted after 17:00 have longer LOS than patient admitted before 17:00. The process mapping revealed that the decision to admit a patient is (almost) at the end of the entire process in the ED. After that many activity steps by various actors have to be performed to get a patient in the wards of the hospital. Only few of these steps actually add value for the admission patient. Most of the time from decision to transfer to the wards is spend **after** the bed is assigned to a patient. Moreover we saw that the capacity of the ward-nurses does not fit the actual arrivals of patients.

This paragraph suggests two main interventions to improve the LOS of admission patients and improve patient flow from the ED to the wards. First, announce patients earlier in the process (4.3.1). Second, match capacity of beds and nurses to the number of admission patients (4.3.2). The hospital proposes to implement an observation unit to cope with the emergency admission flow from the ED. Within this research we cannot suggest this intervention, in Appendix C we elaborate on the advantages and disadvantages of an observation unit.

4.3.1 Intervention C: Early admission announcements

For this intervention we use literature of Coyle et al. (2003) who mentions early decision-making as an idea to reduce cycle times, so patient LOS. If the decision of admission could be taken earlier, the process of admission (all steps in the ED following to get a patient in the wards) are parallel to for example results of laboratory or writing admission papers. This leads to a reduction of the patient LOS. We suggest admitting patients in an early (earlier) phase of the process. The difficulty of this intervention is that the resident is not involved at an early stage so that the ED-nurse has to make the decision to announce and admission. The ED-nurse is not qualified to make the decision, so there has to be a certain accepted criterion on which the ED-nurse can base his/her decision.

Below we present a possible practical implementation of this intervention to benefit of early decision-making. Since 70% of all internal medicine patients are admitted in the wards, this intervention focuses on these patients. A suggestion is to announce all yellow, orange and red triage urgency patients of internal medicine for admission. Table 13 shows that internal medicine residents eventually admitted 76% of all yellow patients, 82% of all orange patients and 83% of all red patients in 2008 (Eridanos, 2009). If the ED had announced these patients during triage a total of 894 (800 + 89 + 5) or 2,4 patients a day (average) were announced unnecessarily. According to the admission offices and the involved internist, this is an acceptable amount. They understand that this is an average so there is a possibility that more announcements could be cancelled on a day.

Internal medicine patients in 2008				
Colour	**LOS**	**Total patients**	**Admissions**	**Percentage of adm.**
Blue	2:15	8	4	50%
Green	3:32	1451	775	53%
Yellow	3:39	3356	2556	76%
Orange	3:16	502	413	82%
Red	2:23	29	24	83%

Table 13: Percentage of admission patients a colour (n= 5346, *Eridanos*, 2009)

The triage nurse or coordinator-nurse announces a patient just after triage (yellow, orange and red). The admission office plans this patient at a ward and the nurses of these wards track the admission path of the patient with, for example, three slots: *uncertain-more certain-patient is certain*. The resident gives a first confirmation during or just after the anamnesis to the coordinator-nurse (more certain). If the resident discusses the diagnosis with the specialist, the actual decision to admit is confirmed or cancelled. At this time the ward-nurses sees the confirmation of the resident and expect to come and get the patient within 30 minutes.

An example: Patient enters the ED at 10:00 and receives a colour yellow at 10:15. The triage nurse contacts a resident and announces the admission to the receptionist. At the same time the office arranges a bed, the nurse draws blood from the patient, sends it to the lab and place the patient in a patient room. The office calls the ward with the announcement of the patient and the ED with the ward number. The ward-nurses have 45 minutes (arrangement of the hospital) to come and get the patient from the ED. In the meanwhile the resident visits the patient (at 11:00) and gives the code *more certain for admission*. The wards expect the patient. If results are available (11:20), the resident contacts the specialist and decides for admission at 11:30. The ward nurse can come and get the patient as soon as possible, since they already know the arrival of the patient. The patient will be prepared by the ED-nurses so the patient could leave quickly. If bed assignment takes longer, this has no influence on the patient LOS, since the resident still has to perform an anamnesis. ***A main discussion issue of this idea is that the final diagnosis of the patient is probably written after the patient left the ED***.

This intervention can be extended with the idea to finish a patient's diagnosis in the wards. The ward-nurses can take the patient if the diagnosis is not finished. The manual measurements show that the results of the requested diagnostics become available at different points in time, but the resident does not have to wait for all results and already sends the patient to the wards. A prerequisite of this suggestion is that the wards have an admission/examination room were the residents and nurses perform the diagnosis and anamneses in private. Moreover, the resident and nurses in the wards do not have to ask the patient history for a second time. They 'only' have to finalise the diagnosis and treatment.

We expect the following advantages:

- The process of admission is parallel to the normal process in the ED. Working in this way is more robust, since problems with bed-assignment do not deteriorate the patients LOS.
- The ward-nurses expect a patient from the ED with an amount of certainty. They are able to come and get a patient earlier from the ED than if they hear it the decision is made at the end of the process and still have 45 minutes.

- By transferring patients earlier to the wards, the ED creates more vacant beds for acute patients and the residents have time to see other patients. It improves the patient flow which results in a reduction of the patients LOS.
- Overall we expect a reduction of the LOS of admission patients and satisfaction of ward-nurses.
- The ED should practice if this reduction in LOS can justify the risk of over-announcements of patients.

And the following pitfalls:

- Since patients are announced and assigned early to a bed in a ward, it will get easier for specialists and residents to admit a patient. This can lead to over admission.
- Extra communication is required between the resident and nurses, ED and admission office and the admission office and the ward.
- Confirmation or cancellation of an announcement after anamnesis could be difficult for a resident.

4.3.2 Intervention D and E: Capacity fits demand of admissions

During observations and interviews we noticed that admission stops occur frequently and patients stay in the ED too long because of a lack of beds in the hospital. Sometimes the hospital transfers patients to inpatient departments that do not correspond to their specialty and complaints. These problems with bed-capacity could also lead to longer patient LOS on the ED. We discuss a possible solution, from the ED-analysis, for the hospital to cope with the problems of assigning a bed. The first intervention explains how many beds should be free for emergency patients.

Intervention D: Match bed capacity to admissions

During the manual measurement and interviews with staff of the ED and the admission office it became clear that the hospital suffers from difficulties of bed capacity and overcrowding or admission stops. These problems occur because of variability in the demand. If demand is stable, it would be easy to plan the right amount of beds. After the analysis in 4.1.2 we conclude that the variability of admissions per day from the ED is very low. Other admissions in the hospital are elective admissions. The next figures show the distributions of the elective admissions of 366 days in 2008 for general surgery and internal medicine. Comparing this variability to that of the emergency admissions (Table 14 and Table 14), we conclude that elective admissions have a higher variability than emergency admissions. This is contrary to the expectations of the hospital, since the elective admissions are 'planned' by an admission office.

For the data in the figures and tables we used data from the hospital information system (iZIS, 2009) which also provides emergency admissions. Note that these emergency admissions are higher than the numbers we presented in paragraph 4.1. This is because the hospital system does not divide emergency admissions between the outpatient departments and the emergency department.

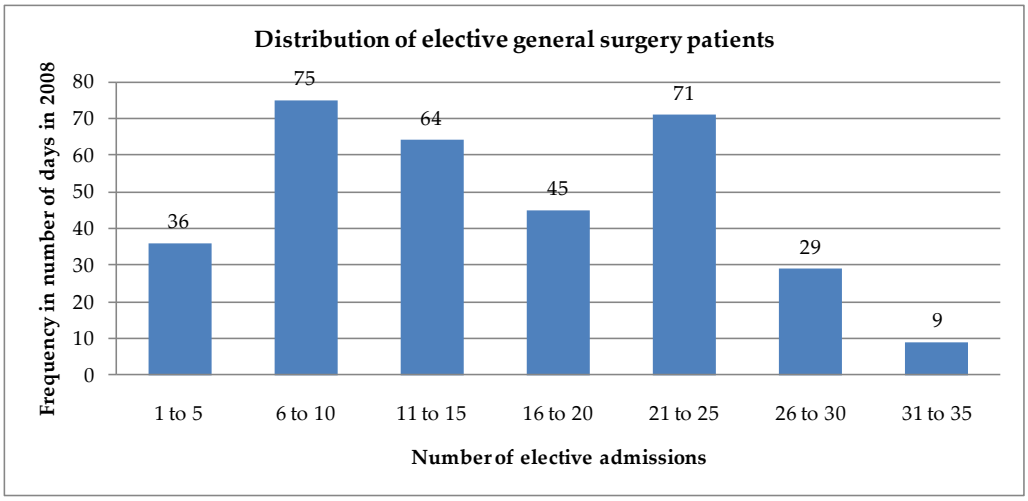


Figure 46: Number of days with x to y admissions for general surgery (iZIS, 2009). There were 64 days on which 11 to 15 patients were admitted in 2008 (this is 18% of the days).

	General Surgery admissions	
	Elective	Emergency
Total Admissions	4919	4538
Monday	22,9	13,3
Tuesday	21,6	13,5
Wednesday	16,8	13,2
Thursday	16,9	14,6
Friday	10,1	13,2
Saturday	0,1	9,8
Sunday	5,4	9,2
Average	13,4	12,4
Standard dev.	9,4	4,4
Variability	0,70	0,35

Table 14: Admissions of general surgery patients (iZIS, 2009)

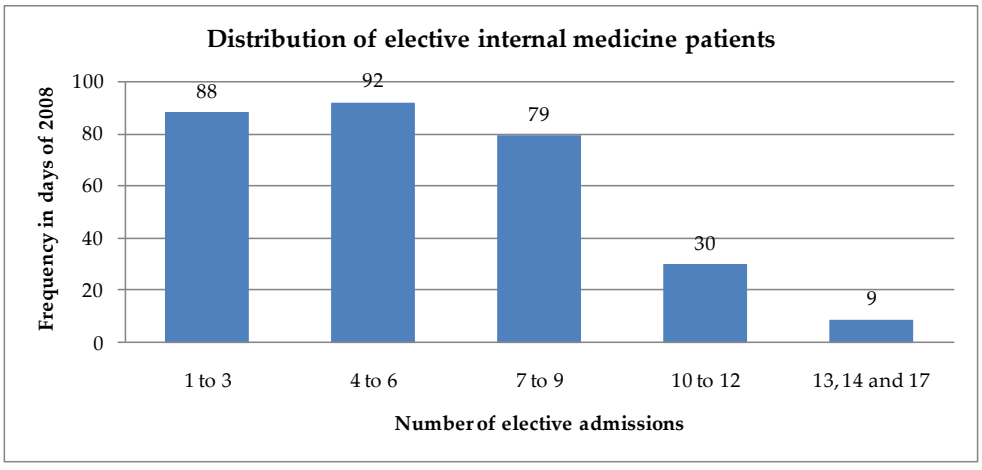


Figure 47: Number of days with x to y admissions for internal medicine (iZIS, 2009). There were 92 days (25% of all days in 2008) on which 4 to 6 patients were admitted (elective).

	Internal Medicine admissions	
	Elective	Emergency
Total admissions	1702	3789
Monday	8,2	11,8
Tuesday	6,8	10,5
Wednesday	6,1	11,7
Thursday	7,1	10,3
Friday	3,4	12,3
Saturday	0,3	7,7
Sunday	0,7	8,1
Average	4,7	13,3
Standard dev.	3,7	4,89
Variability	0,8	0,37

Table 15: Admissions of Internal Medicine patients (iZIS, 2009)

According to the differences in variability, we give the following suggestions to improve the fit of bed capacity to demand:

- **Intervention D-1:** Reserve a fixed amount of empty free beds for emergency patients. The number depends on the percentage of acceptances of admissions.
- **Intervention D-2:** Decrease the variability of elective admissions by planning more accurately. This ought to be possible due to the nature of elective admissions and the function of an admission office.

We cannot give exact numbers and practical interventions on the basis of this research.

We are aware of the fact that the elective admissions of general surgery patients are led by the operation room planning and scheduling of surgeons to operate. This suggestion therefore implicates a hospital wide implementation and cannot be done instantly. A lot of extra research is needed to understand the implications and changes needed to manage elective patients. The hospital needs to know how much and in which departments beds have to be free for emergency admissions and also on how to implement a more planned elective admission planning.

Intervention E: Match capacity of the ward-nurses to admissions

The LOS of admission patients is higher if the patient is admitted after 17:00 than from 0:00 to 17:00. In chapter 3 we showed that most patients are admitted between 18:00 and 20:00 and currently, the capacity of the ward nurses does not fit with this high admittance rate. With the intervention of early announcement, the first intervention to free beds and plan elective patients and the other suggested interventions in this research; we expect that the admission of patients takes place at an earlier time. Changing the capacity of the wards is not needed. But if these are not affective, we suggest to fit capacity of ward-nurses to the number of admissions from the ED in the evening. The working schedules of the ward-nurses should be changed to cope with the high admission rate between 18:00 and 20:00; a middle shift could be convenient instead of only a day shift that ends at 15:30.

With nurses in the ward arranged around elective and emergency admissions, the nurses are able to accept more patients and come and get the patient more quickly from the ED. We expect that this has a positive effect on the patient LOS.

4.3.3 Organisational impact

The interventions presented in this paragraph impact the organisation in three areas. Because of early announcement improvements, the ED should change the work during triage and arranges the patient flow out of the ED to the wards in a different way. Changes are needed that implies a quicker transfer of the patient at the end of the process. For a restructure of the planning of emergency and elective admission, the strategic and tactical level are involved and no exact operational impact is expected yet. If changing the capacity of the wards is necessary, it is a big impact for the nursing departments. Figure 48 gives a graphic representation of the areas of organisational impact.

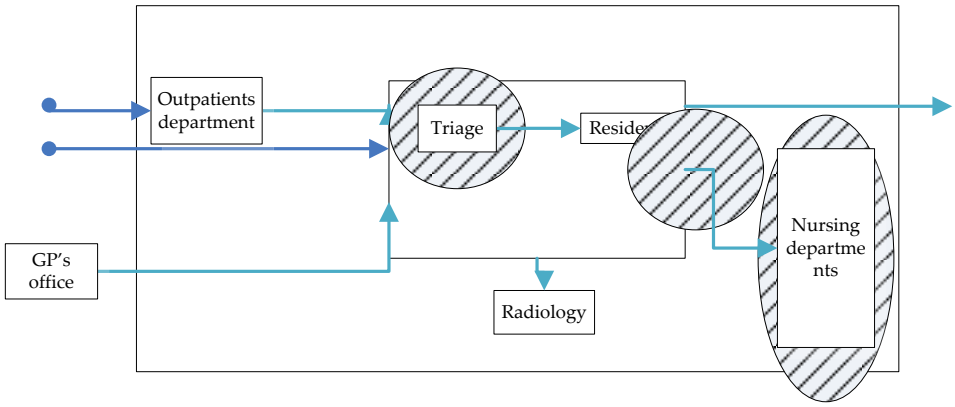


Figure 48: Areas of organisational impact of the admission interventions.

4.4 Increase content and effectiveness of triage

In chapter 3 we concluded that part of triage is a non-value added activity from a manufacturing perspective. It is not our objective to completely delete triage, so this paragraph gives interventions to increase the value or effectiveness of triage. We apply basic ideas of manufacturing theory to look for improvement suggestions. As said in chapter 3, it is difficult to determine the influence of triage on patient LOS. Therefore the inefficiencies at triage are more linked to the purpose and value added activity rather than to reduce patient LOS by changing triage.

Since triage is the actual start of the process, we use early decision making of Coyle et al (2003) as a possible intervention method to reduce the patient LOS from the beginning and increase decisions at triage (4.4.1). Also the idea to share and centralise information are transferred into an intervention to improve the effectiveness of triage (4.4.2).

4.4.1 Intervention F: Advanced triage

In the current triage system diagnostic tests would not be initiated until the anamnesis of the resident, because they have the authority and the education to take decisions. The analysis of 4.3.1 showed that the time from arrival until the initial anamnesis of the resident is on average 60 minutes for general surgery patients and 118 minutes for Internal Medicine patients. This waiting adds no value for the patient in the current situation and it delays the important diagnostic decisions for the patient. Early decision making of Coyle et al. (2003) uses this non value added waiting time between triage and resident by requesting diagnostics and admission at an earlier in the process. This paragraph introduces advanced triage as an intervention to reduce patient LOS.

A study of Cheung et al. (2002) applied advanced triage as a response to long patient LOS and waiting times. This resulted in advanced triage as a process where a triage nurse initiates appropriate diagnostic tests for eligible patients based on an established set of protocols or algorithms. This eliminates the additional patient waiting time for laboratory and diagnostic imaging processes; moreover it utilizes patient waiting time more efficiently. They showed improvements in total LOS for both urgent and non-urgent patients (74 and 40 minutes) and even higher improvements in LOS after initial resident anamnesis (89 and 62 minutes). Although we expect less improvements than in the study of Cheung (more GP patients), we suggest to implement an improved system of triage in the ED to reduce the patient LOS. We suggest requesting all possible and needed diagnostics for a patient during triage (or just after triage).

GPs (51%) and specialists (12%) refer their patients to the ED with information on these patients. The resident in the ED decides with the GP or specialist which diagnostics have to start first. For 36% of all patients (self-referred) the triage-nurse cannot guarantee the start of diagnostics at an early stage.

To achieve an appropriate advanced triage system in the ED for these arrivals of patients, we suggest the two following sub-interventions:

Intervention F-1: Advance triage for self-referred patients

Intervention 1.1: Improve collaboration with the plaster department within fracture protocols

Intervention 1.2: Develop groups of complaints of patients with the same diagnostic trajectory and standard diagnostics

Intervention F-2: Announcement improvement for referred patients

Implementing advanced triage requires involvement of staff, residents and specialists. Everybody should agree that advanced diagnostics improves patient LOS and quick decision making. Furthermore, it is a benefit for the nurses that advanced triage empowers them to initiate diagnostic investigations and improves the nurses' sense of autonomy (Cheung et al. 2002).

Intervention F-1: Advanced triage for self-referred patients

20% of all patients that enter the ED are fast track patients; they have a fracture or small injury and end up in a fast track surgery process. 16% are self-referred patients for who the triage-nurse is more difficult to determine for triage nurses. Both of these groups are self-referrals, who enter the ED as a walk-in patient (24% of the total patients) or with the 112-emergency ambulance (12% of the total patients). There are currently no rules for the triage-nurse to adequately start with the appropriate diagnostics.

For the 20% of fast track patients the management of the ED is involved in a fracture protocol implementation. We suggest to further specify these fracture protocols in order that the triage-nurse knows which x-ray request are appropriate to what fracture. This enables the resident to quickly decide on further treatment, without requesting a second x-ray. An unspecified percentage of this group are patients with an appointment of the GP's diagnostic centre who already had an x-ray. The centre sends them to the ED because of a (usually old) fracture. To give appropriate care to this patient

group we recommend involving the plaster outpatients department. This department has emergency appointments and provides specialised plasters that are more efficiently.

Self-referrals, other than the fast track patients and 112-ambulance patients, are 4% of the total patient (16% - 12% ambulance) who arrive without prescribed diagnostics. Because in the current situation, only the nurse performs a triage we suggest to first develop groups of patients and structure these complaints and diagnosis in a protocol. Triage nurses can indicate the type of patient with individual guides for specific complaints and determine which protocol to follow. The protocol exists of standard diagnostics or nurse-tasks to perform and can be implemented in a computerised system. The system can use, just like the triage system itself, questions and flows to follow and determine the type of diagnostics to request. The algorithms (protocols) within the computer program have to be set up by a committee that guides which diagnostics have to be performed. It has to be very easy for the triage-nurse to make these decisions. We suggest to watch and monitor properly the changing complaints and syndromes to update the protocols and prevent over diagnosing a patient.

For a practical implementation of such as system, we use the example of (DVT) vascular thrombosis. Patients with a suspicion of this diagnosis undergo a specific lab examination and an echography. If a nurse recognises such a patient during triage, he/she can start and request these diagnostics immediately without interference of a resident. For certain groups the ED can use standard protocols for diagnostics and or admission.

We expect that the number of self-referred patients will increase in the next years, due to an increase of patient self awareness (TPG, 2004). It is important to regulate this flow of self-referred patients, for example by collaborations with GP offices or the availability of emergency residents.

Intervention F-2: Improve announcement

According to self-referrals, the referred patients enter the ED with an announcement of the GP or specialist. Problems with announcements are that it is not yet completely optimized since a lot of patient data vanishes. Most of the time the phone call of the GP/specialist disturbs a resident in general work and the announcement is quickly handled. We suggest to communicate and educate stricter announcement protocols. Isala's Patient Safety organisation refers to the SBAR communication method, which underlines the need to ask for the *situation* and *background* of a patient and to further communicate the *assessment* and *recommendation*. Introducing and stimulating this method in the ED makes residents and specialist increasingly aware of the importance of correct announcement information. This is essential in decision making about the diagnostics and implicates a reduction of the patient LOS. Next to a reduction of the LOS after anamnesis, early requests significantly influence the work insecurity of diagnosing and lower the barrier to contact a specialist.

Associated with this intervention, we suggest that the resident who receives the phone call of the announcement should also perform the anamnesis of the patient. To decrease the pressure on the residents, the specialist can also directly call the receptionists instead of the resident (only if the resident does not have to know any extra medical history about the patient).

The ED works with small announcement papers, which are given by the resident to the coordinator nurse, concurrently the coordinator-nurse hands them over to the receptionist. She places one copy on

the arrival board. In order to stimulate the residents and the coordinator nurse to completely and correctly fill out the patient data, admission (yes/no) and needed diagnostics (type lab, x-ray, echo, CT), we suggest to improve the announcement papers with SBAR communication rules and/or developed patient groups protocols (DVT, yes/no?).

Improving triage with advanced triage means changing the content of triage and transforming it to triage that adds more value for the patient. Moreover we expect a reduction in the patient LOS by starting the first diagnostics earlier in the process (literature and process workshops, 2009).

4.4.2 Intervention G: Prevent overlap of asking patient information

During the process workshops we discussed the discrepancy of the need to perform triage within 5 minutes after arrival and the need to start lab tests immediately. Is it possible to collect blood during triage without exceeding the 5 minutes time-interval between enter and triage? We suggest ideas to attack this problem en decrease waste in the begin process. When more than 2 patients wait for triage:

- Call an extra triage nurse
- Send a patient to the laboratory if the patient is well enough
- Send a patient back to the waiting room and start collecting blood if there are no more patients left
- Research possibility to scan a patient's request to the x-ray technicians. The triage nurse does not need to walk to the Bucky-room.

Intervention G: Prevent repeating history

In the ED every staff member works on his own field of expertise that provides opportunities to reduce patient LOS. At first a nurse is responsible for triage and afterwards the resident has his first anamnesis. The information of the status of the patient and decisions about the patient is not shared with ED-nurses, residents, and ward nurses. Although the ED-nurse informs a ward nurse about the diagnosis of an admission patient, this ward-nurse also performs a new anamnesis in the ward. Coyle et al. (2003) state that in order to reduce cycle times, a department (or system) should share and provide information with all involved partners, actors and other processes (Coyle et al, 2003). We apply this method to triage in the ED and suggest to prevent overlap of information.

During one of the process improvement workshops the content of triage and the nurse anamnesis within triage were subject of discussion. The resident clarified that the residents almost never use the information of the nurse anamnesis (except e.g. temperature), because they ask the same and more of a patient to obtain a complete picture of the complaint. Together they identified the nurse anamnesis as a 'waste-activity', which is the same conclusion that Walley (2003) makes: triage is a non-value adding task of a nurse, which is based on the assumption that the nurse asks the history of the patient, while this information is not used by the resident.

With the process mapping and Coyle et al. in mind, we suggest decreasing or even eliminating the current nurse anamnesis. Work in the ED has to focus on supplementary information for both nurse and resident to add their part of the value to the patient. For example the tasks that a nurse performs (e.g. blood pressure, temperature, and heart-massage) add value and are not repeated by the resident. With this intervention the ED-nurse and resident actually share information about the patient (Coyle et al., 2003).

As a result of the output of the process improvement workshops, three student nurses in the ED picked up this intervention and perform a research on the necessary content of an ED-nurse, residents and ward-nurse anamnesis. They take into account the changing (juridical) responsibilities in the ED. Afterwards we suggest to change the EPR to discourage nurses and residents to fill out complementary information on a patient and to integrate both parts into one.

4.4.3 Organisational impact

The actual changes of the organisation for both interventions are needed in the first part of the process, the triage. This involves the nurses, who need education. The residents and specialists should share their knowledge about patients' medical path, so they are affected too. In addition, they need to improve the announcement structure, which is the beginning of the process of referral patients and includes interference of the residents and specialists.

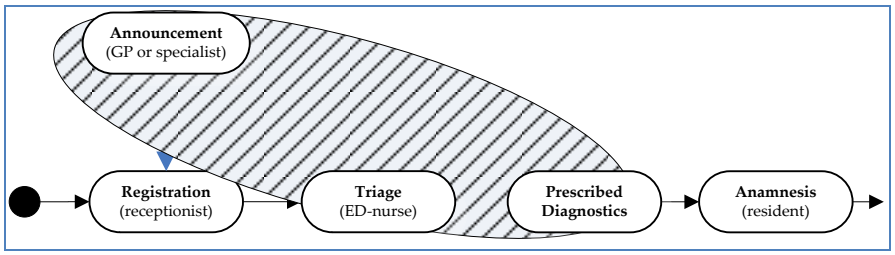


Figure 49: Areas of impact of triage interventions in the ED

4.5 Process intervention

4.5.1 Introduction

In paragraph 3.4 we concluded that despite of the urgency categories, the work on the ED is not split or structured. Both residents and nurse work independently of each other on patients. Second, the current work for most of the patients (excluding type 1 patients of 1%) **depends** on the availability of rooms, nurses and residents. The patients are pushed through the process of the ED and the staff has no focus on process outcomes so queues exist.

Further we analysed that more than 75% of all internal medicine patients receive a colour yellow. If a resident starts with a new patient they always look at this triage colour, but if almost all patients are yellow, they help the patient who first came in. The question is: What does triage actually add to the process and its sequence, if 75% of all patients are yellow? And if a patient receives a colour green, what does this colour adds for this patient? There is almost always a patient with a more urgent colour in the ED and after delaying the anamnesis of the 'green' patient, the patient becomes urgent himself.

If we combine both the ineffectiveness of urgency colours to improve patient flow and the dependency of the flow of the patients on the availability of resources, we suggest to improve the whole process in the ED in order to eliminate both aspects.

This paragraph suggests an intervention that exceeds the boundary of the ED.

4.5.2 Intervention H: Together Triage

We suggest changing triage done by only one nurses to a triage of resident and nursing together. The patient arrives in the ED to get medical help from a specialist or resident, not to wait for first 1 hour (general surgery patients) or almost 2 hours (internal medicine patients). This improves the effectiveness of triage and changes the current process sequence of the patient. Both nurse and resident enter the triage room (or patient room) and get the patient's history at the same time and the urgency colours do not determine the waiting times any more.

Currently there are not enough triage rooms to support this intervention, so we defined two alternative interventions to introduce together triage. First it is possible to let the nurse join the resident during anamnesis or that the resident joins the nurse when he/she begins with a patient (when a patient enters a patient room). Second, the ED can use a second triage rooms with one nurse working in both rooms. The nurse calls a resident to come in if the patient is a self-referral. In between, the ED-nurse sees another triage patient in the second room or stays with the resident in case of an empty waiting room.

Advantages of together triage:

- The patient immediately receives the health care he/she needs (anamnesis of resident)
- The intervention deletes non-value added activities of nurse and residents anamnesis and improves decision making earlier in the process (apply of Coyle et al., 2003)
- There will be less cases of additional diagnosing or ineffective requests during triage
- An increase in communication between nurses and residents. This reduces the (waste) time between request of a resident and action of a nurse. An executed study in the ED of Isala Klinieken showed that teamwork between the resident and nurses reduces the patient LOS and increases work satisfaction of the staff members.
- The resident is not bounded by the colours (that do not add value). The availability of the first results stimulates the resident to further help this patient. Colour is not a delay factor anymore, so the results determine that the patient is ready for the next process step.

4.5.3 Further elaboration on process approach

According to the last benefit of the solution, we discuss the start of a practical implication of this intervention in the ED. Aside from the process way of approaching the ED with manufacturing theories (like Walley, 2006), we use the ideas of Schuring and Van der Wiel (see for an elaboration Appendix D)

We agree with Walley (2006) to segment patients in groups based on process sequence. In paragraph 3.3.2 we already introduced four possible flows of patients. Currently the ED is not working with these flows, so three types of these patients do not receive the correct care. Together triage could be

the start of introducing these process flows and assigning capacity to the flows. This suggestion of Walley (2006) is the beginning of what Schuring and Van der Wiel (2005) call a process oriented organisation. It contradicts the common departmental approach were every resource is dedicated to a department instead of to a process outcome. They proclaim to change the organisation into a process oriented organisation to be flexible and innovative (Appendix D).

We suggest to start with the segmentation of the arriving patients according to their process sequence. After triage the nurse and resident decide together to allocate the patient to one of the four groups: *fast track*, *rapid assessment and discharge*, *multiple investigation and admission* or *emergency health care*. First the ED determines the arrival rate and percentages of these flows and makes a first rough division of the staff and rooms over these segments. Second, a number of χ nurses (and χ residents), with specific expertise and preferences, are allocated to each process flow. Third, on operational level, the coordinator nurse controls the four processes and determines which resources to use at which moment in time. This nurse coordinates the processes and is attentive to track the slowest part of the process or the bottleneck activity that exists at any moment. For example, if the coordinator nurse notices an increasing demand of emergency patients, nurses of the process *rapid assessment* (fewer patients) could be assigned to work for this process. One room dedicated to one sequence can be 'transferred' to another to repair the bottleneck. It is preferable that residents work with the same flows to maintain and improve communication between nurses and residents and the optimal focus on the process. In this way, the staff focuses on the process needs. Schuring and Van der Wiel (2005) also mention that the management of the ED should use an employee role matrix. The matrix enlightens the current skills and expertise of the employees (which process to work on) and the preferred learning opportunities and career planning.

This intervention causes a complete restructuring of the current work in the ED and the normal accepted practices. The residents should be convinced that this intervention reduces the patient LOS and that it increases the satisfaction of minor complaint patients. The need to help a patient according to urgency is a grounded believe of the current ED. It is difficult to convince staff that the intervention is feasible and currently there are not enough triage rooms to support the intervention.

<u>We suggest further analysing and investigating the effects of the early involvement of a resident on the patient LOS, the workload and division of work and advantages for the residents and patients.</u>

Advantages of process oriented ED (extension)

We expect that the following advantages appear in the ED if process thinking is introduced:

- The health care of a patient is centralised around this patient (not the available capacity in the ED) and well defined groups of patients with the same process needs leads to improvements in patient LOS. The focus of both nurses and residents is on the needs of the patient and on the output (quick departure) of the process.
- Process orientation is a pull-system: A pull system will achieve the same level of throughput with a lower average WIP level, focus on throughput and lower cycle times
- All categories of urgencies are helped in the same way, despite the urgency. With process thinking and a start of resident and nurses together, the ED controls the expected generated output and the entire process and not on each individual activity that might not contribute to

this output. The process is aimed at the demands of the patient, so optimal for this individual patient.

- Empowering of the ED-nurses. Nurses are aware of their part of the generated output and are able to evaluate their performance in the process. Implementing an information board with average length of stay, number of patients, hours of the day and admissions contributes to the involvement.
- The flexibility of staff is essential in this approach, but we expect more willingness to help other process flows then when nurses are divided over specialties.
- Better communication between residents and nurses. Currently the part of the department determines the communication (nurses vs. residents), but this will diminish with the process oriented approach. Communication is based on the output of the process, so on the process needs.

4.6 Workshop interventions

As mentioned in chapter 1, the process mapping workshops involves staff in the research and let them understand the patient's journey and each other's activities and work out the current process and activity steps in the ED. During these workshops the staff mentioned problems that increase patient queuing and waste activities in the ED. With the philosophy of lean management and the elimination of this waste, the staff formulates practical interventions in process improvement workshops. Together they contribute to interventions and come up with brilliant ideas. The outcomes were specifically defined projects, driven and guided by various staff members or operational executives. They coordinate the progress of the projects and initiate further research. This paragraph shortly introduces the analysed problems and ideas to attack these problems with defined projects.

4.6.1 Communication improvements and collaboration between nurses and residents

Focussing on the time after resident's anamnesis the staff mentions the several problems (see paragraph 3.4) and focussed on the difficulties with communication between residents and nurses. All participants acknowledged that a better communication leads to better cooperation and a reduction in patient LOS. The manual measurements underline the long times between request of a resident and action of a nurse or decision of a resident and actual request. To improve collaboration between residents and nurses the following projects we suggest the following projects:

Sharing information by an introduction program and booklet and communication in the news letter
Residents are assigned to the ED by their specialists. Most of the times they have minor experiences in efficiently work in an ED. To involve residents in the process and the standards of working in the ED, we start to make a booklet with information for new residents. In addition we suggest to give new residents an introduction program in the ED to get to know the process. They should walk along with the nurses and maybe patients also. We also see possibilities for nurses to walk along with residents and patients. Furthermore we suggest that residents share new ideas and developments of the care groups with the nurses on the ED. In this way the nurses are better informed about e.g. lunch breaks and carry over hours.

Improve digital board with results of diagnostics

We suggest to improve the monitoring possibilities of nurses and residents by arranging that results are available and **visible** in the ED. The reasons and explanation for this intervention are explained in paragraph 4.2 but the operational effort to change and implement this intervention is coordinated from the workshops.

Request bin for requests of residents for all patients

We suggest to improve the time from request to actual diagnostics by implementing a request bin for all patients. Currently every patient has its own tube that contains a lot of papers. New requests (lab, x-ray) are not visible and the nurse is not always around to receive the request from the resident. By implementing a collective bin, the coordinator nurse can easily notice if there are new requests and informs the assigned nurse.

Digital requests for radiology

The best intervention is probably to immediately scan a request for radiology (currently 9 minutes between request and start x-ray) to the computer of the technicians in the Bucky-room, but due to a lack of digital technology this intervention is not possible yet.

Resident informs receptionist for admission

The activity steps in the process from decision of an admission until the actual departure of the patient show almost no added value for the patient. In addition, the manual measurements calculated that the carryover times of the decision from resident to receptionist and from receptionist to nurse are unnecessary high. In this project we attack the 'waste' between the actual decision of the resident to admit a patient and the contact with the admission office. After decision the resident contacts the nurse of the patient. Most of the time the nurse is busy and not available or the resident first starts writing the papers. After communication the nurse, informs the receptionist, who makes the call. The staff of the ED decided to improve these decision transfers from resident to receptionist. We suggest that the resident immediately calls the receptionist who marks the admission on the digital board (silent alarm), visible to the coordinator nurse. The coordinator nurse informs the ED-nurse the next time they have contact (red alarm). In addition, the coordinator is responsible to track all admissions and has contacts with the receptionist.

4.6.2 Involvement of ward-nurses

We suggest to perform a process mapping workshop with ED-nurses and ward-nurses, since the last group is part of the process of the patient. Currently there is almost no communication between the two, but the nurses of the wards feel that they aren't understood by the ED-nurses and vice versa. It is important to involve both groups to attain consensus and solutions. The research of the student nurses that is already started can increase the awareness of the involvement of the ward-nurses (research of student nurses can be successful in accomplishing the first communication). Important is that all staff involved in the admission process (so also specialists) should agree that any patient admitted as an inpatient should not remain in the ED (Burley et al.,2007).

4.6.3 Improvements of protocol coordinator nurse

One of the most important conclusions of the process improvement workshops was the increased responsibility of the coordinator nurse. Almost all interventions show the need to change the current protocol of the coordinator. He/she has to be aware of the position of the patient in the process to be able to control the admission for the residents and nurses. This is a critical position when the ED wants to change into a more process oriented ED. The workshops made a start with this protocol.

4.7 Conclusion

This chapter answers the fourth research question: *"What interventions can be suggested to reduce the patient length of stay in the emergency department?"*

- Figure 50 summarises the interventions we suggest to reduce the patient LOS. The third column describes the defined inefficiencies in the process from chapter 3, that the suggested intervention attacks:

Paragraph number	Intervention	Inefficiency in the ED
4.2 intervention A	Decrease patients in process	Residents' process
4.2 intervention B	Change residents schedule	Waiting for anamnesis, residents' process
4.3 intervention C	Early announcement	Admission flow
4.3 intervention D	Match bed-capacity to emergency admissions	Admission flow
4.3 intervention E	Match ward-nurse capacity to emergency admissions	Admission flow
4.4 intervention F	Advanced triage	Effectiveness Triage
4.4 intervention G	Prevent overlap anamnesis	Effectiveness Triage
4.5 intervention H	Together triage	Entire process

Figure 50: Summary of the interventions to reduce the patient LOS

- Figure 51 presents the interventions followed from the process improvement workshops with staff of the ED:

Interventions from process improvement workshops	
Paragraph number	**Intervention**
4.6.1	*Reducing the LOS by improving the communication and collaboration between nurses and residents* Sharing information by an introduction program and booklet and communication in the news letter Improve digital board with results of diagnostics Request bin for requests from residents for all patients Resident announces admission at receptionist first
4.6.2	*Involve ward-nurses in admission problems*
4.6.3	*Improveme the content of the work of the coordinator nurse*

Figure 51: Interventions from the process improvement workshops

Looking at these different interventions we conclude that it is not possible to perfectly quantify the expected reduction in patient LOS. With the interventions we only describe the possible impact on patient LOS if the interventions are implemented in the current ED. To be able to classify the suggested interventions we divided them in a time-slots and decision levels.

At this moment we are able to position all the interventions into the three hierarchical levels of the framework of Van Houdenhoven et al. (2007) from 3.2 within the two authority levels. Figure 52

shows this classification of the suggested interventions, on which level they have impact, the level of decision-making and if it is a hospital or medical decision line authority decision.

	Categorisation of the interventions in decision level	
Hierarchical levels vs. Decision line	***Hospital authority line***	***Medical authority line***
Strategic	Match bed-capacity to admissions (D)	
Tactical	Advanced triage (F) Early announcement admissions (C) Nurse and residents triage (H)	
	Capacity of ward-nurses (E)	Capacity of residents in the ED (B)
Operational	Prevent overlap anamnesis (G)	Decrease patient in process (A)

Figure 52: Interventions within framework of Van Houdenhoven et al. (2007), applied to the ED with a hospital authority line and a medical authority line.

- Strategy can be defined as a course of action, a scheme, or a principal idea through which an organization or individual hopes to accomplish a specific objective or goal. For example, matching bed-capacity to admissions is a strategy decision, since it has impact on e.g. the capacity dimension of beds in the hospital.
- Tactical decision making refers to operational aspects that are necessary to support strategy. They are more likely to involve daily short-run operations that help strategic decision than the impact and decisions on tactical level. We categorise the interventions B, C, D, F and H in this level. As an example we explain the advanced triage intervention as an intervention that is tactical, since it refers to a change in operational aspects. Advanced triage connects with a strategic decision, for example, to improve the patient flow in the ED. Both hospital and medical authority lines should be involved in this intervention, because formulating protocols and improving the announcement structure asks for involvement and medical input of specialists. The nurses should be trained in advanced triage and so on.
- Operational planning deals with the in-advance day-to-day control of expected activities (offline) and unexpected activities (online). Preventing the overlap of anamnesis and the interventions that decrease the patient in process level both requires an operational decision and implementation.

Second we conclude that the interventions have a different implementation possibility over time, because of difficulties with decisions, changing the organisation and so on. We divide the interventions in the time-slots *Short-term*, *Medium* and *Long-term* that refers generally to the possibility to implement within three months, three months to one year and longer than a year:

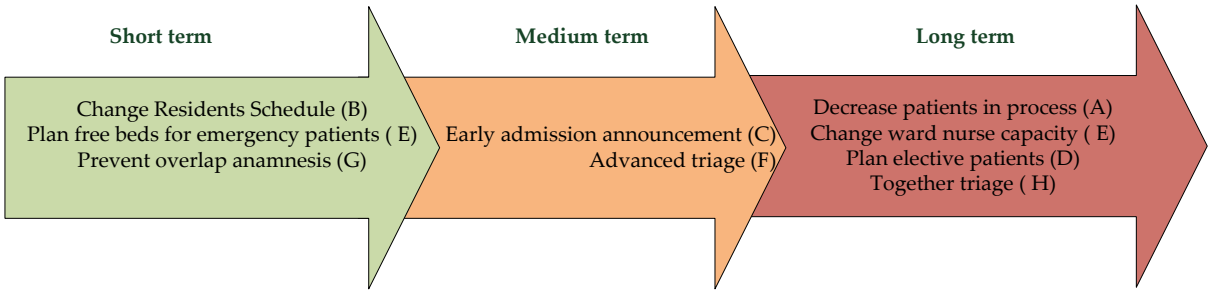


Figure 53: Time planning of suggested interventions

Finally, the interventions have an overlap in the areas of inefficiency they focus on and the way how they reduce patient LOS. Although we expect that all interventions can improve the patient LOS, from previous analysis, we choose especially one intervention that we recommend to implement:

We suggest to implement a process oriented intervention were nurse and residents perform triage together. We expect that this intervention (H) has the biggest impact on the patient length of stay in the ED. The needs of the patients determine the process and availabilities. The intervention increases advanced triage (F), early announcement of admission (C) and value added waiting time. In addition it eliminates the most overlap in the nurse- and residents anamnesis (G) and both staff communicate more with each other. Improve the ED to a process oriented ED and let the nurse and resident perform triage together is the most convenient intervention that implicitly includes other suggested interventions.

As we saw in the planning framework, this intervention requires strategic decision-making on both medical and hospital authority lines. The intervention has impact on the entire ED; the processes, staff and patients and the practical implications and structure of the implementation should be further researched. For all these reasons, we expect that this intervention could only be implemented in a long-term perspective were further research about the practical implications and benefits is conducted and participants of all levels are involved.

5 Conclusion, discussion and recommendations

Paragraph 5.1 describes the main conclusions of this research. Paragraph 5.2 discusses the results of the study. This chapter ends in paragraph 5.3 with practical recommendations and suggestions for further research.

5.1 Conclusion

In Isala Klinieken, the ED observed an increasing demand for emergency care in 2007, which results in long waiting times, a need for increasing capacity and dissatisfied patients in the emergency department. To cope with these changes, the patient length of stay (LOS; time from enter until departure in the ED) has to be improved. Since residents, ED-nurses, and specialists give various causes for a long patient LOS, the management realised more insight is needed into the processes and activities of the ED to be able to suggest length of stay improvements and to adapt to an expected increase of the number of patients in the future.

The objective of this research (see chapter 1), is ***to suggest interventions to reduce the patient length of stay in the emergency department by mapping all the processes, assess the duration of separate activities and analyse inefficiencies*".**

This paragraph presents the conclusions of the three research questions of this research.

How can the ED be described from a logistic perspective in terms of patient in- and outflow, resources, processes, activities and supporting processes, and what is the current patient LOS?
The ED should use a general system approach to analyse the main components of the ED: input, output, resources, planning and control structure and current patient LOS of the ED. This means that the ED is a black box that uncovers quantitative data (daily and hourly arrival and departure) of patient in- and outflow. When opening the black box, we follow patients who have their own process path in the ED. During this process they use resources, like staff and beds, until they leave the ED to home or to other departments of the hospital. Various steps of a patient in the process represent workstations or activities that add or do not add value for a patient. Furthermore, the availability of staff in the ED is plotted to the demand of patients arriving for every hour of the day. Measuring the duration of activities and time between these activities in the process leads to a quantitative and objective overview of the ED. The current patient LOS from a logistic perspective is the sum of all activities including the waiting time for these activities. In general internal medicine patients have an average LOS of 3 hours and 33 minutes (variability of 0,43) and general surgery patients stay on average for 2 hours and 12 minutes (variability of 0,78). In depth data can be found in chapter three.

Which parts of the process indicate the most room for improvement to reduce the patient's length of stay?
Manufacturing theories, lean management and capacity management are able to evaluate the current process in the ED. Lean management is a management paradigm that categories waste that should be eliminated to improve the performance of the system. Capacity management relates the incoming patient demand to the available capacity of resources (staff) to help this demand. With the indicated

waste and the (un)fit between capacity and demand, both theories can define the inefficiencies in the process on the ED.

We conclude that the ED is a complex process with unplanned patient arrivals and unknown care paths through the ED. When a patient enters the ED, all the steps of care are unknown because decisions about these steps (care path) are taken by staff later in the process. In manufacturing theory, faster provision of information and early decision making, provide an opportunity to reduce cycle time and reduce uncertainty about the further process (Coyle et al, 2003). In the ED, decisions about the patients' path are postponed to the time a resident has all results. Depending on the further needs (for diagnostics), the care path of a patient adjusts during the process. As a result, the allocation of resources (staff) to these patient is hard to plan and important processes start after each other (e.g. steps before a patient is admitted), instead of parallel towards each other.

Not only the decision of further diagnostics is postponed, but with that also the needs of the patient are postponed to the time the resident is available. When a patient enters the ED the main goal is to get a consult of a resident. From a manufacturing perspective, the demand of a product (process steps) determines the amount of supplies (resources) that are needed. This should also be the case within the ED. Currently, the demands of the patients do not determine the process in the ED. Patients are segmented by their urgency colours. In manufacturing theory (Walley, 2006) the volume and variety of patient groups lead to different manufacturing process choices. Examples of these choices are 'batching' or 'mass production'. Within the ED, groups of patients with the same process needs could be distinguished, but currently all the patients are treated as one group. Every patient follows the same (unstructured) process in the ED, where they enter separate queues with an unspecified waiting time.

Staff in the ED (especially residents) work on many patients at the same time, since they are scarce, they divide their time over all patients in the ED. This staff only performs work on one patient at the time, while the other patients are waiting and no activities are performed for them. These issues imply a high work in process. An increase in work in process leads to an increase in patient LOS. Another problem with the unavailability of staff is that the working schedules of residents unfit arriving patient demand. The number of patients arriving in the ED changes every hour. From a manufacturing perspective the capacity of resources (staff) should correspond with this changing (patient) demand. In the ED the working schedules of residents unfit the patient demand. In the analysis, time-slots of high patient demand were found where less residents were available than in hours of low demand. These two issues together make the resident the bottleneck of the process and room for improvement. Also the capacity of nurses in the nursing departments and radiology modalities does not fit the demand of emergency patients.

Summarising, the process in the ED is complex with unknown care paths of patients, important decisions are postponed and the availability of resources determines the process of a patient. Staff in the ED work on many patients at the same time that increases patients LOS and their working schedules does not fit the demand of these patients. Since the urgency colours determine the process, patients are not helped according to their needs and patients enter separate queues within the process.

These problems indicate the most room for improvement in the process and solving these problems reduce patient LOS. The research translates the problems in four main areas of inefficiency in the ED: *the resident process*, *admission process*, *content of triage* (begin of the process) and *process approach*.

What interventions can be suggested to reduce the patient length of stay in the emergency department?
The combination of the proposed literature and the conclusion of the analysis lead to overall ideas how to reduce the patients LOS.

A first important idea is to early decide the process steps of a patient to perform processes parallel to each other instead of sequential and to have information about a patient earlier in the process. Possibilities to improve early decision making and earlier available information are crucial and indicate a reduction in patient LOS. The second idea to reduce patient LOS from a logistic perspective is that the ED should focus on a reduction of the work in process of staff. A decrease in work in process leads to a decrease in patient LOS. As a result waiting time for a patient is reduced. A third idea is to attack the inefficiency between capacity and demand. The mismatch can be solved, at least partially, by allocating residents better. Balancing staff will also lead to a more equal distribution (use) of beds. Fourth, the ED should focus on the track and trace of patients to determine the position of the patient in the process. With track and trace, the ED can get insight in patient queuing, the demands of the patients during the process and trigger the coordinator to allocate staff to queues. In this way staff is more focused on patients' needs. The ideas also prevent long waiting times for patients in separate queues in the ED. Fifth, the ED should get more structure to cope with the complexity of various processes. The ED must segment patients in groups of the same process needs. Resources (staff and patient rooms) can be allocated to these patient groups that focus on various process outcomes.

The ideas result in practical interventions to reduce patients LOS in the ED. One of these practical interventions is to reduce the number of patients in process for the resident by implementing a track and trace system that shows the patient's position in the process of the ED and gives triggers to residents to return to patients by providing diagnostic results. During the day, a coordinator nurse can control the release of patients to the ED to prevent a rapid increase in the number of patients in process. Another intervention is to restructure the ED to a (more) process oriented department where nurse and resident perform triage together and segment patients in process based groups. We expect this intervention has the biggest impact on patient LOS, since the needs of the patients determine the process, instead of the available resources and it uses patient waiting time more efficiently. Furthermore it implies early decision making and information sharing between resident and nurse and there are good possibilities to track the position of these patients in the process and assign resources to bottlenecks.

5.2 Discussion

This paragraph discusses the research results (5.2.1) and the research methods (5.2.2)

5.2.1 Research results

Generality of the results

The analysis and conclusions of this research and the interventions that we suggest to reduce the patient LOS in the ED can be (partly) generalised and used by other hospitals. We give three examples:

- In other hospitals have the same problems with decisions to admit patients at the end of the process. This results in longer patients LOS for admission patients. The interventions to increase early decision making and to fit bed- and staff capacity of nursing departments to emergency demand could be introduced in these hospitals too.
- A high number of patients in process could be indicated in other hospitals. Ideas to track a patients' position in the process and trigger residents to finish patients could be a convenient method to reduce patients LOS.
- Much of the (larger) EDs in the Netherlands are based on old insights of organising, so we think that problems within process structure (determined by resources), exists in these hospitals too. In general hospitals deliver supply driven care, instead of patient driven care. The restructuring of processes in patient driven care is innovative, difficult to implement, but applicable to the health care sector as a whole. Every ED could begin with a triage system of resident and nurse together.

Future developments

The research interventions and the analysis are based on data of 2008 and current working practices in the ED. Three future developments should be taken into account when implementing the interventions:

- In 2013 Isala Klinieken expects to rebuild the hospital, in which the new ED has another positioning of patient and waiting rooms. In this new situation, the heart and pulmonary patients enter the same ED as other patients. This could positively influence the patient LOS (more residents, more beds, less nurses) or negatively (change of working methods, overcapacity, more queuing in front of diagnostics).
- A new education is started for the function '*emergency resident*', a resident assigned explicitly to EDs. With this 'new' resident, the ED has a new stakeholder who is not part of the specialists, but works for the ED. The new emergency resident is going to take over some work of the current care group residents, which could lead to struggles and changing power structures. A change in the organisation of processes could lead to e.g. higher patient LOS because of changing activity sequences (first emergency anamnesis, then internal medicine anamnesis) or admission difficulties. On the other hand the ED could benefit from the start of emergency residents to use it to discuss and easier implement some interventions e.g. different working schedules (intervention B), advanced triage (intervention F) or together triage (intervention G).
- We expect that the number of self-referrals will increase, due to changing circumstances of patients and their view on health care. When arriving at the ED they have no referral of a GP, so no initial diagnostics can start. In the current situation, these patients wait until the anamnesis before the first diagnostics are requested. If these patient numbers increase, we expect that interventions as advanced triage or a process oriented approach, with triage of resident and nurse, are even more convenient. The ED should always support patients in the surroundings of the hospital to visit a GP (collaboration with GP offices) to prevent growing patient numbers (and as a result increasing patient LOS) in the ED.

In general, the mentioned developments result in a change of in- and outflow of patients, process sequence and/or availability of residents and nurses.

Data

Although the electronic patient record provides a lot of reliable data of patients we discuss the following aspects:

- Although the times of enter, triage, anamnesis and departure were reliable, the accompanying dates of visiting the ED differed for some patients. In the calculation of the total patient LOS we took these patients along in the analysis. When determining the three time-slots we could not use all these times and dates, so we left them out. In this way it is possible that the sum of the averages of the time-slots does not correspond with the averages calculated in the analysis of LOS. For some patients the EPR did not record any information of triage, we kept them out too. (total left out: n=8324 general surgery patients and n=2416 internal medicine patients)
- Variability impacts the performance of a system or process. This is one of the most important characters of emergency departments. In this research, we analyse the arrival and departure of patients and give the variability of the number of patients and patients LOS. Although we measure and mention this, we were not able to include results that specifically consider this high variability. For example, we did not compare the duration of the activities of patients with high LOS and lower LOS.

The interventions

We recommend (chapter 4) the intervention of together triage (intervention H) and a process change in the ED. We mention that this intervention has impact on the entire organisation, both hierarchy lines and a long term planning and implementation. Further we expect the following challenges:

- The decision process will take a long time and involves a lot of stakeholders
- Further research is needed to calculate the consequences of this intervention
- Not only decision-making, but also a change in the lay-out of the ED should be established
- This intervention needs flexibility of staff in the ED and a strong involvement to change and improve.

In this research we did many process measurements (e.g. length of stay, numbers of patients' inflow, outflow, and admission data) and we analysed the inefficiencies and room for improvements. This analysis resulted in interventions that impact the organisation. The scope of this research is to give quantitative causes for long patients LOS in the ED and suggest interventions to overcome these causes. Therefore we did not measure the impact of every intervention on the organisation.

Results within the medical and hospital authority line

The framework of Van Houdenhoven et al. (2007) explains that there is a shift in medical and hospital planning. During the analysis of the planning of our resources we mention the same shift in authority lines in the ED. For our interventions this leads to the following restrictions:

- (Almost) all interventions involve residents and specialist work. This means that the advice for the ED suggest changes in the medical authority line of which the management of the ED cannot directly influence.
- The split in authority possibly leads to long decision making and intertwined interests.

And a possibility:

- This research analyses the inefficiencies with quantitative data on long patients LOS. This ends a discussion of 'feelings' and 'thoughts' about how long some activities take or opinions grounded on the two levels of specialties and an 'us against them' feeling.

5.2.2 Evaluation of the methods

We decided to approach the ED from a general business perspective and analyse the ED as a system with an input and output. This system approach allowed us to reveal first the most important components of the ED and second to quantify these components. Seen from this logistic perspective we conclude that the system approach delivers us a structured analysis of the ED. Manufacturing laws and theories give appropriate measures to quantify, analyse and improve current systems processes. We used a management paradigm, lean management, to introduce the staff to logistic 'thinking' in processes and a grip to analyse their own work. Summarising, a business logistic perspective provides quantitative measures to analyse inefficiencies and improvement ideas to improve performance in health care.

Discussion on earlier research

In the introduction in chapter 1 we mention the earlier project in 2007 that tried to reduce the patient LOS. During that project, the staff of the ED did not see the benefits of the interventions suggested by the project team. In this research we took two measures to overcome this problem. First we quantified steps in the ED and find inefficiencies that lead to longer patients LOS. With this analysis we can exactly formulate interventions that attack the inefficiencies. Second, we involve staff of the ED that leads to more conformity with the results and interventions.

Discussion on research limitations and approach

We focussed on two of the main care groups of patients in the ED. The final realisation of the objective gives suggestions for the ED as a whole and not only for general surgery and internal medicine care groups. A second limitation of the research was the focus on the ED of *location Sophia*. The nurses that work on location *Sophia* also work on the acute care department in *Weezenlanden*. It could be possible that the positive changes in structure of work and way of thinking about the ED has a positive influence on the performance of the ED in *Weezenlanden.*

For this research we used various methods to approach the ED. Aside from the observations and interviews; we involved staff to draw up the patient's path from their view. The combination of this process mapping and observations and interviewed led to the analysis. We applied the same when gathering patient data. We did not only focus on data from the electronic patient record, but also did our own manual measurements. This resulted in a combined and objective view of the process and activities in the ED.

Manual measurements

During the manual measurements we noticed the following factors that could influence the results of these measures:

- The staff of the ED keep track of the patients during the measurements. They filled out paper forms and there is a chance

- Especially in periods of high patient demand the forms were not filled in correctly. There is a chance that acute emergency patients were not followed with a form.
- Because of the brightly coloured papers, the announcements of admission were visible to nurses and residents. This could have improved the duration of transfer of admissions to nurses.
- The averages from e.g. time of enter to triage of the manual measurements differ with the same times in the EPR *Eridanos*, possibly because the number of patients from the EPR is higher.
- During the measurements the nurses just finished a training of the new requirements for triage. Within this training, the time to triage (maximum of 5 minutes) and content of triage were discussed. It is possible that this training had an influence on the results of the manual measurements.

Workshops

The workshops gave the research a two-level approach. In contrast to the interventions of literature, the workshops with staff of the ED focused on patient level instead of on a more general process level. A result of this is that the interventions of the staff provided even more practical interventions that were easy to implement. Part of the interventions of the staff overlaps the interventions from analysis and literature.

The advantage of the workshop approach is that the nurses and residents come up with their own solutions. The involvement within this research and its results increase the acceptance of the proposed ideas and less pressure to feel forced to institute top-down improvements. Aside from this acceptance, the workshops made clear that it is possible to 'educate' and help staff looking at a different way at their own specialistic work. We changed the way of looking at the ED.

This research needs a lot of cooperation between the ED and the medical authority lines. From the experience of this research we conclude that intertwining the knowledge of residents and nurses, a lot of improvement ideas became visible. In addition, a lot of understanding was created about the reasons of long patients LOS and the reasons of inefficiencies. We see possibilities to extend this approach outside the boundaries of the ED and involve ward-nurses and management to drop the boundaries of the departmental thinking.

5.3 Recommendations

The results of the research give interventions to reduce the patient LOS. During the research, we get familiar with the ED, so we formulate practical recommendations (5.3.1). During the 7 months of this research, there were new questions for which we propose recommendations for further research (5.3.2).

5.3.1 Practical recommendations

We recommend to benchmark the current situation of the ED periodically with new statistics and performance figures and check the following parameters: length of stay (departure, admission patients), number of patients per time-slot of the day, number of admissions, hours of admission, triage times, time to residents' anamnesis, and time from anamnesis to departure. The current data-

warehouse system is able to present and measure these parameters. The management of the ED should change these parameters into practical form (graphs, histograms) for staff. For other parameters the current system is unable to present useful measures: diagnostic times of request and time of results available. We recommend to change the electronic patient record *Eridanos* in such a way that it stores data and numbers of these performed diagnostics result times. After that the ED can measure the percentages of patients who need diagnostics, the effective waiting time, the queues that patients enter and waste time between result and further action. With every performance check, the ED finds exact inefficiencies and can compare these with earlier performance and patients in- and outflow. This benchmark should be routine for the management to increase (operational) control of the performance and problems in the ED.

A further step is to involve staff in the performance of their work and outcomes of this benchmark. We recommend to implement a (monthly or weekly) performance board in the department for nurses and residents or specialists with e.g. length of stay of the week, triage times, number of admissions. With this open culture, staff in the ED is able to increase their involvement in policy and decision-making. We expect that this idea increases the awareness of staff in the process flow of emergency patients and, just as in manufacturing companies, leads to better performance and employee satisfaction.

A second extension of the benchmark is to include and exchange information about (emergency) patients with other departments, such as radiology (access times during the day, number of patients) and nursing departments (number of elective and emergency admissions). This increases hospital awareness for the impact of emergency patients on normal day-to-day processes and appointments. The other way around it gives staff of the ED the opportunity to gain insight into the reasons and difficulties of patient LOS. A prerequisite is that the radiology department enhances its digital system with information if a patient is an emergency patient from the ED, an outpatient or a patient from the wards.

The benchmark or day-to-day performance of the ED could be extended to an initiative to constantly keep patients informed of their position in the process. With digital information a track and trace system could be build to give patients insights into their waiting times.

Finally, we recommend to continue the process mapping and improvement workshops started in this research. These workshops lead to remarkable results and involvement of staff into performance improvements in the ED. Furthermore we recommend to involve also other staff in these workshops. Patients of the ED visit or end up at various departments in the hospital, where staff of these departments also notice problems in patient flow and capacity. Process mapping and improving is a perfect tool to involve these staff together with ED-staff and increase awareness of problems that exceeds the boundaries of the ED and improves cooperation.

5.3.2 Recommendations for further research

This research provides an extensive analysis with quantitative and qualitative data of patient flow in the ED. The ED can use this analysis to measure the impact of future developments (exploding self-referrals, the impact of emergency residents in the ED and merge of two emergency departments into one; see section 5.2) on the performance and improvement possibilities in the ED. Furthermore, by

modelling the department the management of the ED is able to decide what is the best configuration to cope with this future changes in the organisation of the ED. Important sections of the report that could be used for such a model of the ED are the description of the patient flow, lay-out of the ED, the referral percentages of arriving patients, the days and hours of the day patients enter the ED, the mean and deviations of duration of activities (server times). From this the following important aspects of a model are already finalised: the flow of patients through the department, the (expected) arrival of patients, types of patients, arrival and service distributions, utilisation of staff and rooms, and the way of departure.

In section 3.5 we concluded that the capacity of the radiology modalities did not match the demand from the ED. This results in high access times for an echo or CT, with increasing access times in the afternoon to 2 hours for one patient. We recommend to further research possibilities to restructure the current planning and scheduling methods of the radiology department to cope with unexpected examinations. More and more operational methods are used in radiology departments of hospitals in the Netherlands that shows improvements by for example open access of the department or rescheduling emergency slots in the planning.

In the system approach of this research we observe a high percentage of specialist referral patients. Patients from the outpatient departments enter the ED in the late afternoon, which increases the pressure on the residents of the ED. We recommend to further research the possibility to open an acute outpatients department (acute OPD) to cope with problems of specialists of the inability to request fast diagnostics for their outpatients. First ideas to measure the feasibility of an acute OPD could be done by a queuing model (with A inter-arrival times, B service times, S number of servers) that models the queuing behaviour (average patients in the queue, average time spent in the queue) of the patients referred by specialists. Furthermore, a queuing model determines the utilisation of the servers (specialists) and possible opening times. The ED first needs to analyse: the number of arrivals of specialist patients that could enter the outpatient emergency department, possible opening hours, the use of ED-diagnostics and nurses and the feasibility in terms of costs and time of specialists.

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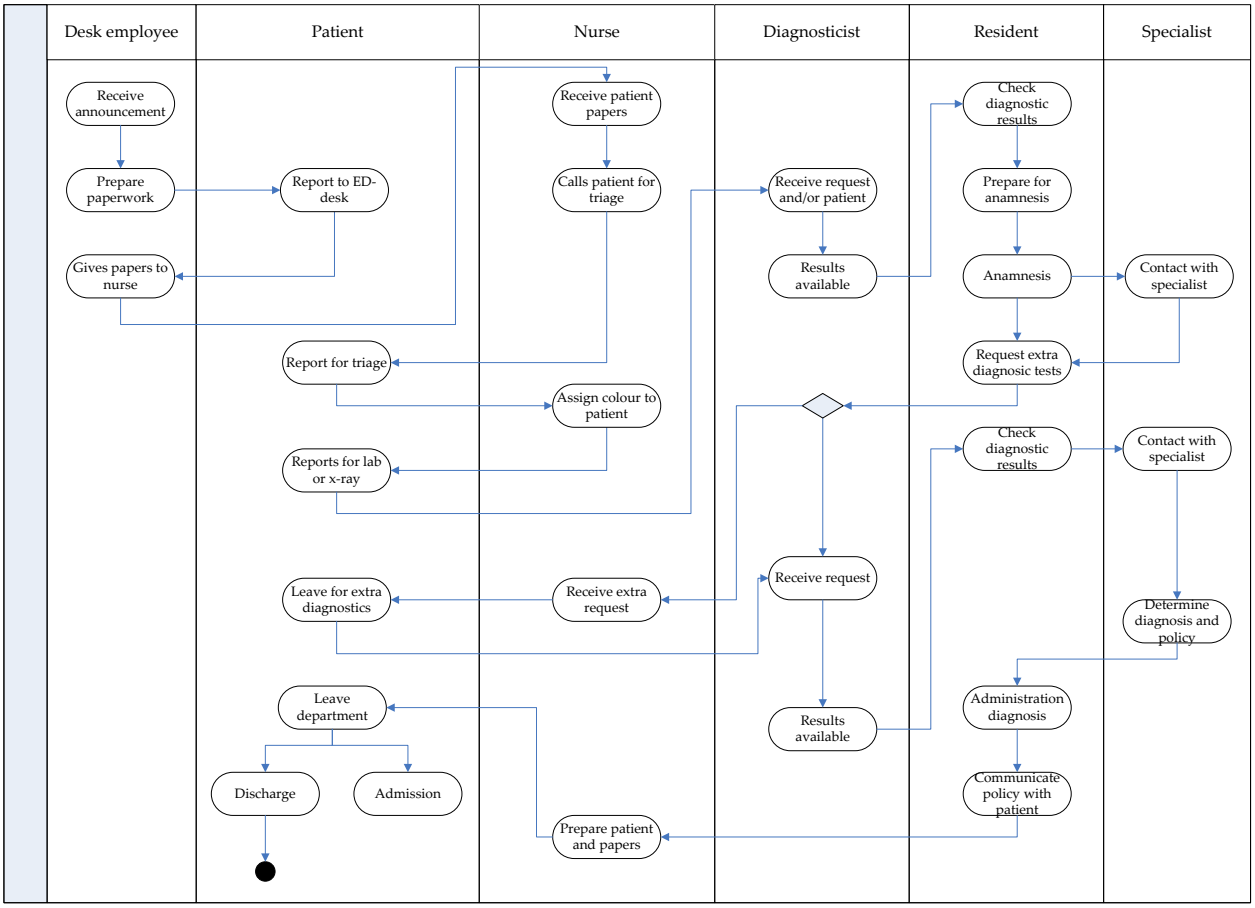
Appendix

Appendix A: Division of specialties into care groups

Total patients visits in 2008			
Care Group 2008	**Specialty**	**# patient**	**% of total**
Care group General Surgery	Surgery (78% trauma)	15519	
	Orthopeadic Surgery (89% trauma)	2003	
	Plastic Surgery	403	
	Revalidation	0	
	Total patients	17925	70%
Care group Internal Medicine	Gastro-enterology	769	
	Internal Medicine	4628	
	Radiotherapy	1	
	Rheumatology	6	
	Total patients	5404	21%
Care group Child and Parent	Gynaecology	169	
	Paediatrics	1438	
	Urology	34	
	Birth Attendences	8	
	Total patients	1649	6%
Caregroup Head and Sensory Organs	Oral Surgery	48	
	ENT medicine	325	
	Neurosurgery	9	
	Neurology	57	
	Ophtalmology	36	
	Psychiatry	10	
	Total patients	485	2%
Else	**Total patients**	57	0,223%
Caregroup Heart and Lungs	Cardiology	16	
	Lung diseases	3	
	Thorax surgery	12	
	Total patients	31	0%
Total patients visits in 2008		**25551**	

Appendix B: Department process



Appendix C: Observation unit to improve patient flow

The (instable) flow of patients out of the ED to the wards causes many (capacity) problems in the wards. The variability law (2.2.2) mentions the possibility to buffer the variability with inventory. As discussed previously, for the arrival of patients this is not an option, but for admission patients this could be. A buffer of admission patients gives extra opportunities to plan the arrival in the wards, which lowers the variability for next step. This gathering of patients is described in literature as an observation unit apart from the ED were patients are transferred for observations. The advantages of such an observation unit are a stable and predictable outflow of demand for the wards and a quicker outflow of patients from the ED.

A study of Roskam (2007) in the AMC hospital researched the opportunities of an observation unit for internal medicine patients. The study mentioned that an observation unit can reduce the amount of inappropriate discharges and unnecessary admissions, improvement of the quality of care for patients who wait for admission, a decrease of high admission pressure on the ward-nurses in the evening and night and an increase of the patient flow through the ED. Pitfalls of an observation unit are the tendency to use the unit inappropriately, which reverses the advantages in disadvantages an observation unit. A lot of admission and discharge criteria are important to avoid this disadvantage. The research concluded that an observation unit is not the right solution to solve logistic problems in the patient flow, although it has benefits for the quality of care for the patients. It only adds capacity to

the internal medicine's wards and the ED, but not solves the capacity and demand problem (Roskam, 2007).

Although it seems like a perfect solution to a difficult problem we recommend avoiding this suggestion, unless the goals of the observation unit are clear and intensify the care for the patient. To improve the patient flow out of the ED we recommend to change elective planning and implement early admission to improve the patient flow from the ED.

Appendix D: Process oriented literature of Schuring & Van der Wiel

Schuring and van der Wiel (2005) explicate the urge to focus on flexibility and innovation to cope with increasing changes and competitive forces in the environment. For the hospital this is a possibility to cope with changing and increasing patient demands. To stimulate this flexibility and innovativeness, the structure of the organisation should make a shift from departmental structure to a focus on process leading structure (Van der Wiel, 2005).

This theory defines a process as a chain of activities to generate a predefined output. It distinguishes three kinds of output:

- Products and services for customers (pull process, executive processes)
- People and resources for business process (push process /executive processes)
- Types of control of the company (control of processes/management)

To adapt to changes in a system, a company have to have the ability to organise in a flexible way. In this process oriented approach, organising means two things; first activate available manpower and resources towards processes. Secondly, group these resources to separate activities within the process with the defined output. In other words: group the staff-members together around activities in a process that need these employees to produce the output, so at the time this process needs people. To determine which staff performs which activities, the management of the ED makes use of an employee role matrix. The matrix enlightens the current skills and expertise of the employee and the preferred learning opportunities and career planning.

The transition from departmental thinking to process thinking also indicates a fundamental change in the hierarchy and relationships of people in the organisation. For employees it differs if you are assigned to a department where you have to perform your own tasks or that you first learn to understand which tasks have to be performed to achieve an output and you determine yourself what your contribution is to achieve the output. Then it doesn't matter for which department and manager you work, but it matters what the essence is of the work you perform to achieve company goals. Employees get the opportunity to participate in controlling the processes and come up with ideas for process-improvements.