# Outpatient Scheduling in the Outpatient Pediatric Center of GHZ

*A simulation study to decrease the patient waiting time and pediatrician overtime*

**Master Thesis Industrial Engineering & Management**
**Marcel van Eijken, April 2010**

Groene Hart Ziekenhuis

Kinder Genees Kunde

Universiteit Twente
de ondernemende universiteit

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***Master thesis***
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***- The change that creates the best performance takes care of the biggest problem. -***

# Preface

This report represents the final stage of my study career. A career that started with the bachelor Biomedical Engineering and ends with the master Industrial Engineering and Management. A career that gave an insight in the world of healthcare bottom up: starting with hip prostheses and stem cells and finishing with optimal outpatient scheduling. Now the time has come to brighten the world with these various experiences.

I thank my supervisors at the University of Twente, Erwin Hans and Peter Hulshof, for all their efforts. I also thank the pediatricians of the GHZ, especially Jurriaan Hoekx and Florens Versteegh, who gave me the opportunity to discover a new world. Also, a special thanks to Peter Lodder and Nico van der Kraan for their efforts in retrieving the correct data. Last but not least I give a special thanks to my friend Richelle for all her support,

Marcel van Eijken,
April 27, 2010

# Management Summary

Pediatricians of the GHZ (Groene Hart Ziekenhuis) experience long overtimes in their outpatient center, while outpatients experience long waiting times. To monitor their performance they set up a time registration system. This study uses the data gathered with this system to analyze the current performance of the outpatient center and to create a discrete event simulation model of a consultation session. We use this simulation model to test the impact of various changes in the current scheduling on the patient waiting time and the pediatrician overtime.

***Motivation and Objective***
Although waiting patients and physicians experiencing overtime are well-known phenomena in outpatient centers, the pediatricians of the GHZ believe that the current performance of their center can be improved on these aspects. To improve the patient waiting time and the pediatrician overtime we focus on the used scheduling methods, i.e. a set of rules that depict in what order and at what times patients are consulted. Our objective is to test various outpatient scheduling methods on their ability to decrease the patient waiting time and pediatrician overtime of the outpatient center.

***The Current Situation***
The outpatient center uses consultation sessions of 3 hours in which 12 patients can be scheduled in slots of 15 minutes each. The center differentiates between new patients and follow-up patients, i.e. follow-up patients are only consulted by a pediatrician, while new patients are first consulted by an intern and then by a pediatrician. Before consulting the new patient, the pediatrician discusses the new patient with the intern after which the pediatrician consults the new patient accompanied by the intern. These different consultations are scheduled in a specific order, the so-called 4-patient cycle: one consultation by an intern of a new patient is scheduled at the same time as three consultations of follow-up patients by a pediatrician. Consultations of new patients are therefore scheduled on specific appointment slots, follow-up patient on the other hand are scheduled arbitrary on one of the other slots.

These outpatient scheduling methods result in an average pediatrician overtime of 24 minutes and an average patient waiting time of 20 minutes for an average of 10 patients per consultation session. Analysis on the flow of patients reveals that consultation durations approach the standard slot size of 15 minutes except for new patients which have average consultation durations of 18 minutes. Also standard deviation of consultations durations varies among patient groups. Another disturbing factor is the 'waiting moment' caused by the 4-patient cycle: either the pediatrician or the intern has to wait for the other to finish his or her consultation before they can both proceed with the new patient.

***Interventions***
We suggest five basic interventions on the current scheduling method to improve the pediatrician overtime and patient waiting time. (1) Bailey-Welch rule, i.e. scheduling of two patients on the initial slot. This creates a buffer of patients reducing the probability of the pediatrician staying idle. (2) Variable slot, i.e. increasing the slot size of new patients to 20 minutes. This creates a better match between the slot size and the consultation duration of new patients. (3) Flexible 4-patient cycle, shifting the appointment slot of the follow-up patients succeeding the new patient fifteen minutes forwards. This gives the pediatrician the opportunity to consult another patient instead of waiting for the intern to finish his or her consultation. (4) LVBEG rule ('low variance beginning' rule), i.e. the scheduling of patients with low variance on consultation duration at the beginning of the consultation session and patients with a high variance at the end of the consultation session. By grouping patients with low variance on consultation duration at the beginning of the consultation session, the probability of delayed consultations at the start of the consultation session is reduced. (5) Allocation rule, i.e. introducing a sequence in which appointment slots are filled: starting with the first slot and continue with the successive slots. The rule prevents a scheduling in which appointment slots in the middle of the consultation session are left open. Besides these basic interventions, we create another twelve interventions through combinations of the five basic interventions.

***Analysis of Interventions***
Since the various interventions change the currently used scheduling rules for consultation sessions, we build a simulation model of a consultation session to compare the impact of the interventions with the current scheduling. We use two scenarios to examine the performance of the various interventions. (1) Historical, i.e.

the representation of the current situation of the outpatient center. (2) Maximum utilization, i.e. a situation in which all appointment slots are filled. Instead of appointing one of the interventions as the 'winner', we use an efficient frontier to select a group of interventions that organize the consultation session most efficiently according to the patient waiting time and the pediatrician overtime. Three interventions are present on the efficient frontier of both scenarios (1) and (2): (A) the flexible 4-patient cycle, (B) a combination of the LVBEG rule and the flexible 4-patient cycle and (C) a combination of the LVBEG rule, the Bailey-Welch rule and the flexible 4-patient cycle. These interventions have the ability to reduce the patient waiting time up to 10 % or the pediatrician overtime up to 20 %.

***Conclusion***

The three best performing interventions have the flexible 4-patient cycle in common, an intervention that alters the strict sequence in which consultations have to take place. Therefore the most valuable conclusion is not that performance can be increased but that the pediatric department has to loosen the strict sequence in which consultations have to take place.

# Content

# Glossary

***Patients***

| | | |
|---|---|---|
| Outpatient | : | A patient who visits the hospital but does not get admitted |
| Inpatient | : | A patient who is scheduled to get admitted in the hospital |
| Emergency patient | : | A patient who is not scheduled but needs medical attention immediately |

***Organizational Structure***

| | | |
|---|---|---|
| Groene Hart Ziekenhuis (GHZ) | : | Hospital of the city Gouda and the surrounding villages |
| Department of pediatrics | : | The pediatric department of GHZ |
| Outpatient pediatric center | : | Pediatric center for outpatients |
| Inpatient pediatric center | : | Pediatric center for inpatients |
| Pediatric daycare center | : | Pediatric center for day treatments |

***Employees***

| | | |
|---|---|---|
| Pediatrician | : | Physician specialized in child care |
| Resident | : | A qualified doctor training to become specialist |
| Intern | : | A medicine student undergoing supervised practical training |
| Nurse | : | A person educated and trained to care for the sick or disabled |
| Pediatric nurse | : | A nurse specialized in pediatrics |
| Secretary | : | A person employed to handle correspondence, keep files, and do clerical work for another person or an organization |

***Processes***

| | | |
|---|---|---|
| Consultation | : | A pediatrician consulting a patient |
| Consultation session | : | Multiple consultations in a multiple hour session |
| Special consultation session | : | A consultation session for a specific patient group |

# 1 - Introduction

Pediatricians of the GHZ are familiar with long admission times for follow-up patients, full consultation sessions, long patient waiting times and a high workload on their outpatient center. Although waiting patients and physicians experiencing overtime are well-known experiences in outpatient centers, the pediatricians of the GHZ believe that the current performance of their center on these aspects can be improved. Therefore this research report focuses on the performance of consultation sessions on the outpatient center of the pediatric department of Groene Hart Ziekenhuis (GHZ) in Gouda. We build a simulation model to test various ways to schedule patients with the objective to decrease the patient waiting time and the pediatrician overtime. In this chapter we introduce GHZ and its pediatric department (Section 1.1), give the motivation for this research (Section 1.2) and state the research objective and approach (Section 1.3).

## 1.1 - 'Groene Hart Ziekenhuis' and its Pediatric Department

Groene Hart Ziekenhuis (GHZ) is created in 1992 by a merger of the two hospitals 'Bleuland' and 'Sint Jozef', and is situated on the locations of these former hospitals. Besides these two locations, GHZ also has an outpatient center in Nieuwekerk aan de IJssel. The hospital treats patients of the city Gouda as well as the surrounding villages. 125 specialists work in the hospital together with 2000 employees. GHZ is a top clinical hospital, which means, among other things, that it distinguishes itself by offering special treatments and contributing in education. Figure 1.1 shows the organizational structure of GHZ.

***Mission***

The mission of GHZ is: "*to make the hospital the logical choice for seeking healthcare services*". The corresponding vision is to be a modern, flexible and decisive hospital for the citizens of Gouda and the surrounding region and to offer good quality healthcare services in a hospitable environment. GHZ also wants to be a good employer by offering educational possibilities and an inspiring atmosphere at work.

***Department of Pediatrics***

The pediatric department is located in the 'Sint Jozef'-building and is divided in three sections which are located on different floors: the outpatient section, the inpatient section and the day-care center. The department of pediatrics employs seven pediatricians, seven residents and six or seven interns. Annually the pediatric department has 12.000 patient contacts of which 4.500 are administrative first consults.

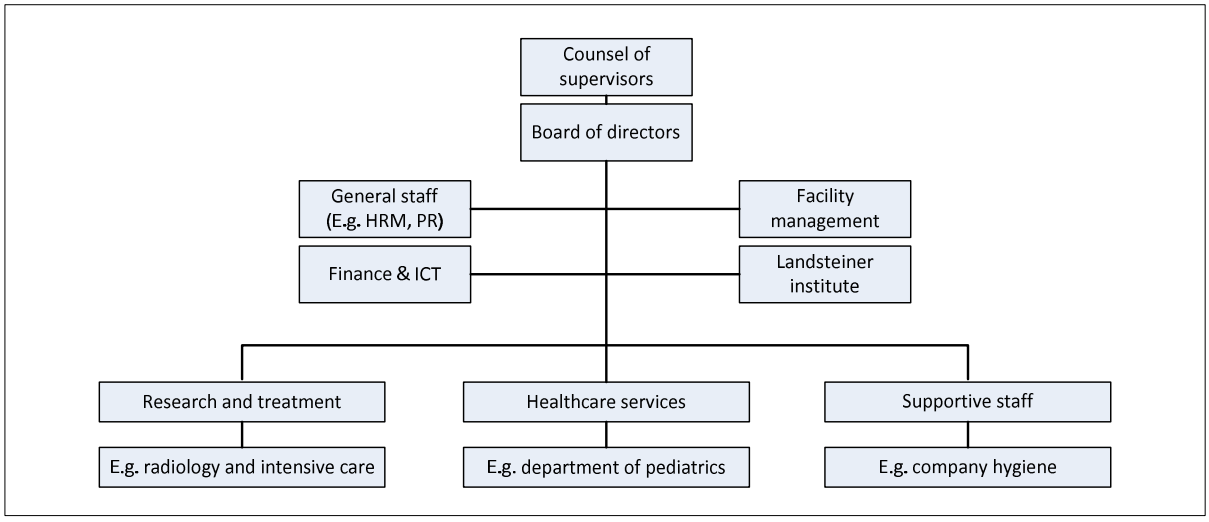


*Figure 1.1 - Organizational chart of the GHZ*

## 1.2 - Motivation for this Research

In 2007 a study was conducted on the efficiency of the pediatric department [Schrama, 2007] which stated the situation at the department of pediatrics as follows: *"The outpatient section of the pediatric department of the GHZ experiences long admission times for follow-up patients, full consultation sessions, long patient waiting times and a high workload of pediatricians."* The study recommends a simulation study to investigate the effect of changes in the appointment system on overtime and waiting time, e.g. to investigate the effect of changing the size of appointments on the overtime of pediatricians. A requirement of this simulation study was the gathering of data on the flow of patients to analyze the current situation. Therefore the pediatric department created a time registration system with which time-based data on the flow of outpatients was gathered, starting in March 2008. Our research is the recommended follow-up study.

## 1.3 - Research Objectives and Approach

Our objective is to test various outpatient scheduling methods on their ability to decrease the patient waiting time and pediatrician overtime of the outpatient center. We focus on scheduling methods because patient waiting time and pediatrician overtime are shaped by the used scheduling methods, i.e. a set of rules that depict in what order and at what times patients are consulted. Changes in the currently used scheduling methods can positively influence the patient waiting time and/or pediatrician overtime. Therefore we formulate the following research questions:

1. How is the outpatient center organized and what methods does it use to schedule patients? (Section 2.1 and 2.2)
2. What is the current performance of the outpatient center? (Section 2.3)
3. What scheduling methods have the ability to improve the current scheduling of outpatients on the outpatient center? (Chapter 3)
4. What is the impact of these scheduling methods on the performance of the system measured by the patient waiting time and pediatrician overtime? (Chapter 4 and 5)

We answer the first question by a context analysis: Section 2.1 describes the organization of consultation sessions and Section 2.2 explains various management decisions that create the current scheduling of outpatients. The performance of the outpatient center (Question 2) is explained in Section 2.3 and is based on gathered data on the flow of patients. This makes the calculation of various performance indicators possible, e.g. the patient waiting time. The third question is answered in Chapter 3: based on our context analysis and suggestions from the literature on outpatient scheduling, we formulate various scheduling rules that have the ability to increase performance of the outpatient center. We test these rules with a simulation model of a consultation session (Question 4). The various parts of the simulation model and the different steps in this simulation study are explained in Chapter 4. The conclusion and implementation are stated in Chapter 5.

# 2 - Context Description

This context description focuses on the process of a consultation. We describe the components shaping a single consultation in Section 2.1 and the scheduling of patients with the use of consultation sessions in Section 2.2. In Section 2.3 we state the current performance, which we discuss in Section 2.4.

## 2.1 - Process of a Consultation

We describe the process of a consultation by describing the various persons involved (Section 2.1.1) and by the different steps a patient follows (Section 2.1.2). Figure 2.1 gives an overview of this process.

### 2.1.1 - Persons Involved in a Consultation

The main persons involved in a consultation are: a patient, a pediatrician, an intern and a secretary. This section describes the characteristics of these persons.

***Patients***

In a pediatric department, the patient base involves children under the age of 18. Therefore, the patient is almost always accompanied by one or two parents. Since the patient base of the pediatric department is based on age instead of a specific disease, patients can suffer from all different kinds of diseases. Most consultations are filled by patients with Asthma and ADHD (see Table 2.1).

Three types of patients visit the outpatient center: new patients, follow-up patients and urgent patients. In case of a new patient the department strives to consult these patients within a week. The new patient is first consulted by an intern and then by a pediatrician. Follow-up patients are only consulted by a pediatrician. Urgent patients are consulted as soon as possible, separately from the new and follow-up patients.

***Pediatricians***

The pediatric department employs seven pediatricians: physicians who are specialized in child health care. Each of these pediatricians has one or more specialties in specific areas of child health care (see Table 2.2). Therefore the patient base of every pediatrician differs from the total patient base (see Figure 2.2 for a comparison based on the three most frequent diagnoses and see Appendix D1 for overviews of the frequency of diagnoses for every pediatrician).

Every weekday the pediatricians start with a general meeting about the status of the inpatients. After this meeting the pediatricians continue with their own duties, which can either be a consultation session, duties on the inpatient section, directing residents or interns or study duties. Besides weekdays the pediatricians also have weekend and night shifts for which the pediatricians take turns. Once a week, all the pediatricians visit the inpatient section, which takes a whole morning.

***Secretaries***

Every secretary is appointed to a specific pediatrician. In case the pediatrician has a consultation session, the secretary assists by carrying out a basic examination which comes down to measuring the weight and length of the visiting patients. After this basic examination, the secretary updates the patients' medical record with these new data and gives the pediatrician the medical record. In case the pediatrician does not have a consultation session the secretaries either prepares the next consultation session or takes phone calls.

***Interns***

In the outpatient center, six or seven interns are in training. Every consultation session, these interns consult the new patients. After a consultation by an intern, the intern discusses the patient with the pediatrician, after which the pediatrician starts the consultation with the new patient together with the intern.

***Other Personnel***

Besides pediatricians, secretaries and interns, the pediatric department contains three other groups of employees. There is a group of seven pediatric residents: physicians who are in training to be a pediatrician and who have their own consultation sessions. There are also nurses who are specialized in pediatrics and assist with urgent patients and the group of front desk personnel with whom the patient checks in and out.

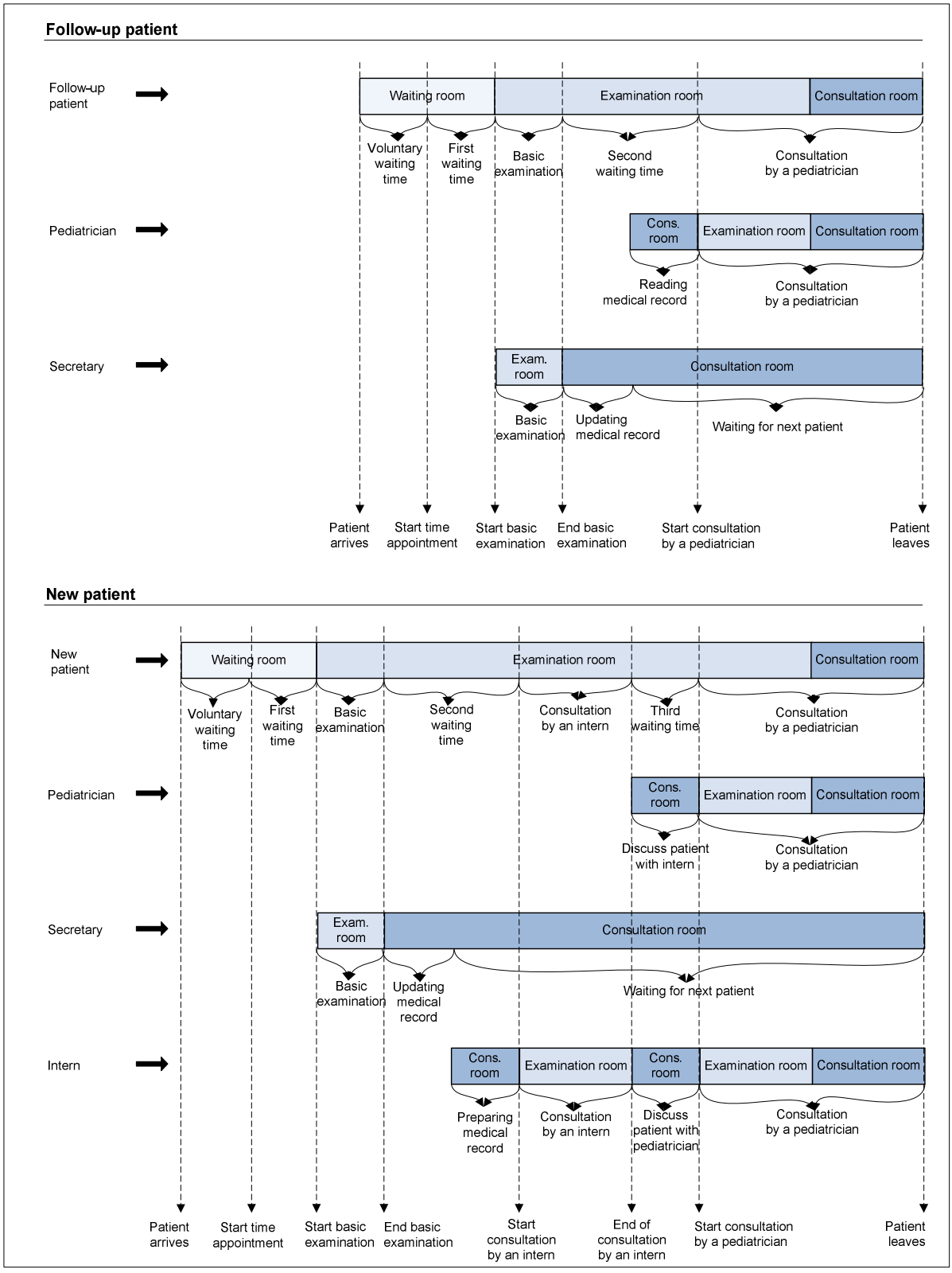


*Figure 2.1 - Outpatient flow model for new and follow-up patients*

| Occurrence of diagnoses | | | | | |
|---|---|---|---|---|---|
| *Diagnosis* | *Consultation count* | *Percentage* | *Diagnosis* | *Consultation count* | *Percentage* |
| Asthma | 1663 | 25,52 % | Urinary tract infection, no anatomical deviation | 59 | 0,91 % |
| ADHD | 747 | 11,46 % | | | |
| Constipation (habitual) | 404 | 6,20 % | Down syndrome | 58 | 0,89 % |
| Follow-up neonatal problems (no Neonatal intensive-care unit) | 273 | 4,19 % | Depression/Fatigue (no chronic fatigue syndrome) | 58 | 0,89 % |
| Atop syndrome | 250 | 3,84 % | Upper respiratory infection | 56 | 0,86 % |
| Small body height/ deviating growth curve | 213 | 3,27 % | Hypothyroidism (CHT among other things) | 53 | 0,81 % |
| Food allergy (cow's milk among other things) | 141 | 2,16 % | Heart murmur, harmless | 50 | 0,77 % |
| | | | Abdominal pain, chronically recurrent | 48 | 0,74 % |
| Gastro-esophageal reflux | 130 | 1,99 % | | | |
| Follow-up "Neonatal intensive-care unit"-population | 106 | 1,63 % | Urinary tract infection, anatomical deviation | 47 | 0,72 % |
| Psychiatric disorders | 104 | 1,60 % | Obesity | 46 | 0,71 % |
| Remaining psychosocial problems | 101 | 1,55 % | Failure-to-thrive eci | 44 | 0,68 % |
| | | | Lower respiratory infection | 41 | 0,63 % |
| Epilepsy | 98 | 1,50 % | Headache (no migraine) | 40 | 0,61 % |
| Mental and motorial retardation | 97 | 1,49 % | Speech (developmental) impediment | 40 | 0,61 % |
| Atop syndrome | 67 | 1,03 % | Anemia, remaining | 40 | 0,61 % |
| Feeding problems/-mistakes | 66 | 1,01 % | Dysfunctional voiding | 38 | 0,58 % |

*Table 2.1 - An overview of different diagnoses and the corresponding percentage of occupied consultations (based on data gathered from May 6th 2008 until August 31st 2009).*

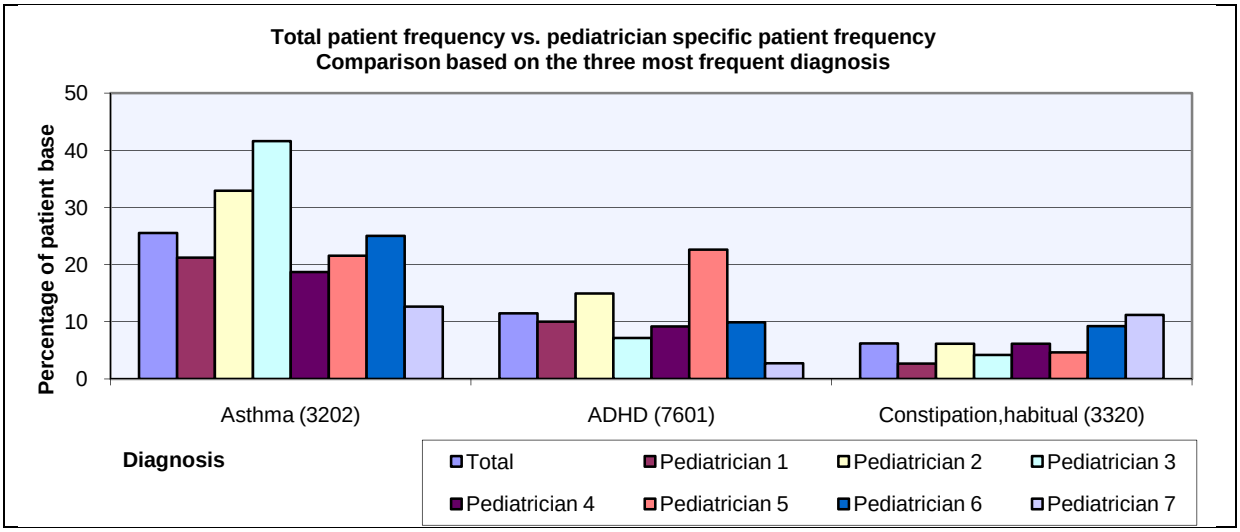


*Figure 2.2 - Comparison of the patient base of pediatricians based on the three largest patient groups that come for consultation (based on data gathered from May 6th 2008 until August 31st 2009, see Appendix D1 for number of consultations).*

| Pediatrician and their specialties | |
|---|---|
| *Pediatrician* | *Specialties* |
| xxxxxx | - Pediatric endocrinology, pediatric neurology and children with multiple disabilities |
| xxxxxx | - Allergies |
| xxxxxx | - Neonatal care |
| xxxxxx | - Pediatric cardiology |
| xxxxxx | - Diabetes mellitus and psychosocial pediatrics |
| xxxxxx | - Pediatric respiratory diseases, pediatric inflammations and hematology (no malignancy) |
| xxxxxx | - Neonatal care and oncology |

*Table 2.2 - The pediatricians of the GHZ and their specialties*

### 2.1.2 - Consultation

In this section, we describe the process of a consultation by the different steps a patient follows and how the pediatrician, the secretary and the intern participate in these steps. The four basic steps are: the arrival of a patient, the basic examination, the consultation and the exit of a patient. Figure 2.1 and 2.3 clarify these steps. In Figure 2.3 visualizes the actual route the patient follows through the outpatient center on the map of the outpatient center. Figure 2.1 on the other hand, gives the outpatient flow model for new and follow-up patients. The model clarifies the relationships between the four basic steps and various time windows which can be distinguished in the visit of an outpatient, e.g. waiting time and consultation duration.

***1. Arrival of a patient***

In most cases, the patient arrives before the official appointment time. The patient checks in at the front desk where he or she is registered as 'arrived', gets a cup of coffee and waits in the waiting room. During the visit the patient can experience waiting time. The experienced waiting time can be separated in 'voluntary waiting time' and 'first waiting time'. 'Voluntary waiting time' is the time between the arrival of the patient and the start time of the appointment or the start of the consultation in case the consultation starts earlier than planned. 'First waiting time' is the time between the start time of the appointment and the actual start of the consultation.

***2. Basic examination***

The secretary of the pediatrician leads the patient, in case an examination room is free, to one of the examination rooms. There, the patient is asked to undress and the weight and the length of the patient are measured. The secretary makes sure that no examination room is unused. After this time window, the so-called 'basic examination time', the patient can experience a 'second waiting time' in which the patient waits for the pediatrician or the intern to start the consultation.

***3. Consultation***

After the basic examination, the secretary updates the medical record with the patient's current weight and length after which the consultation with the pediatrician can start. In case of a new patient, the patient gets a consultation by an intern first. The consultation by a pediatrician starts with the pediatrician going through the medical record, after which he or she meets the patient. This patient contact starts with an examination, for example measuring the patients' blood pressure and therefore takes place in the examination room. After the examination is done, the pediatrician can choose to continue the consultation in either the examination or the consultation room. One of the pediatricians chooses to end the consultations in the examination room while the other six end the consultation in the consultation room. For the consultation by an intern, 45 minutes are available in which the intern prepares the medical record, consults the patient and updates his or her record. If this is done, the intern talks with the pediatrician about the patient after which the consultation by a pediatrician can start, together with the intern.

***4. Patient leaves***

When the consultation is done, the patient goes to the front desk again for another appointment or leaves without another appointment. Another possibility is a direct referral to the inpatient section of the pediatric department or a referral to an external examination in one of the other departments of the GHZ.

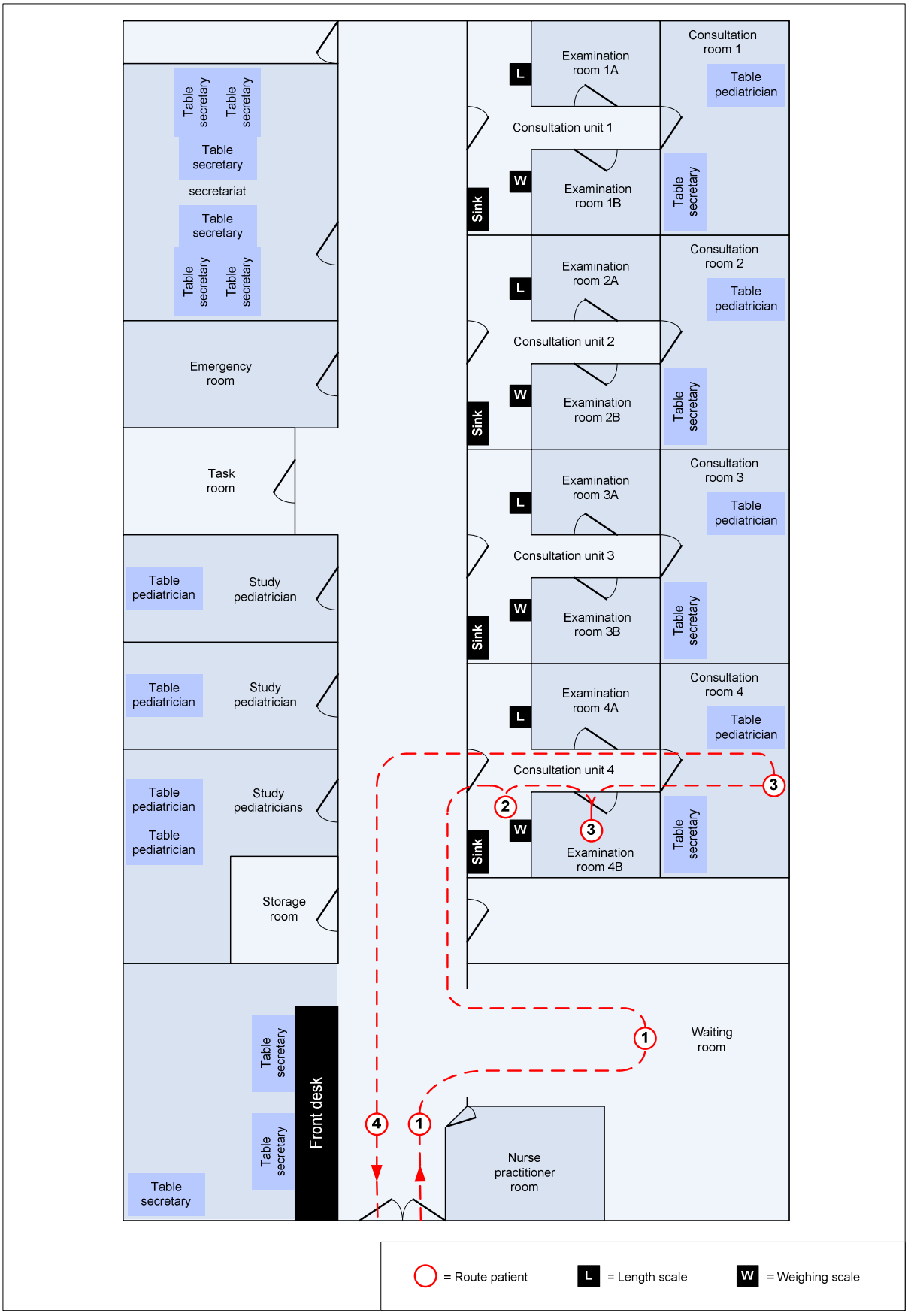


*Figure 2.3 - Map of the outpatient pediatric department and the route of outpatient consulting a pediatrician in consultation unit 4*

## 2.2 - Management Levels

The management decisions that eventually result in the day-to-day activities are discussed using a framework for hospital planning and control [Hans et al, 2006] (see Figure 2.4). This framework clarifies the relationships between the four levels of control in different managerial areas. For this research, the main area of interest is the resource capacity planning.

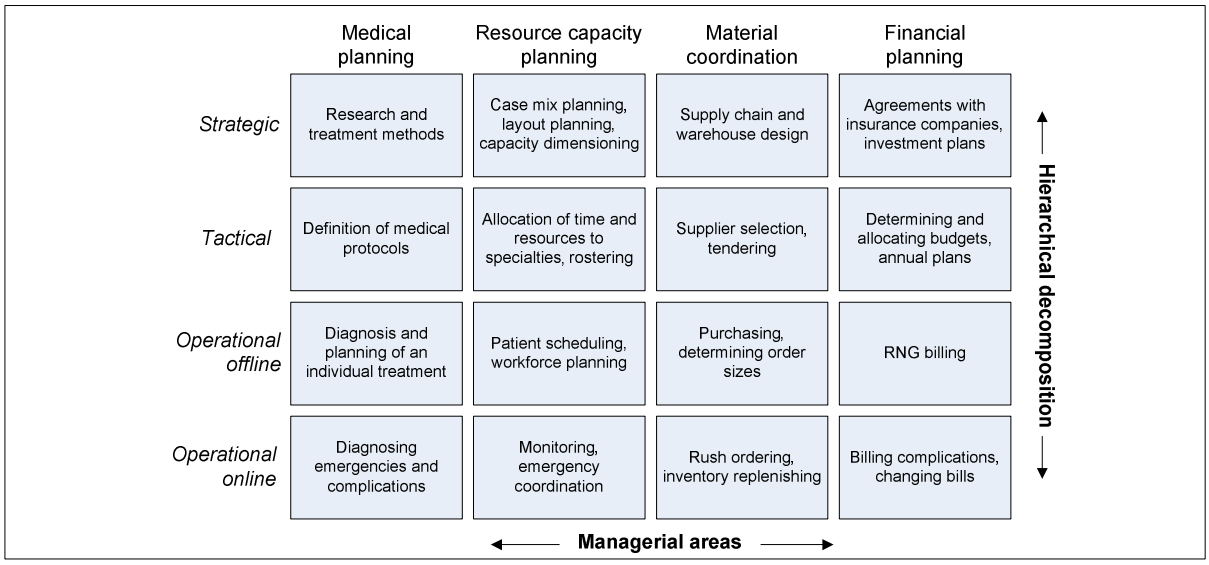


*Figure 2.4 - Framework for hospital planning and control [Hans et al, 2006]*

### 2.2.1 - Strategic Management Level

Management on the strategic level concerns the organization's long term goals. A strategic management decision that has a great impact on how the pediatric outpatient center currently operates is the choice to give the GHZ a top clinical character. This means that the hospital contributes to education. Therefore every six weeks, a new group of six of seven interns is trained on the pediatric department by consulting new patients. Besides the interns, the department also educates seven residents, who stay a longer period (approximately two years).

### 2.2.2 - Tactical Management Level

Management on the tactical level concerns medium term objectives. For the pediatric department these management decisions result in the annual work schedule. This schedule is made by one of the pediatricians and is formed by the following tactical management decisions:

***Number of pediatricians***
In the past couple of years, the number of pediatricians has grown to seven.

***Scheduling pediatricians on either the inpatient or outpatient section***
Every two weeks, a different pediatrician is allocated on the inpatient section. Since there are seven pediatricians, there is a fourteen week cycle in which every pediatrician is allocated on the inpatient section for two weeks and on the outpatient section for twelve weeks.

***Separating urgent patients***
A couple of years ago, the pediatricians chose to separate the care of urgent patients from the care of outpatients, i.e. pediatricians are allocated on either consultation sessions for outpatients or on the care of urgent patients that arrive in the outpatient center.

***Usage of consultation rooms***
During a consultation session, a pediatrician uses one consultation unit. A consultation unit consists of one consultation room and two examination rooms: one for the intern and one for the pediatrician.

***Differentiating consultation sessions***
The pediatricians choose to create three kinds of consultation sessions: the 'basic' general consultation sessions, special consultation sessions and consultation sessions by phone. During the weeks that a

pediatrician has his or her duties in the outpatient center, the pediatrician has three general consultation sessions on specific times (see Figure 2.5) in specific consultation units and one consultation session by phone, e.g. to tell patients the results of a test. For the group of pediatric residents, four general consultation sessions per week are available. The special consultation sessions are created for specific patient groups. Reasons for these deviating consultation sessions are the size of the patient group or the complicated disease for which a consultation by more than one health care professional is necessary (see Appendix B).

### 2.2.3 - Operational Offline Management Level

The operational offline management level comes down to detailed plans and schedules to control the day-to-day activities. For the outpatient center these day-to-day activities are the consultations of patients by pediatricians which are scheduled in consultation sessions with the use of an appointment system.

*We describe the appointment system with the use of various parameters mentioned in the literature on appointment systems (see Table 2.4). The currently used appointment system schedules patients into consultation sessions which take place from Monday to Friday from 9 a.m. to 12 a.m. and from 2 p.m. to 5 p.m. The system does not use patient classification to determine the size of the appointment slots, but uses intervals of 15 minutes and schedules one patient per slot, i.e. a consultation by a pediatrician is scheduled in a slot of 15 minutes (see Figure 2.6). Patients are consulted in the order that they are scheduled, and there is no specific discipline on how to handle no-shows.*

Since interns are trained in performing consultations, patients are scheduled in a specific sequence. A group of 3 follow-up patients and 1 new patient form a 4-patient cycle which is repeated two times during a consultation session. Figure 2.7 gives an overview of the allocation of personnel and the usage of the consultation unit for this 4-patient cycle.

| Definitions of Descriptive Parameters of an Appointment System | | |
|---|---|---|
| Appointment interval | : | Scheduled time windows between appointments |
| Block size | : | Number of patients that are scheduled in the $i^{th}$ block |
| Initial block size | : | Number of patients that are scheduled at the start of the consultation session |
| Queue discipline | : | Rule that depicts who is consulted next, e.g. first-come first-served |
| Patient classification | : | The use of patient classification to determine the size of the appointment slot |
| No-shows discipline | : | Rules that depict how to handle with disruptive effects of no-shows, e.g. overbooking: planning more patients than available slots |

*Table 2.4 - Definitions of descriptive parameters of an appointment system based on literature [Cayirli, 2003]*

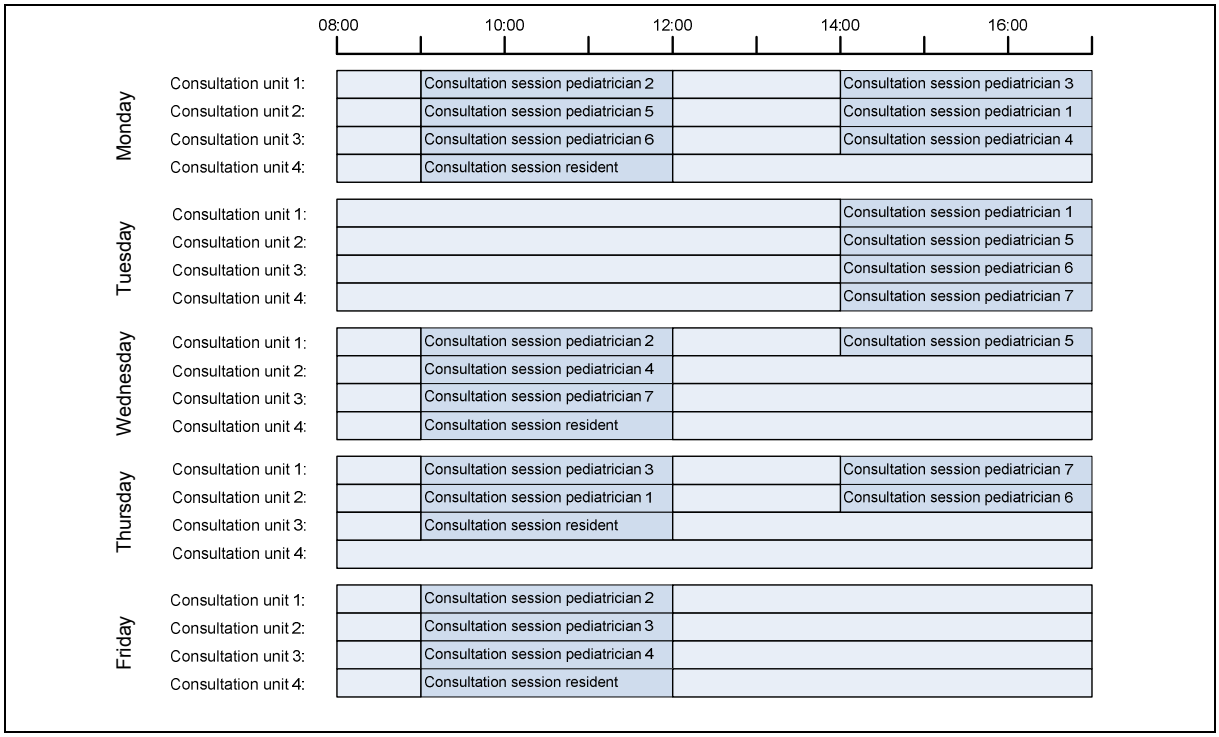


*Figure 2.5 - Overview of the usage of the capacity of consultation units*

### 2.2.4 - Operational Online Management Level

The operational online management level handles disturbances within the offline schedule. Since urgent patients are consulted separately from outpatients, the inflow of urgent patients does not disturb the scheduled consultations. New patients that have to visit the center within a week do disturb the scheduled consultation sessions. In this case these consultations are planned outside the outpatient consultation sessions.

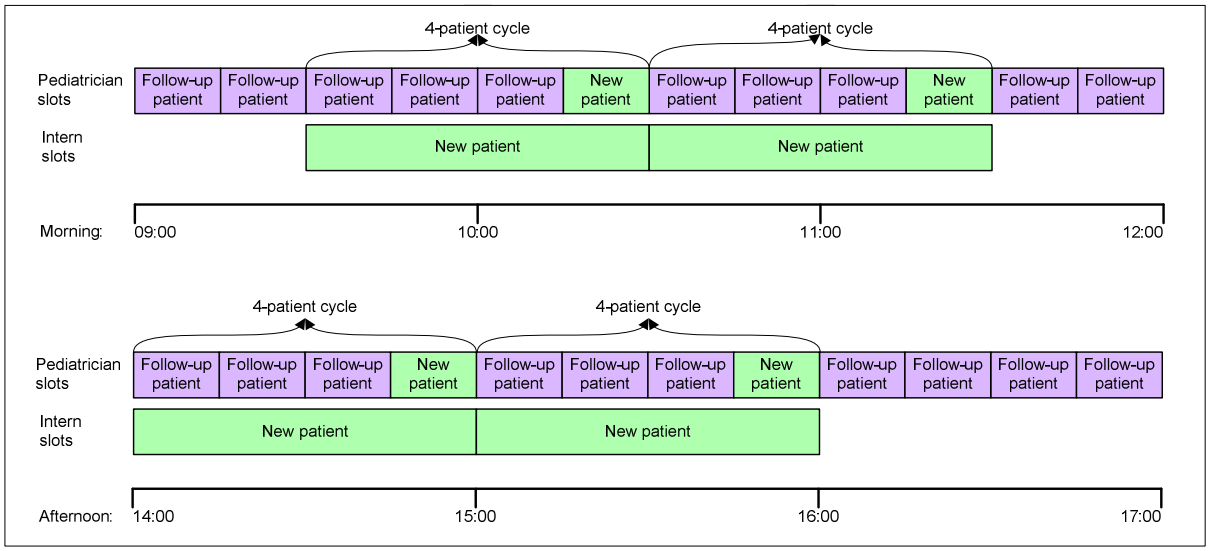


*Figure 2.6 - Appointment time slots of a consultation session*

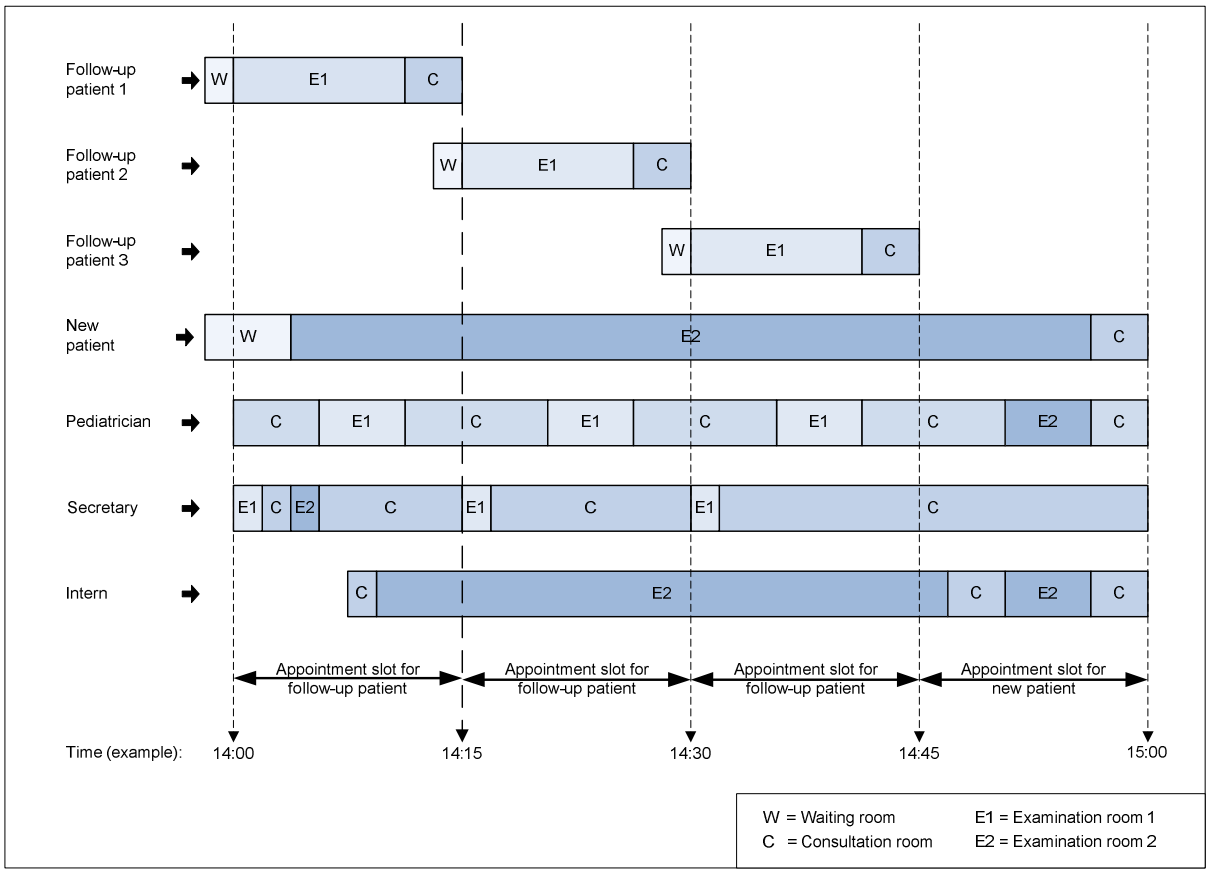


*Figure 2.7 - The allocation of personnel and rooms for a 4-patient cycle*

## 2.3 - Performance

This section gives an overview of the performance of the process of a consultation session. We describe the utilization of both consultation units (Section 2.3.2) and appointment slots (Section 2.3.3). We also present a quantification of the current system with the use of performance indicators (Section 2.3.4). The performance indicators quantify the performance of the system in for example waiting time and overtime. The calculation of these indicators is possible because the pediatric department has set up a time registration system. The gathered data can be transformed into indicators describing the current state of the system (see Section 2.3.1).

### 2.3.1 - Transforming Data into Parameters

The employees of the pediatric department gather data on the flow of patients through the pediatric department (see Appendix C1). This data is used to retrieve parameters like the waiting time or number of no-shows. Since the data contains flaws or fragmented registrations (see Appendix C2), 'basic selection criteria' are created (see Appendix C3). With these selection criteria, inaccurate entered data caused by human mistakes is excluded as well as the special consultation sessions of the pediatricians and special and regular consultation sessions of other employees of the pediatric department. Despite the 'basic selection criteria' the selected data can still be fragmented or contain flaws. To determine a parameter, parameter specific selection criteria have to be met (see Appendix D). The determination of the parameter 'the consultation duration' for example needs two registrations: one of the beginning of the consultation and one of the end of a consultation unlike the parameter 'kind of patients' which only needs one registration to determine the parameter.

### 2.3.2 - Utilization of Consultation Units

The consultation units can be used from 9 a.m. until 5 p.m. from Monday morning until Friday afternoon. Since there are 4 consultation units, 160 hours per week are available to schedule patients. How these 160 hours are used is presented in table 2.5. Due to lunch breaks, a weekly visit to the inpatient section of all pediatricians and staff-meetings, 54 % of the available time the consultation units are not used.

### 2.3.3 - Utilization of Appointment Slots

In a general consultation session, twelve appointment slots are available for consultations by a pediatrician. Two of those slots are especially for new patients and the remaining slots are used for follow-up patients. These twelve slots are not always filled, i.e. a consultation session does not always contain 10 follow-up patients and 2 new patients (see Table 2.6 and Table 2.7). On average, a consultation session contains 1,82 new patients and 7,77 follow-up patients.

There are two main reasons for the variation in utilization. The first reason is the occurrence of natural events like no-shows: patients who have an appointment but do not show up. Also the connection between the season and the occurrence of specific diseases results in variation of utilization causing both under and over-utilization. The second reason is the existence of partial consultation sessions: sessions from which not all slots are scheduled caused by other commitments of the pediatrician.

Since no specific allocation rule is used that depicts in what order appointment slots should be filled, the usage of appointment slots has a stochastic character. To describe this utilization of appointment slots we determined the usage of every slot for every combination of follow-up patients and new patients, e.g. in case of seven follow-up patients and two new patients, the first slot (9:00 a.m. until 9:15 a.m.) is used in 4 % of the cases. For details on the calculation of this appointment slot utilization see Appendix D2.

| Utilization of consultation units | |
|---|---|
| *Usages* | *Scheduled hours per week* |
| General consultation sessions | |
| There are three consultation sessions scheduled for six pediatricians. Each session is scheduled for three hours. | 54:00 |
| There are four consultation sessions scheduled for the pediatric residents. Each session is scheduled for three hours. | 12:00 |
| Special consultation sessions | |
| Cardio-session, scheduled once every four weeks for three hours | 00:45 |
| Diabetes-session, scheduled three or four times per year for three hours | 00:15 |
| Allergy-session, scheduled once every two weeks for three hours | 01:30 |
| GO-session, scheduled once every two weeks for three hours | 01:30 |
| PIPO-session, scheduled once every four weeks for three hours | 00:45 |
| Down-team, scheduled three or four times per year for three hours | 00:15 |
| Goldfish-session, scheduled once every two weeks for three hours | 01:30 |
| Rehabilitation-session, scheduled six until eight times a year for three hours | 00:30 |
| Lunch break | 40:00 |
| Not scheduled | 47:00 |
| **Total hours available per week:** | **160:00** |

*Table 2.5 - The usage of consultation units in hours per week*

| Number of new patients per consultation session | | |
|---|---|---|
| *Number of new patients on a consultation session* | *Number of consultations* | *Percentage of consultations* |
| 0 | 47 | 7,34 % |
| 1 | 83 | 12,97 % |
| 2 | 453 | 70,78 % |
| 3 | 55 | 8,59 % |
| 4 | 2 | 0,31 % |
| **Total:** | **640** | **100,00 %** |

*Table 2.6 - Number of new patients per consultation session (based on data gathered from May 6th 2008 until August 31th 2009)*

| Number of follow-up patients per consultation session | | |
|---|---|---|
| *Number of follow-up patients on a consultation session* | *Number of consultations* | *Percentage of consultations* |
| 0 | 12 | 1,88 % |
| 1 | 18 | 2,81 % |
| 2 | 16 | 2,50 % |
| 3 | 33 | 5,16 % |
| 4 | 25 | 3,91 % |
| 5 | 38 | 5,94 % |
| 6 | 35 | 5,47 % |
| 7 | 54 | 8,44 % |
| 8 | 87 | 13,59 % |
| 9 | 112 | 17,50 % |
| 10 | 115 | 17,97 % |
| 11 | 57 | 8,91 % |
| 12 | 29 | 4,53 % |
| 13 | 9 | 1,41 % |
| **Total:** | **640** | **100,00 %** |

*Table 2.7 - Number of follow-up patients per consultation session (based on data gathered from May 6th 2008 until August 31th 2009)*

### 2.3.4 - Performance of the Current Appointment System

We measure the performance of an appointment system by calculating various performance indicators. The performance indicators together describe the state of the system. Well-known examples of performance indicators are patients waiting time and pediatrician overtime [Cayirli, 2003]. Together these two values describe the state of the used appointment system, which makes comparison with other appointment systems possible. This section starts with an overview of the definitions of the used performance indicators followed by an example before stating the outcomes.

***Performance indicators: definitions***

Table 2.8 gives an overview of the performance indicators which are calculated for the currently used appointment system. It are indicators from the literature on outpatient scheduling [Cayirli, 2003], which we fit to the currently used appointment system.

| **Definitions of performance indicators** | | |
|---|---|---|
| *Pediatrician* | | |
| Accuracy of pediatrician | : | The accuracy of the pediatrician to show up on time, i.e. the time window between the scheduled start of the consultation session and the time at which the pediatrician shows up. |
| Idle time of pediatrician | : | The sum of various time windows within a consultation session in which the pediatrician does not consult a patient. |
| Overtime of pediatrician | : | The time window between the end of the last scheduled appointment and the actual time at which the pediatrician ends this appointment. |
| *Interns* | | |
| Accuracy of the interns | : | The accuracy of the intern to show up on time, i.e. the time window between the scheduled start of the consultation session and the time at which the intern shows up. |
| Duration of consultation by an intern | : | The time window in which the intern consults the patient. |
| *Patients* | | |
| No-shows | : | Percentage of the patients that are scheduled but never show up. |
| Second consultations | : | Percentage of the patients that are sent to another department in the hospital (for an external examination) before seeing the doctor again. |
| External examination | : | Time window between leaving the pediatric department and returning to the pediatric department for a second consultation. |
| Waiting time | : | Sum of all waiting times a patient experiences during his of her visit to the pediatric outpatient center. |
| -Voluntary waiting time | : | Waiting time caused by the early arrival of the patient: time window between the arrival of the patient and the scheduled start time of the appointment or the start of the consultation in case the consultation starts earlier than planned. |
| -Total system waiting time | : | Sum of the waiting times caused by the pediatric department. |
| -First waiting time | : | The time window between the scheduled start time of the appointment and the time at which the patient enters the examination room. |
| -Second waiting time | : | The time window between entering the examination room and the start of the consultation with either the intern or the pediatrician. |
| -Third waiting time | : | The third waiting time is only applicable for new patients that get a consultation by an intern first and have to wait between the end of this consultation by an intern and the start of the consultation by a pediatrician. |
| Consultation duration | : | The time window in which the pediatrician consults the patient. |
| *Secretaries* | | |
| Idle time of secretaries | : | The sum of various time windows within a consultation session in which the secretary is not devoted to patient care, but to other tasks. |

*Table 2.8 - Definitions of performance indicators*

***Performance indicators: example***

To emphasize the importance and the relationships between these performance indicators, an example of the difference between the scheduled situation and the actual situation is visualized in Figure 2.8. In the scheduled situation, everybody arrives on time and the consultation durations take as long as planned. In the disturbed situation on the other hand, the pediatrician arrives later than planned, causing more waiting time for the first two follow-up patients. The third follow-up patient is a no-show, causing the idle time of the pediatrician and the secretary to increase. A third disturbance is a longer than planned consultation duration of the new patient, causing overtime for the pediatrician.

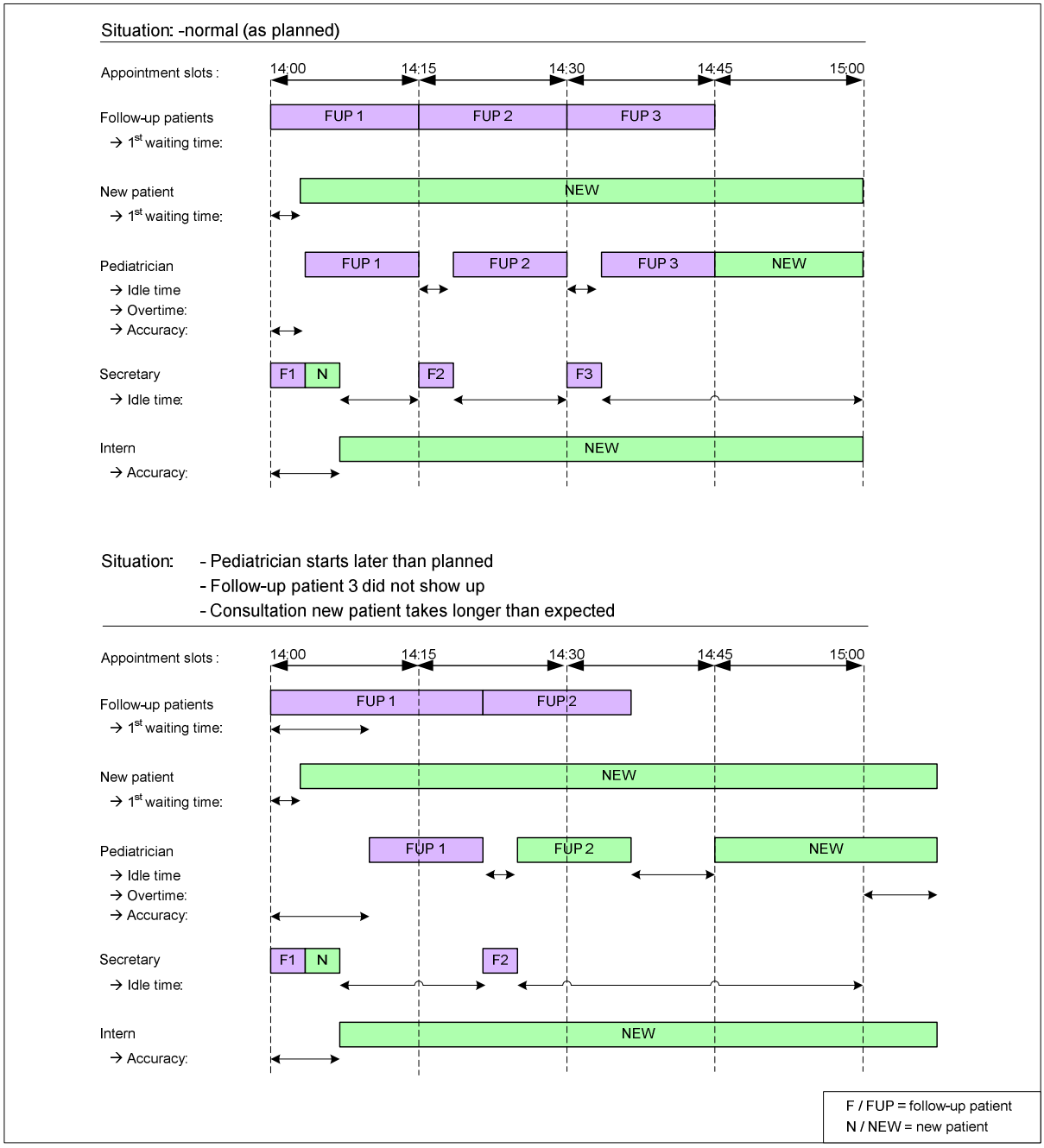


*Figure 2.8 - Allocation of personnel and rooms with various disturbances.*

***Performance indicators: outcomes***

Accuracy of pediatricians

Just as patients arrive for a consultation, so do pediatricians arrive for a consultation session. The accuracy of the pediatrician to show up on time has an important influence on the waiting time of the scheduled patients. Since pediatricians do not have specific tasks at the start of their consultation session we assume that pediatricians start the first consultation just after arrival. We therefore define the accuracy of pediatricians as the difference between the scheduled start time of the first appointment and the time at which the pediatrician starts the first appointment.

We found that pediatricians start the consultation session in the morning on average 4 minutes after the start of the first appointment. This could be caused by the meeting about the inpatients which takes place before the consultation sessions. For the consultation sessions in the afternoon, such a cause does not exist but nevertheless do the pediatricians start the consultation sessions in the afternoon on average 6 minutes later (see Appendix D4).

Idle time of pediatricians

Idle time is defined as the sum of various time windows in which the pediatricians do not consult a patient. This can be caused by a patient who has not (yet) arrived, congestions during the basic examination or updating the medical record of the patient by the secretary. Currently, there is 41 minutes of idle time per consultation session on average (see Appendix D5) with an average consultation length of 2 hours and 33 minutes which makes the percentage of idle time 27 %.

Overtime of pediatricians

Overtime is the time window between the end of the last scheduled appointment and the actual time at which the pediatrician ends this appointment. In case all slots of the appointment system are filled, the last consultation should end at 12 a.m. for consultation sessions in the morning, and at 5 p.m. for consultation sessions in the afternoon. A calculation of the average overtime resulted in 24 minutes (see Appendix D6).

Consultation session end time

The consultation session end time is the time at which the pediatrician has finished consulting the last patient of the session. For consultation sessions in the morning, the average consultation session end time is 12:19 hours and for consultation sessions in the afternoon, the average consultation session end time is 16:53 hours (see Appendix D6).

Accuracy of the interns

The accuracy of the interns has the same definition as the accuracy of the pediatrician. The only difference is their first appointment. Currently, an intern comes on time for 56 % of the cases. In case the intern does not show up on time, the intern starts 6 minutes later on average (see Appendix D7).

Duration of a consultation by an intern

On average, the consultation by an intern takes 52 minutes. The durations of a consultation by an intern are normally distributed with an standard deviation of 13 (see Appendix D8).

No-shows

Every hospital department has no-shows: patients that are scheduled but never show up. For the outpatient center 3,44 % of the follow-up patients do not show up, probably because of the big time window between making the appointment and the appointment itself [Cayirli,2003]. The percentage of new patients that does not show up is low (0,10 %) since only one of all the new patients in the collected data did not to show up (see Appendix D9).

Second consultations and external examination

3,45 % of the patients are appointed to a external examination outside the pediatric department. Part of this group returns to the outpatient center for a second consultations (0,72 % of all consultations). The average length of this external examination is 35 minutes (see Appendix D10).

Waiting time

The performance indicator 'waiting time' is the sum of all waiting times a patient experiences during his or her visit to the pediatric outpatient center: voluntary waiting time, first waiting time and second waiting time (see Table 2.11). The third waiting time can not be calculated since the time registration system does not record the end time of the consultation by an intern (see Appendix C1).

| **Overview of average waiting times** | |
|---|---|
| Voluntary waiting time: | 7:54 minutes |
| First waiting time: | 6:37 minutes |
| Second waiting time: | 5:53 minutes |
| **Total waiting time:** | **20:24 minutes** |

*Table 2.11 - Overview of average patient waiting times (see Appendix D12)*

Consultation duration

An inspection of the consultation durations (see Appendix D13) shows that there are four different groups of patients for which different consultation durations can be calculated (see Table 2.12). The consultation durations are found to be gamma distributed.

| **Groups of patients with the same consultation duration** | |
|---|---|
| *Group of patients* | *Average consultation duration (minutes)* |
| Follow-up patients with diagnose 'Asthma' | 13:37 |
| New and follow-up patients with diagnose 'Depression/Fatigue' (no chronic fatigue syndrome) | 20:29 |
| Remaining new patients (new patients, except patients with 'Depression/Fatigue') | 17:57 |
| Remaining follow-up patients (follow-up patients, except patients with 'Asthma' of ' Depression/Fatigue') | 15:34 |

*Table 2.12 - Patient groups with deviating consultation durations*

Idle time of secretaries

The secretaries that help out during a consultation session have three basic tasks: getting the patient into the examination room, measuring the length and weight of the patient and updating the medical record. Although these tasks are necessary for the consultation process, the tasks do not take as much time as the consultation duration. Although the secretaries spend some of the remaining time on other activities like answering the phone, it is likely the secretaries experience a great deal of idle time.

## 2.4 - Conclusion

This concluding section discusses the most important and apparent findings of the context description: the currently used appointment system, flexibility of the system and room utilization.

***The currently used appointment system***

The time registration system is very useful in analyzing the currently used appointment system since it made the calculation of various parameters and performance indicators possible. The average duration of a consultation session is 2 hours and 33 minutes in which the pediatricians experienced an average idle time of 41 minutes and an average overtime of 24 minutes. An average of 9,5 patients are consulted which experienced an average waiting time of 20 minutes. The striking conclusion is that pediatricians still experience a great deal of idle and overtime despite the medium utilization of appointment slots. The same can be stated for patient waiting time.

One of the reasons is the accuracy of pediatricians. Pediatricians start minutes after the scheduled start of the consultation sessions, i.e. 4 minutes for sessions in the morning and 6 minutes for sessions in the afternoon. This delay has an impact on the pediatrician overtime as well as the waiting time for all patients in the consultation session.

Another reason is the size of the appointment slots, i.e. fifteen minutes per consultation. We found that the duration of a consultation depends on the type of patient and the diagnosis, e.g. 14 minutes for follow-up patients with asthma, and 20 minutes for patients with depression and 18 minutes for new patients. Using appointment slots of fifteen minutes for all patients eventually leads to either more pediatrician idle time or more waiting time for patients who are scheduled at the end of the consultation session.

Another finding is the absence of an allocation rule, i.e. a rule that depicts in what order appointment slots are filled. The absence of this rule resulted frequently in unused appointment slots in the middle of a consultation session. Instead of planning a series of appointments without interruption, appointments are planned based on the patients' wishes resulting in a patchwork of appointments. It is obvious that this way of filling appointment slots has an impact on the idle time of pediatricians.

***Flexibility of the system***

Another influence on the idle time of a pediatrician is the sequence of steps that have to take place for every patient, i.e. first basic examination by the secretary, second updating medical record by the secretary and third consultation by a pediatrician. The first two steps can cause a delay of the start of a consultation by a pediatrician. This is not always the case, since the consultation by a pediatrician starts in the examination room and ends in the consultation room which creates a time window in which the examination room is free and the secretary is able to perform the first two steps. But in case the created time window is too small, the time window is not created (pediatrician ends the consultation in the examination room) or the patient arrives too late, the pediatrician experiences idle time because of the two preceding steps in the sequence every patient goes through.

A comparable situation is present in the 4-patient cycle in which also a sequence of steps has to be taken in a precise order, i.e. first the pediatrician consults three follow-up patients and the intern consults a new patient, second the pediatrician and the intern discuss the new patient and third the pediatrician starts consulting the new patient accompanied by the intern. A single delay in one of the four consultations in the first step, results in idle time of either pediatrician or intern, and increased average waiting time of the four patients involved as well as the following patients.

***Room utilization***

Consultation units are necessary for consultation sessions and special consultation sessions. Although some situations give the impression that the outpatient center has a shortage on consultation units, the consultation sessions altogether occupy only 46 % of the time the units are available. The rest of the time is used for lunch breaks, group meetings and other kind of duties. Focusing on the main purpose of consultation units, to host consultation sessions, the units are under-utilized. The impression of shortage is caused by snapshots of special consultation sessions planned on the same day as the regular consultation sessions. Since some special consultation sessions use more than two examination rooms, shortage of rooms can become a problem in those specific situations. Nevertheless does every week contain two half workdays in which none of the

consultation units is used. Therefore the shortage of rooms in specific situations can be solved by another arrangement of consultation sessions during the week.

***Recommendations***

Our context analysis reveals various opportunities to improve the performance of the outpatient center measured in patient waiting time, pediatrician overtime and consultation end time. Main factors which directly influence the performance are:

1. The accuracy of pediatricians and interns
2. The inflexibility of the 4-patient cycle
3. The absence of an allocation rule
4. The insufficient standard slot size of 15 minutes for new patients

We expect that altering these factors, would improve the performance of the current consultation sessions. The impact on alterations based on these factors can be tested with the use of a simulation model through changes in scenarios or changes in the current scheduling method.

# 3 - Design of Interventions

Key in improving the organization of consultation sessions is the appointment system, i.e. a set of rules that determine how patients are scheduled. The literature on appointment scheduling (see Appendix A) suggests different so-called appointment rules to improve appointment scheduling. Based on these options and the results of the context analysis (see Chapter 2), we suggest five interventions to improve the performance of the outpatient center. We describe these interventions in detail in this chapter. An overview of the interventions is given in Table 3.2.

***Bailey-Welch***

The Bailey-Welch rule [Bailey, 1952] is well known in the literature on appointment scheduling (see Appendix A). It states that two patients have to be scheduled on the initial slot of a consultation session and none at the last slot. This creates a buffer of patients causing a decrease of pediatrician overtime and pediatrician idle time without substantially increasing the patient waiting time. The rule also minimizes the probability that the first consultation can not start on time and thereby minimizes the probability that the pediatrician has to wait for the first patient to arrive. Therefore a possible motivation for the pediatrician to arrive late because of possible waiting time is also diminished [Cayirli, 2003].

Although it is likely that the Bailey-Welch rule improves the performance, the positive effect of the buffer it creates can be disrupted by the 4-patient cycle (see Section 2.2.3). This currently used scheduling rule determines the sequence in which new and follow-up patients are consulted in order to align the consultations of a pediatrician and an intern. Scheduling two patients on the initial slot will cause a delay in the appointment scheduling of the intern. Therefore we created the following variations of the Bailey-Welch rule suitable for the current situation (see Figure 3.1):

> *Intervention 1, Bailey-Welch rule: schedule two patients on the initial slot and leave the slot preceding the first new patient open*

***Variable interval***

Instead of using one slot size for all patients, slot sizes can also be tailored to a patient specific attribute, i.e. if the average consultation duration of a patient group is 20 minutes, patients from this group are scheduled in appointment slots of 20 minutes instead of the currently used 15 minutes. This scheduling with variable intervals has the ability to positively influence the patient waiting time in case the 'actual consultation duration' exceeds the appointment slot. But in this case it may increase pediatrician idle time and decrease throughput. In case the 'appointment slot' exceeds the 'actual consultation duration', the pediatrician overtime could decrease.

The current scheduling on the outpatient center uses slots of 15 minutes for all patients. Our analysis of the actual consultation durations found that the substantial group of new patients consumes an average of 18 minutes for a consultation. We therefore suggest the following variable interval scheduling rule (see Figure 3.1):

> *Intervention 2, variable slot rule: use slots of 20 minutes for new patients*

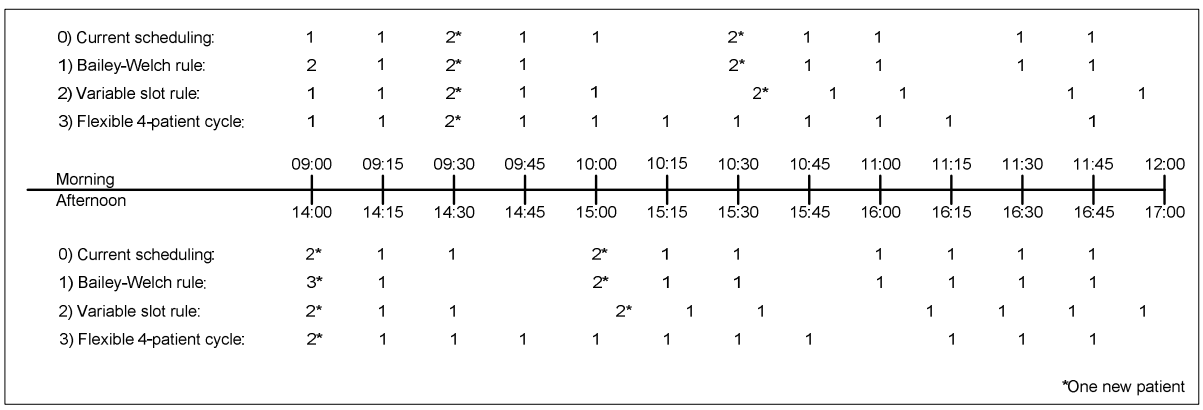


*Figure 3.1 - Scheduling patients according to the current situation and intervention 1, 2 and 3*

***4-Patient cycle***

One of the negative side effects of scheduling patients with the use of a 4-patient cycle (see Section 2.2.3) is the 'waiting moment': either the pediatrician or the intern has to wait on the other one to finish his or her consultation before they can both proceed with the new patient. To overcome this situation we introduce the following intervention (see Figure 3.1):

> *Intervention 3, flexible 4-patient cycle rule: schedule the patient succeeding the new patient 15 minutes earlier*

Shifting the appointment slot after a 4-patient cycle one slot forwards gives the pediatrician the choice to consult this patient in case the intern has not finished the consultation with the new patient of the 4-patient cycle. Instead of experiencing idle time, the pediatrician can continue consulting patients. Therefore the rule can positively influence the pediatrician overtime. The changes in consultation session flow model are visualized in Figure 3.2.

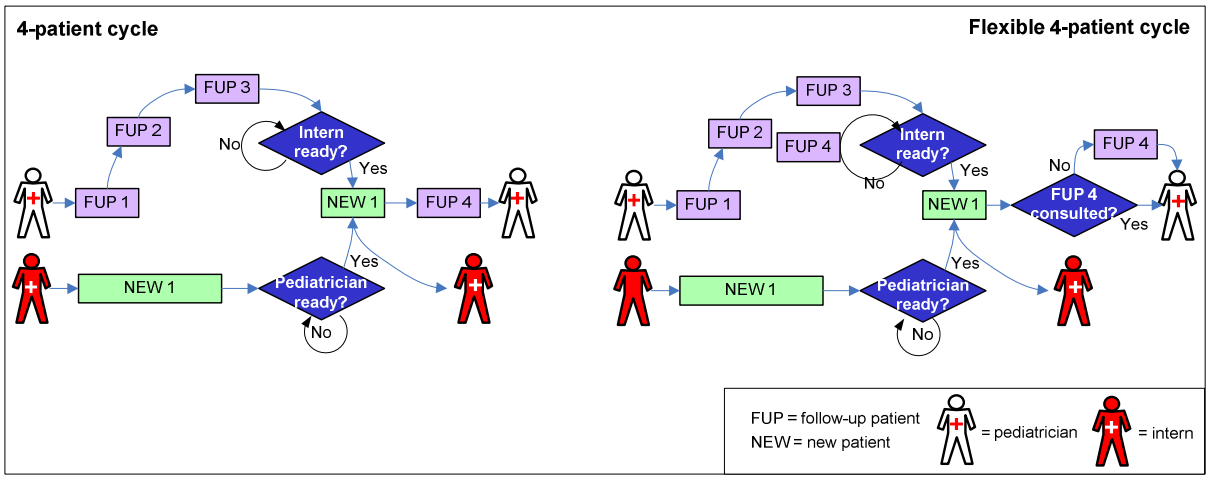


*Figure 3.2 - Current 4-patient cycle vs. flexible 4-patient cycle*

***Variance***

A study by Klassen [1996] investigates the performance of outpatient scheduling methods using the standard deviation of the consultation duration of patients to define the sequence in which patients are scheduled. They found that in case patients could be differentiated into low and high variance, the best way to schedule these two groups is to put the appointments with the low variance patients at the beginning of the consultation session and high variance patients at the end. The so-called LVBEG (low variance beginning) rule outperformed the FCFA (first call, first appointment) rule on patient waiting time and pediatrician idle time.

Since the time registration system makes it possible to investigate the variance of patient groups, an introduction of the LVBEG rule is possible. This applies especially for follow-up patients, for whom ten slots per consultation session are available and they can also be differentiated into two groups with differentiating variations: asthma patients and remaining follow-up patients. The roots of these variances, i.e. the standard deviations of these two groups are 5:47 minutes for asthma follow-up patients and 8:07 minutes for remaining follow-up patients. We suggest the following intervention:

> *Intervention 4, LVBEG rule: schedule low variance patients at the beginning of the consultation session and high variance patients at the end of the consultation session*

***Allocation of appointment slots***

One of the conclusions of the context analysis is that appointment slots are filled arbitrarily, i.e. no specific order exists in which appointment slots are filled. In case not all appointments of a consultation session are used, the probability that all appointments are connected is small and therefore the probability of 'holes' in the scheduling, i.e. unused appointment slots, is substantial. Therefore we introduce the following intervention:

> *Intervention 5, allocation rule: start scheduling appointment slots with the initial slot and continue with the successive slots*

***Combinations of interventions***

Combinations of the five proposed interventions are possible (see Table 3.1) although not all interventions can be applied together. The proposed interventions change the current system in either one of two ways: or the allocation of appointments slots is altered or the times at which patients should arrive changes. Interventions that change the allocation of appointment slots can not be applied simultaneously, i.e. the allocation rule and the LVBEG can not be combined. Interventions that change the times at which patients should arrive can all be combined, except one: the combination of the 4-patient cycle and the variable slot. These rules differ too much to form a promising combined rule.

| ***Combinations of interventions*** | | | | | | |
|---|---|---|---|---|---|---|
| *Intervention number* | *Allocation of appointment slots* | | | *Changes in appointment times* | | |
| | *(5) Allocation rule* | *(4) LVBEG* | *(0) historic* | *(3) Flexible 4-patient cycle* | *(2) Variable slot* | *(1) Bailey-Welch* |
| 0 | false | false | true | false | false | false |
| 1 | false | false | true | false | false | true |
| 2 | false | false | true | false | true | false |
| 3 | false | false | true | true | false | false |
| 4 | false | true | false | false | false | false |
| 5 | true | false | false | false | false | false |
| 6 | false | false | true | false | true | true |
| 7 | false | false | true | true | false | true |
| 8 | false | true | false | false | false | true |
| 9 | false | true | false | false | true | false |
| 10 | false | true | false | true | false | false |
| 11 | false | true | false | false | true | true |
| 12 | false | true | false | true | false | true |
| 13 | true | false | false | false | false | true |
| 14 | true | false | false | false | true | false |
| 15 | true | false | false | true | false | false |
| 16 | true | false | false | false | true | true |
| 17 | true | false | false | true | false | true |

*Table 3.1 - Overview of the 17 possible interventions*

| **Overview of Interventions** | | |
|---|---|---|
| 1) Bailey-Welch rule | : | Schedule of two patients on the initial slot and none on the slot preceding the first new patient |
| 2) Variable slot | : | Schedule new patients in slots sizes of 20 minutes |
| 3) Flexible 4-patient cycle | : | Schedule the patient succeeding the new patient one slot earlier |
| 4) LVBEG rule | : | Schedule low variance patients at the beginning of the consultation session and high variance patients at the end of the consultation session |
| 5) Allocation rule | : | Start scheduling appointment slots with the initial slot and continue with the successive slots |

*Table 3.2 - Overview of the proposed interventions*

# 4 - Analysis of Interventions

We analyze the interventions (see Chapter 3) with a simulation study. By using a simulation of the current situation the impact of the proposed interventions on the patient waiting time and the pediatrician overtime can be measured.

Figure 4.1 gives an overview of the steps in a simulation study [Law, 2000]. The first steps after the problem definition are data collection and determination of the conceptual model. Data collection is aimed at specifying model parameters and input probability distributions, e.g. the distribution of consultation durations (Section 4.2). The conceptual model gives an overview of the assumptions made about the operating procedures (Section 4.1).

After these steps, validation of the conceptual model has to take place with all parties involved until the conceptual model is accepted as a (simplified) representation of the current system. After the conceptual model is validated, the conceptual model and the data collection together are used to construct a technical model (Section 4.3). We validate this technical model by comparing the outcomes of the simulation with historic data (Section 4.4). Eventually we use the simulation to run experiments and produce results (Sections 4.5 and 4.6).

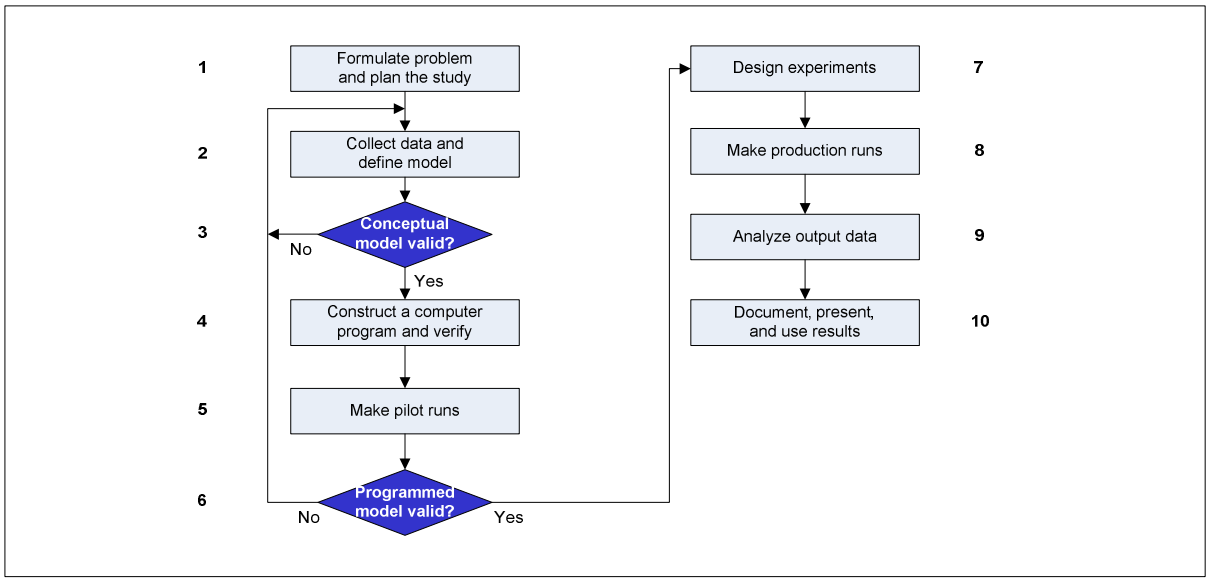


*Figure 4.1 - Steps in a simulation study [Law, 2000]*

## 4.1 - Conceptual Model

The conceptual model of the current system (the outpatient center) consists of a descriptive model and a set of performance measures with which the various interventions can be evaluated (see Table 4.1). The descriptive model of a consultation session is a combination of two models: the patient flow model (see Section 4.1.1) and the session model (see Section 4.1.2). The patient flow model explains the flow of a single patient and the session model explains the flow of all patients scheduled on a consultation session. The two models combined create a descriptive model of a consultation session. The model was validated through various meetings with the pediatricians.

### 4.1.1 - Patient Flow Model

The patient flow model (see Figure 4.2) describes the routes a patient can take. This simplified representation of the current system is based on the following assumptions:

- There are two patient types: new and follow-up patients
- A diagnosis is assigned to every patient based on historical ratios of the outpatient center
- The model is not pediatrician specific, it uses the general patient base of the pediatric department
- The arrival of a patient depends on the scheduled appointment time
- The front desk does not take any time
- Waiting rooms have unlimited capacity
- A consultation by a pediatrician starts when the pediatrician is available
- A consultation by an intern starts when the intern is available
- The length of a consultation by pediatrician depends on the diagnosis of the patient
- A portion of the patients are referred to an examination outside the pediatric department and return for a second consultation

### 4.1.2 - Session Model

The session model explains the flow of all patients scheduled on a consultation session by describing the workflow of a pediatrician and an intern. Since consultation sessions in the morning differ from consultation sessions in the afternoon two models are used: the morning session model (see Figure 4.3) and the afternoon session model (see Figure 4.5). The session models simplify the current situation by using the following assumptions:

- The arrival of the pediatrician and the intern depends on the scheduled start of their first consultation
- The arrival of patient depends on the scheduled start of their appointment (see Figure 4.4 for the morning session model and Figure 4.6 for the afternoon session model)
- Patients are consulted in the order in which they are scheduled (see Figure 4.3 for the morning session model and Figure 4.5 for the afternoon session model)
- Consultations can not overlap
- Diagnoses occur in different ratios
- A percentage of the patients does not show up
- A percentage of the patients needs a second consultation
- The number of follow-up patients on a consultation session varies
- There is no allocation rule for the filling of appointment slots

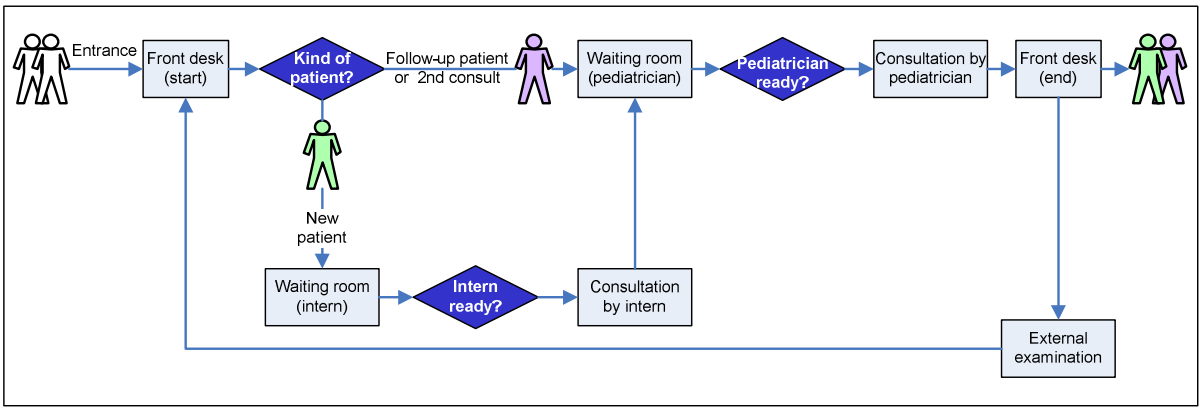


*Figure 4.2 - Patient Flow Model.*

| Definitions of performance indicators | | |
|---|---|---|
| *Performance indicators* | | *Definition* |
| Pediatrician overtime | : | Actual end time of a consultation session minus the scheduled end time of a consultation session. The scheduled end time of a consultation session is calculated with the currently used appointment slots of 15 minutes. |
| Voluntary waiting time | : | Waiting time caused by the early arrival of the patient: time window between the arrival of the patient and the scheduled start time of the appointment or the start of the consultation in case the consultation starts earlier than planned. |
| Total system waiting time | : | The sum of the waiting times caused by the pediatric department. |
| First waiting time | : | The time window between the scheduled start time of the appointment and the time at which the patient enters the examination room. |
| Second waiting time | : | The time window between entering the examination room and the start of the consultation with either the intern or the pediatrician. |
| Third waiting time | : | The third waiting time is only applicable for new patients that get a consultation by an intern first and have to wait between the end of this consultation by an intern and the start of the consultation by a pediatrician. |
| Waiting time service level | : | Percentage of patients with a waiting time of less than 30 minutes |

*Table 4.1 - Overview of performance measures*

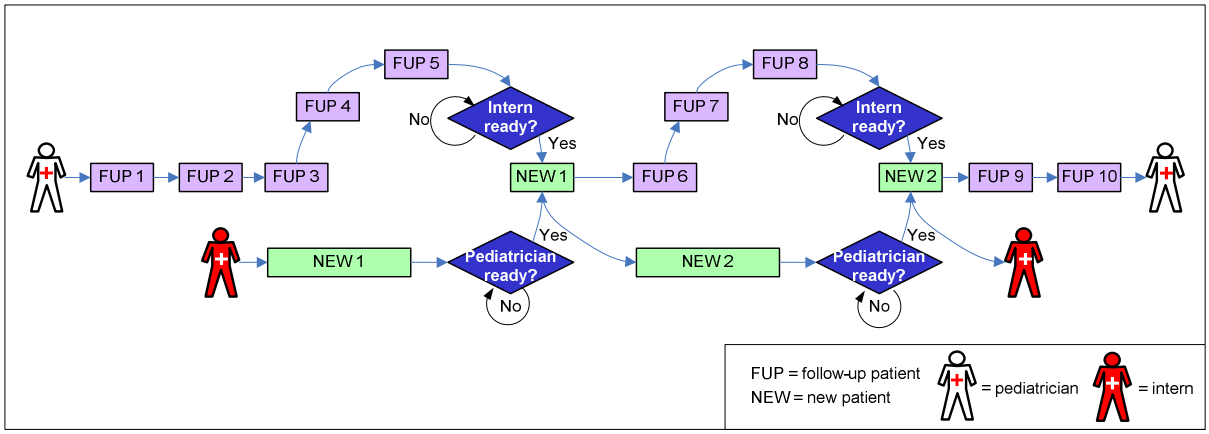


*Figure 4.3 - The morning session model*

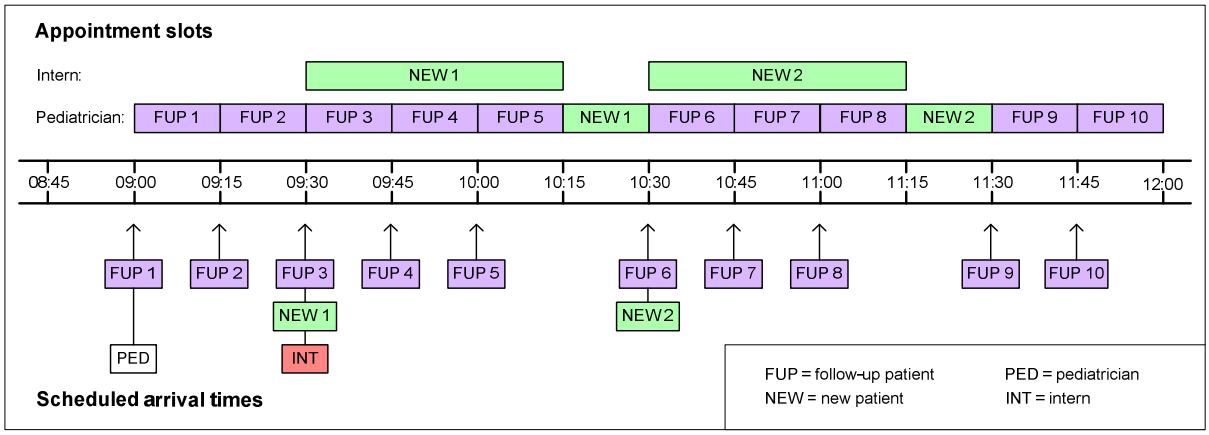


*Figure 4.4 - An overview of the appointment slots and scheduled arrival times of the session model (morning)*

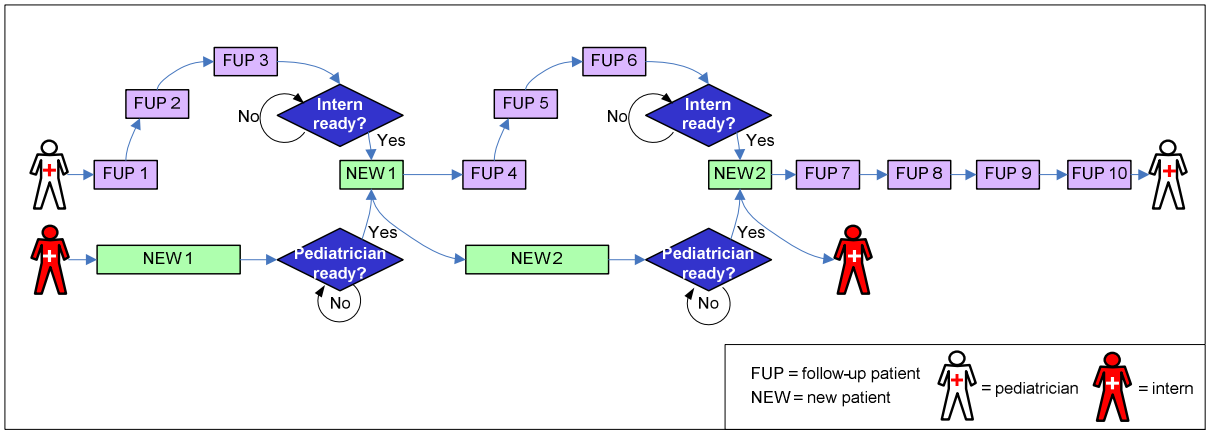


*Figure 4.5 - The afternoon session model*

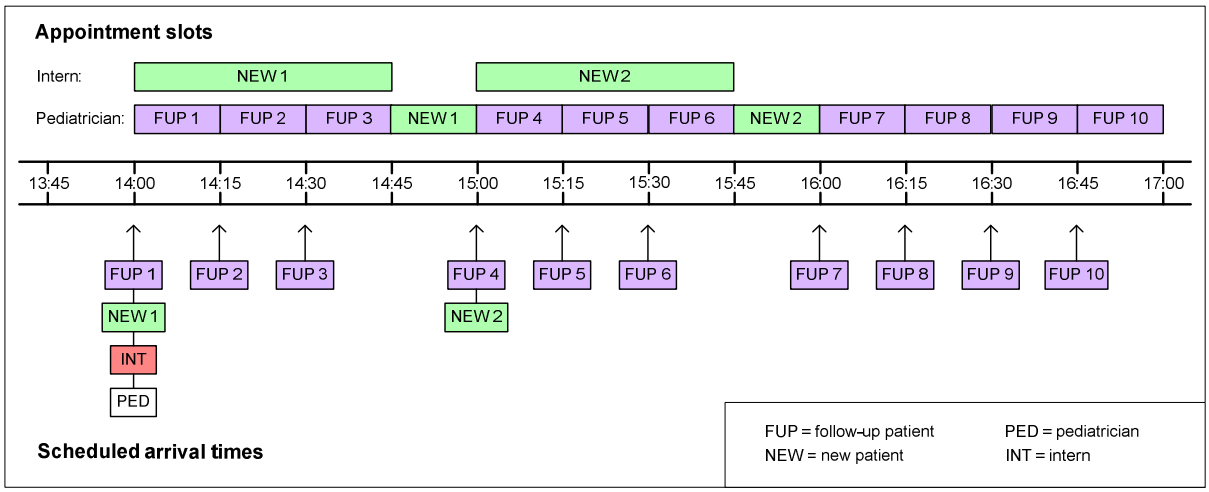


*Figure 4.6 - An overview of the appointment slots and scheduled arrival times of the session model (afternoon)*

## 4.2 - Data Collection

This section gives an overview of the various parameters that we use as input for the simulation model (see Table 4.2). We calculated these parameters using the historic data of the 'time registration system'. Our methods of data collection and parameter calculation are explained for every parameter in the Appendices C1 until D13.

Depending on character of the parameter and the size of the dataset used to determine the parameter, we decide to represent each parameter by a value, a ratio or a distribution. We use a fixed value for the arrival of pediatricians because of the small sample size used to determine this parameter. For the arrival of interns we used two fixed values representing either arriving on time or arriving too late. This is caused by the historic data of the 'time registration system' with which an early arrival can be noticed but can not be calculated. We use ratios for the parameters no-show and occurrence of diagnoses. We decide to represent the utilization of appointment slots also with ratios: one ratio for the number of follow-up patients in a consultation session and various ratios for the appointment slots used for every specific number of follow-up patients. We use a zero-ratio for the number of second consultations since the calculated ratio is low and the duration of the second consultation can not be determined accurately with the historic data of the 'time registration system'. The estimated gamma distributions for the consultations by a pediatrician and the estimated normal distribution for the consultations by an intern fit the historic data well. We found no general distribution that represents the arrival of patients, therefore a distribution is chosen that especially represents the arrivals after the appointment time because of their disruptive effect on the performance.

| Parameter | Value |
|---|---|
| *Arrivals* | |
| Arrival of patients<br>(see Appendix D11) | *Appointment times until 4 p.m.:*<br>Appointment time + normal distribution (mean: -8, standard deviation:13)<br>*Appointment times after 4 p.m.:*<br>Appointment time + normal distribution (mean: -11, standard deviation:10)<br><br>(Goodness of fit: no general distribution is found to represent the arrival of patients, therefore a distribution is chosen that especially represents the arrivals after the appointment time because of their disruptive effect on the performance) |
| Arrival of pediatricians<br>(see Appendix D4) | Morning consultation session: 9:03:51 a.m.<br>Afternoon consultation session: 2:05:55 p.m. |
| Arrival of interns<br>(see Appendix D7) | 56 %: on time<br>44 %: 5:41 minutes late |
| *Durations* | |
| Consultation by an intern (see Appendix D8)<br>- Normally distributed - mean: 51:54, standard deviation: 12:49<br>- Goodness of fit - Chi-square: 17,11, 12 d.f., P=0,15 | |
| Consultation by a pediatrician of follow-up patients with asthma (see Appendix D13)<br>- Gamma distributed - mean: 13:37, standard deviation: 5:47<br>- Goodness of fit - Chi-square: 34,72, 25 d.f., P=0,09 | |
| Consultation by a pediatrician of patients with depression/fatigue (see Appendix D13)<br>- Gamma distributed - mean: 20:29, standard deviation: 8:32<br>- Goodness of fit - Chi-square: 9,91, 5 d.f., P=0,08 | |
| Consultation by a pediatrician of remaining follow-up patients (see Appendix D13)<br>- Gamma distributed - mean: 15:34, standard deviation: 8:07<br>- Goodness of fit - Chi-square: 50,17, 30 d.f., P= 0,01 | |
| Consultation by a pediatrician of remaining new patients (see Appendix D13)<br>- Gamma distributed - mean: 17:57, standard deviation: 8:10<br>- Goodness of fit - Chi-square: 35,54, 30 d.f., P=0,22 | |
| External examination (see Appendix D10)<br>- 35 minutes | |
| *Remaining parameters* | |
| Occurrence of diagnoses (see Appendix D1) | See Table D1.1 |
| No-shows (see Appendix D9) | New patients: -<br>Follow-up patients: 3,44 % |
| Second consultations (see Appendix D10) | - |
| Utilization of appointment slots (see Appendix D2) | Morning consultation session: See Table D2.2<br>Afternoon consultation session: See Table D2.3 |

*Table 4.2 - Overview of calculated parameters*

## 4.3 - Technical Model

A simulation model is created using the software Plant Simulation 8.2. The model of a consultation session is build with the use of the object-oriented programming feature of the software. In order to apply the various interventions and scenarios as described in Chapter 3, the simulation model is build with the possibilities to change to a different configuration of the consultation process and to apply a different scenario. See Appendix E for a screenshot of the simulation model program.

## 4.4 - Simulation Model Validation

To validate the simulation model we use two methods: comparing system data and historic data and a sensitivity analysis. With the comparing-method a simulation model is validated by comparing the output data of the simulation using calculated parameters with the output data of the simulation using historical system data (see Figure 4.4). In case these two sets of data compare “closely”, the model of the existing system is considered “valid”. Sensitivity analysis is used to localize the parameters/distributions which have a significant impact on the performance measurements. This is done by analyzing the effect of changing input parameters/distributions.

For the comparing-method, a historic dataset is created containing information on the flow of patients of 59 consultation session. The average waiting time per consultation session and the overtime per consultation session are compared with the comparable output data of the simulation model. The comparable dataset of the computer model is created with the use of the historic dataset. The computer model is found to represent the current system, based both the paired t-test of the waiting times ($t(58)=0,16$, two-tail $p = 0,87$) and the overtime ($t(58)=0,30$, two-tail $p = 0,77$).

The sensitivity analysis is conducted on the accuracy of pediatricians and interns, the arrival times, the consultation durations of pediatricians and the consultation durations of interns. All of the input parameters/distributions have a profound effect on the patient waiting time and the pediatrician overtime and needs to be modeled carefully (see Appendix F).

## 4.5 - Experiments

The interventions (see Chapter 3) change the rules of the currently used appointment system. To evaluate the impact of the intervention, the performance of the system with the intervention has to be compared with the current system under the same circumstances. Various scenarios can be used to evaluate the performance of the intervention creating different sets of circumstances (Section 4.5.1). The 17 interventions (see Table 3.2) and the scenarios together lead to various possible configurations for which the run length (Section 4.5.2) has to be measured.

### 4.5.1 - Scenarios

A scenario defines the circumstances under which the various interventions can be compared. By using different scenarios, an increasing or decreasing performance of an intervention is more than just a lucky shot: a possible bias caused by the scenario is declined. From the five scenarios we propose in this section, we use historical and maximum utilization to test the interventions. The other scenarios are used to emphasize the influence of small changes on the performance or to test the robustness of the interventions.

***Historical***

The historical scenario represents the current situation at the outpatient center, in case no interventions are applied, the resulting configuration represents the current situation at the outpatient center which can be used to compare with configurations based on interventions. The historical scenario implies that the circumstances for the period ahead do not change compared to the past period: e.g. the consultation durations of specific patient groups stay the same and the accuracy of pediatricians stays the same. In this scenario we assume that all collected parameters (see Section 4.2) which are based on the performance of the outpatient center of the last couple of years, still represent the current state of the outpatient center.

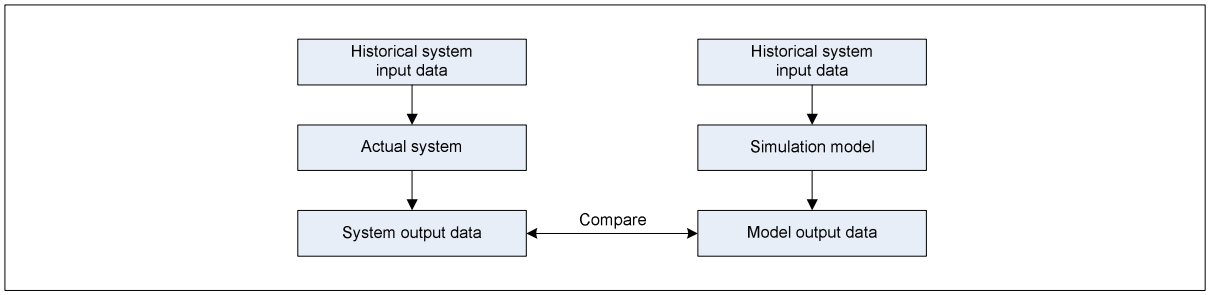

*Figure 4.4 - Computer simulation of the consultation process (Law,2000)*

***Accuracy***
With this scenario the impact of the accuracy on the waiting time of patients can be monitored. Starting point for this scenario is the historical scenario with an exception on the accuracy of pediatricians and interns. Instead of pediatricians arriving after the start of the consultation session, every simulated pediatrician shows up when the consultation starts. This also holds for interns: instead of arriving late for 44 % of the consultation sessions, all interns show up exactly on time.

***Maximum utilization***
The historical scenario assumes that the utilization of consultation sessions does not change and stays at an average of 10 patients per consultation session. Nevertheless is it likely that the outpatient center is faced with an increasing demand resulting in a maximum utilization of the available appointment slots. Therefore this scenario is introduced in which all consultation session are fully booked.

***No interns***
This scenario monitors the effect of the absence of interns on the performance of the outpatient center. It uses the historical scenario as starting point, removes the interns and changes the appointment time of new patients by excluding that part of the appointment time dedicated to the consultation of an intern.

***Three 4-patient cycles***
In case of a shift in the ratio of new and follow-up patients the outpatient center is faced with either unused appointment slots or increasing waiting lists for one of the patient types. This scenario assumes that the outpatient center is faced with an increase in demand of new patient. By introducing an extra 4-patient cycle, the center trades a follow-up patient appointment slot for a new patient appointment slot and gives the intern an extra consultation.

### 4.5.2 - Run Length
Since results of each of the experiments depend on random variables driving the model, the resulting averages of the experiments are also acting as random variables. Therefore the number of independent replications has been determined in order to construct a level of confidence. The simulation of a consultation session is a so-called terminating simulation: every day the system is 'cleaned out' to start over again the next day. Therefore one consultation session is one replication. We use a sequential procedure [Law, 2000] to construct a confidence interval. It adds replications once at a time until the specified confidence interval has been reached.

We applied the sequential procedure on the performance indicators pediatrician overtime and the sum of the first and second waiting time. With a 95% confidence interval and a relative error of 0,030 we found the minimum number of independent replications based on the pediatrician overtime to be 2498 which we round to 2500. For the sum of the first and second waiting time, 2500 independent replications and a 95 % confidence interval result in a relative error of 0,025.

## 4.6 - Results

With the use of the simulation model we gather a dataset of 2500 consultation sessions for each of the possible (combinations of) interventions (see Table 3.1) for both morning and afternoon sessions using two scenarios: historical and maximum utilization. With the use of the scenario accuracy we gather a dataset without applying an intervention since we only want to measure the impact of this different circumstance. The scenarios no interns and three 4-patient cycles are used to generate a dataset for various interventions to test the robustness of these interventions in case of unusual circumstances.

The results of these experiments are discussed in the following three sections. First the performance of the five basic interventions is compared with the use of two scenarios: historical and maximum utilization (Section 4.6.1). Second all the possible (combinations of) interventions are compared by generating a plot of the efficient frontier for the two scenarios (Section 4.6.2). Finally the various scenarios are discussed (Section 4.6.3).

### 4.6.1 - Performance of the Five Basic Interventions

Table 4.3 and 4.4 show the results of the five basic interventions, generated with the use of the scenarios 'historic' and 'maximum utilization' for both morning and afternoon sessions. In Table 4.3 we use the pediatrician overtime and the sum of the first and second overtime to draw an efficient frontier. An efficient frontier is a line based on the interventions that outperform the other interventions on either pediatrician overtime or the sum of the first and second waiting time. The closer an intervention gets to the origin, the better its performance is. In Table 4.4 we present an overview of shifts in the different patient waiting times caused by the different interventions.

***Efficient frontier***

The efficient frontiers (see Table 4.3) are in three of the four configurations formed by two interventions: the flexible 4-patient cycle and the variable slot. They both outperform the current scheduling: the variable slot decreases the patient waiting time by three to five minutes and the flexible 4-patient cycle decreases the pediatrician overtime by six to seven minutes and the patient waiting time by three to four minutes.

The other three basic interventions do not improve current scheduling. Introduction of the Bailey-Welch rule results in slightly smaller pediatrician overtime combined with a small increase of patient waiting time. The probable cause for the disappointing achievement of the Bailey-Welch rule is the 4-patient cycle, which decreases the effect of the buffer this rules creates. The remaining scheduling rules allocation rule and LVBEG do not differ significantly from the current scheduling on both pediatrician overtime and patient waiting time. Although the rules have the potential to decrease both overtime and waiting time, the probable disruptive effect of the 4-patient cycle prevents the rules from reaching their full potential.

In Table 4.3 the four graphics use the same axis which visualizes the effect of the session or the scenario on the intervention and the efficient frontier. Maximum utilization increases both pediatrician overtime and patient waiting time as expected without changing the location of the interventions compared with each other: the 'triangle' (1) Bailey-Welch rule, (3) flexible 4-patient cycle and (2) variable slot roughly remain their distances. Another shift noticeable is the difference in pediatrician overtime between morning and afternoon sessions. Both scenarios show that afternoon sessions increase the pediatrician overtime by four minutes, a difference probably caused by the difference in location of the two 4-patient cycles.

***Waiting times***

The efficient frontiers are created with the sum of the first & second waiting time. Although some interventions decrease these combined waiting times, it is possible that other waiting times have increased. Therefore we present an overview of the different shifts in waiting time in Table 4.4.

The voluntary waiting time does not change significantly. Although this may seem logical, voluntary waiting time can be decreased if pediatricians are able to start their consultations earlier than scheduled. This is not the case since none of the interventions shows a significant decrease of voluntary waiting time.

Significant changes occur in the first and second waiting time. The Bailey-Welch rule has a predictable increase of both of these waiting times just as the variable slot rule has a predictable decrease of both first and second waiting time. This is predictable since the Bailey-Welch rule decreases the pediatrician idle time by creating a buffer of patient and the variable slot rule decreases the patient waiting time by increasing the sizes of the appointment slots.

The only shift in waiting times occurs for the flexible 4-patient cycle. For this intervention the decrease in first and second waiting time by two to three minutes is combined with an increase of the third waiting time of two minutes. This is predictable behavior of this rule since it gives the pediatrician a choice to consult another patient before proceeding with the new patient. Keeping in mind that only the two new patients experience third waiting time and all patients experience first and second waiting time, the flexible 4-patient cycle does not shift two minutes from first & second waiting time to third waiting time but decrease the first and second waiting time for all patient and increases the third waiting time only for the two new patients.

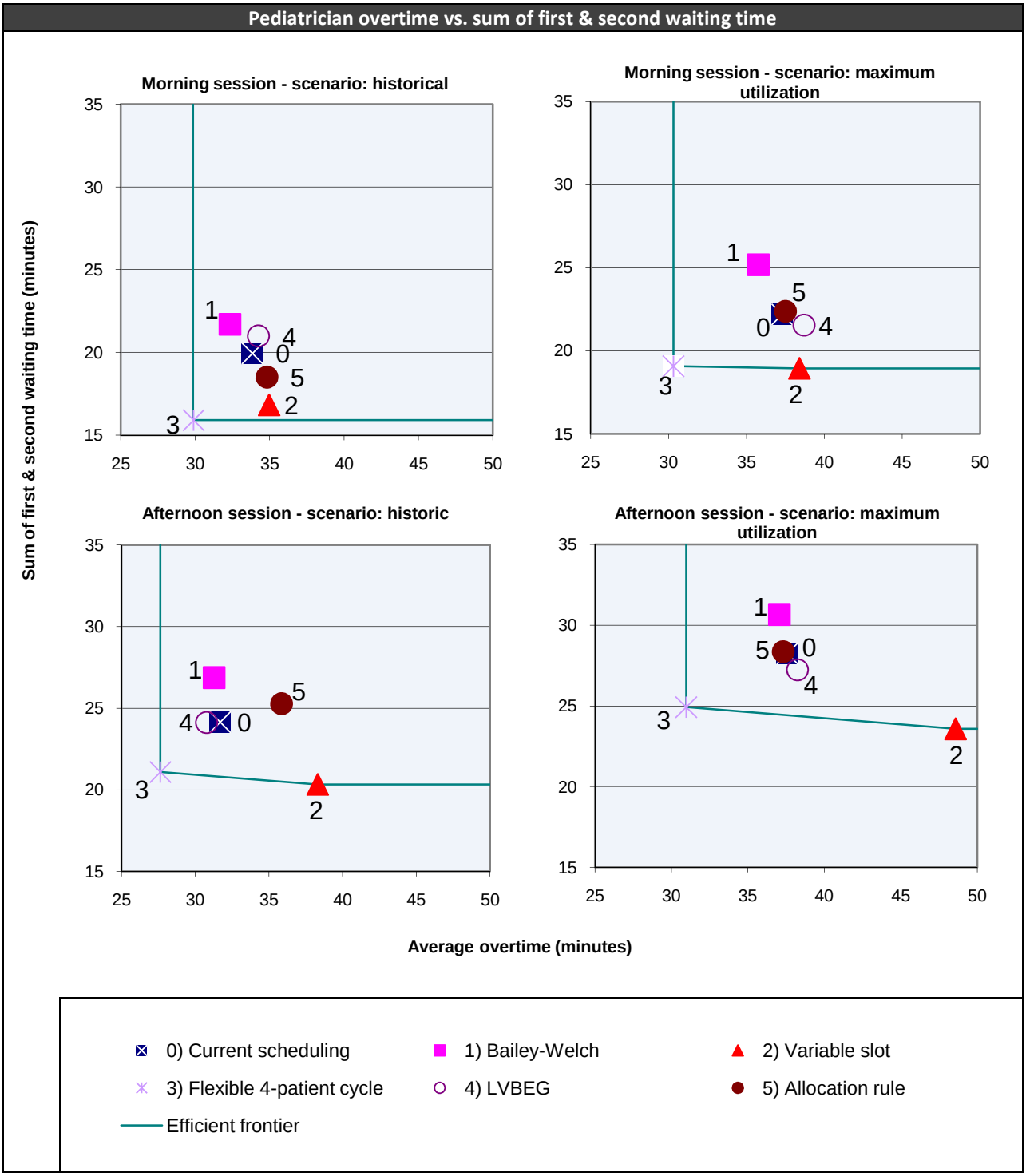


*Table 4.3 – Pediatrician overtime and the sum of first & second waiting time for the scenarios historical and maximum utilization for both morning and afternoon sessions*

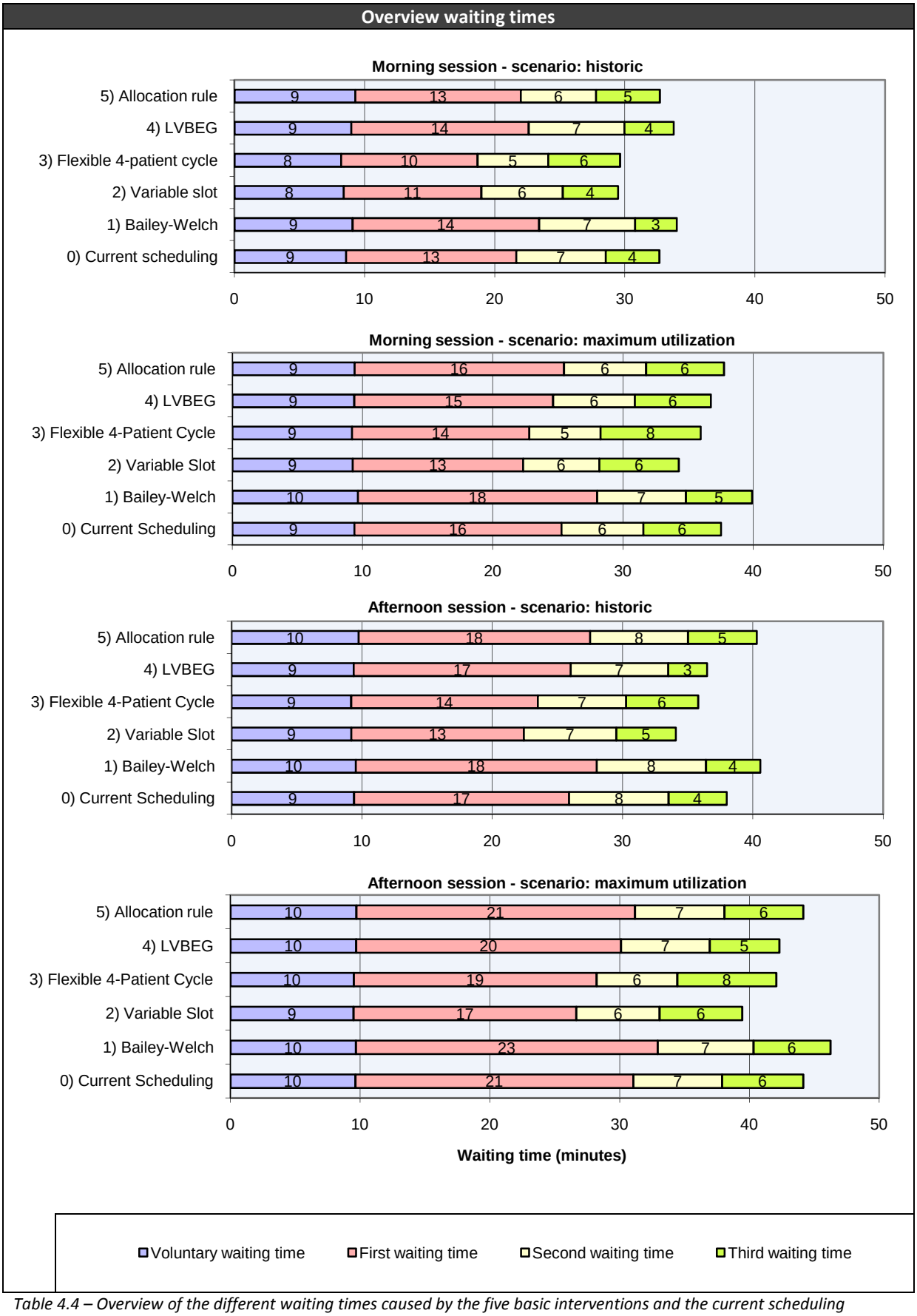


*Table 4.4 – Overview of the different waiting times caused by the five basic interventions and the current scheduling*

### 4.6.2 - Best Performing (Combinations of) Interventions

We present the performance of all (combinations of) interventions in Table 4.6 and 4.7. We also present the efficient frontier for the four configurations of sessions and scenarios. Three of the interventions are present on all the four efficient frontiers: (3) the flexible 4-patient cycle, (10) the combination of the LVBEG rule and the flexible 4-patient cycle and (12) the combination of the LVBEG rule, the Bailey-Welch rule and the flexible 4-patient cycle. The results of these three interventions on all the performance indicators are presented in Table 4.5 and the changes and shifts in the different waiting times are presented in Table 4.8.

The most apparent observation is the presence of the flexible 4-patient cycle in each of the three best performing interventions. It is obvious that application of this scheduling rule decreases the negative effect of the 4-patient cycle on the patient waiting time and the pediatrician overtime. Another finding is the small increase in performance of the flexible 4-patient cycle in combination with other scheduling rules like LVBEG and Bailey-Welch. When introduced as basic interventions, the rules do not decrease either pediatrician overtime or patient waiting time significantly. In combination with the flexible 4-patient cycle the rules seems to have the ability to make the flexible 4-patient cycle perform even better.

By applying one of the three best performing interventions both the patient waiting time and pediatrician overtime can be improved. Pediatrician overtime can be decreased by 16 to 25 % based on combined intervention (12) and patient waiting time can be decreased by 11 to 14 % based on intervention (10).

| **Best performing interventions** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Intervention* | *Service -level* | | *Waiting time (minutes)* | | | | | | *Overtime* | | *Outcomes paired t-test** | |
| | | | *Voluntary* | *First* | *Second* | *Third* | *Percentage reduction of voluntary, first and second waiting time* | | *Minutes* | *Percentage reduction* | *On sum first and second waiting time* | *On over-time* |
| *Morning session – scenario: historical* | | | | | | | | | | | | |
| 0) Current scheduling | 75 % | | 9 | 13 | 7 | 4 | - | | 34 | - | - | - |
| 3) Flexible 4-patient cycle | 81 % | | 8 | 10 | 5 | 6 | 21 % | | 30 | 12 % | 35,5 | 21,6 |
| 10) LVBEG + flexible 4-patient cycle | 81 % | | 9 | 10 | 6 | 5 | 14 % | | 27 | 21 % | 12,0 | 11,9 |
| 12) LVBEG + Bailey-Welch + flexible 4-patient cycle | 80 % | | 9 | 12 | 7 | 5 | 3 % | | 26 | 25 % | 6,05 | 13,9 |
| *Morning session – scenario: maximum utilization* | | | | | | | | | | | | |
| 0) Current scheduling | 72 % | | 9 | 16 | 6 | 6 | - | | 37 | - | - | - |
| 3) Flexible 4-patient cycle | 77 % | | 9 | 14 | 5 | 8 | 10 % | | 30 | 19 % | 33,8 | 40,7 |
| 10) LVBEG + flexible 4-patient cycle | 78 % | | 9 | 13 | 5 | 8 | 13 % | | 31 | 16 % | 17,1 | 11,7 |
| 12) LVBEG + Bailey-Welch + flexible 4-patient cycle | 77 % | | 9 | 15 | 6 | 6 | 3 % | | 29 | 22 % | 7,54 | 16,1 |
| *Afternoon session – scenario: historical* | | | | | | | | | | | | |
| 0) Current scheduling | 65 % | | 9 | 17 | 8 | 4 | - | | 32 | - | - | - |
| 3) Flexible 4-patient cycle | 71 % | | 9 | 14 | 7 | 6 | 12 % | | 28 | 13 % | 25,3 | 25,8 |
| 10) LVBEG + flexible 4-patient cycle | 72 % | | 9 | 14 | 7 | 4 | 12 % | | 25 | 22 % | 11,8 | 10,8 |
| 12) LVBEG + Bailey-Welch + flexible 4-patient cycle | 69 % | | 9 | 15 | 7 | 4 | 9 % | | 25 | 22 % | 5,34 | 10,7 |
| *Afternoon session – scenario: maximum utilization* | | | | | | | | | | | | |
| 0) Current scheduling | 60 % | | 10 | 21 | 7 | 6 | - | | 38 | - | - | - |
| 3) Flexible 4-patient cycle | 66 % | | 10 | 19 | 6 | 8 | 8 % | | 31 | 18 % | 29,9 | 42,0 |
| 10) LVBEG + flexible 4-patient cycle | 68 % | | 10 | 18 | 6 | 7 | 11 % | | 32 | 16 % | 14,0 | 9,17 |
| 12) LVBEG + Bailey-Welch + flexible 4-patient cycle | 64 % | | 10 | 19 | 7 | 7 | 5 % | | 32 | 16 % | 6,68 | 9,33 |

*Table 4.5 - Overview of interventions on all efficient frontiers, * Results of paired t-tests with the results of the current scheduling determining the significance of the difference*

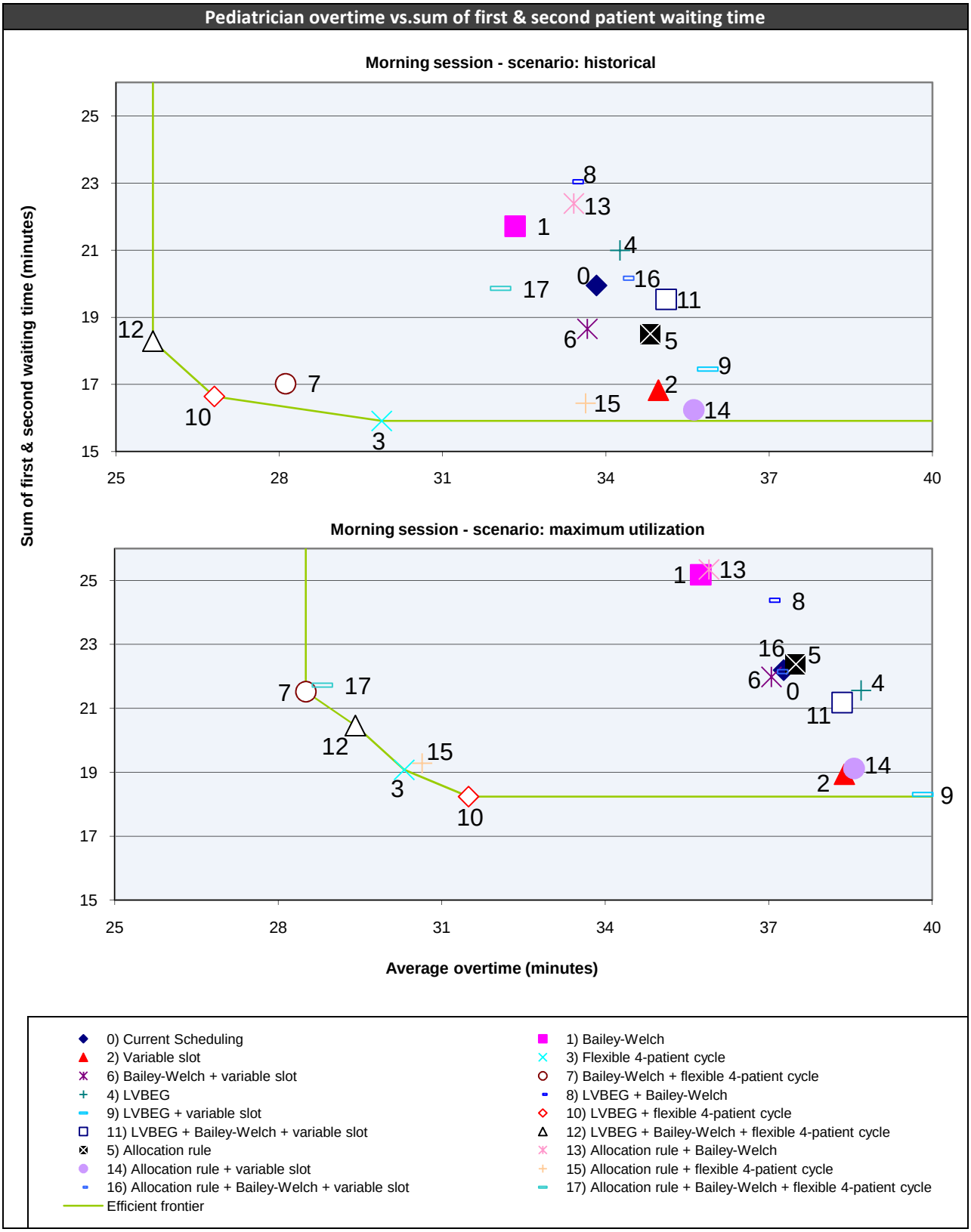


*Table 4.6 - The efficient frontier of (combinations of) interventions based upon the patient waiting time and the pediatrician overtime for morning sessions in case of the scenarios historical and maximum utilization*

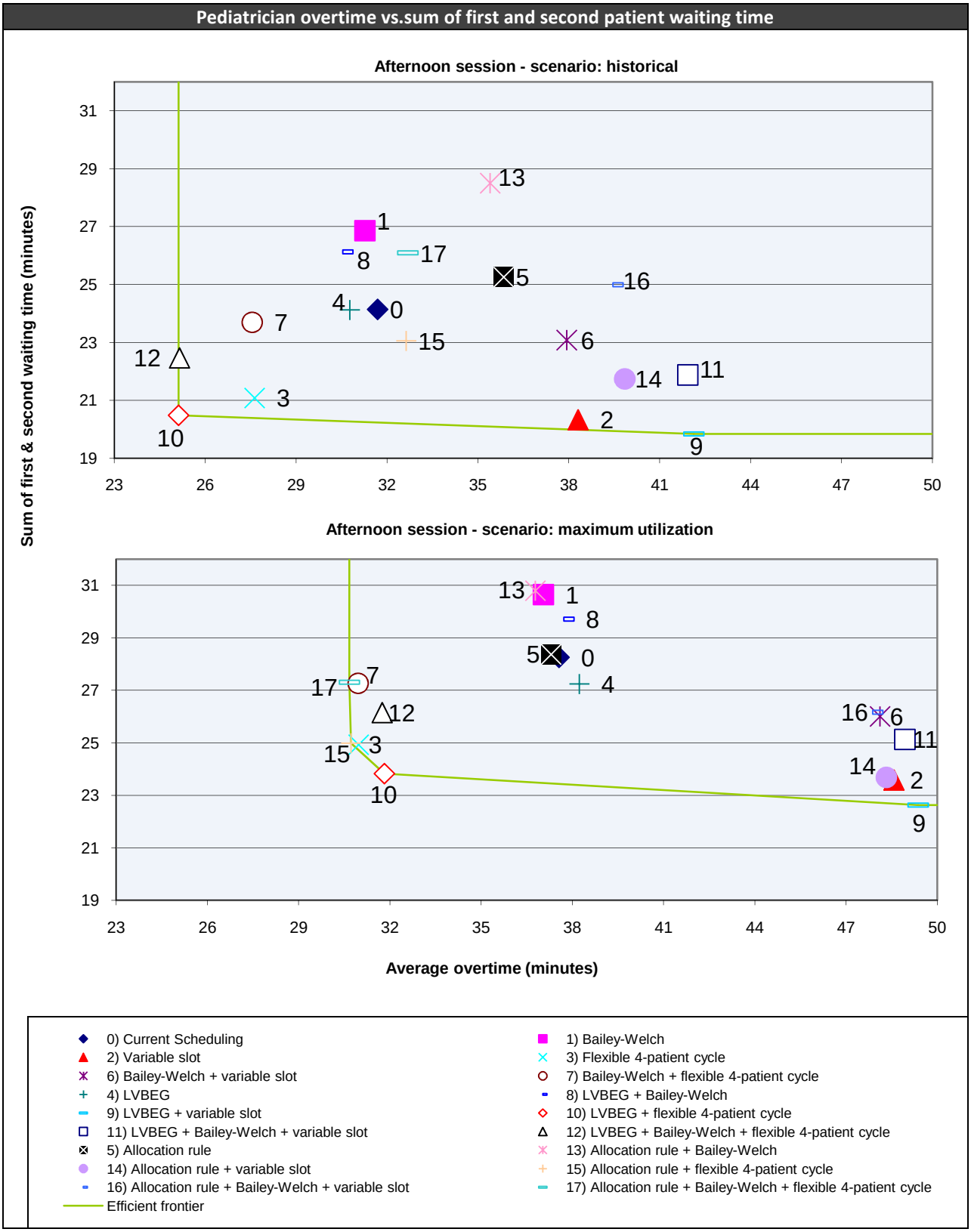


*Table 4.7 - The efficient frontier of (combinations of) interventions based upon the patient waiting time and the pediatrician overtime for afternoon sessions in case of the scenarios historical and maximum utilization*

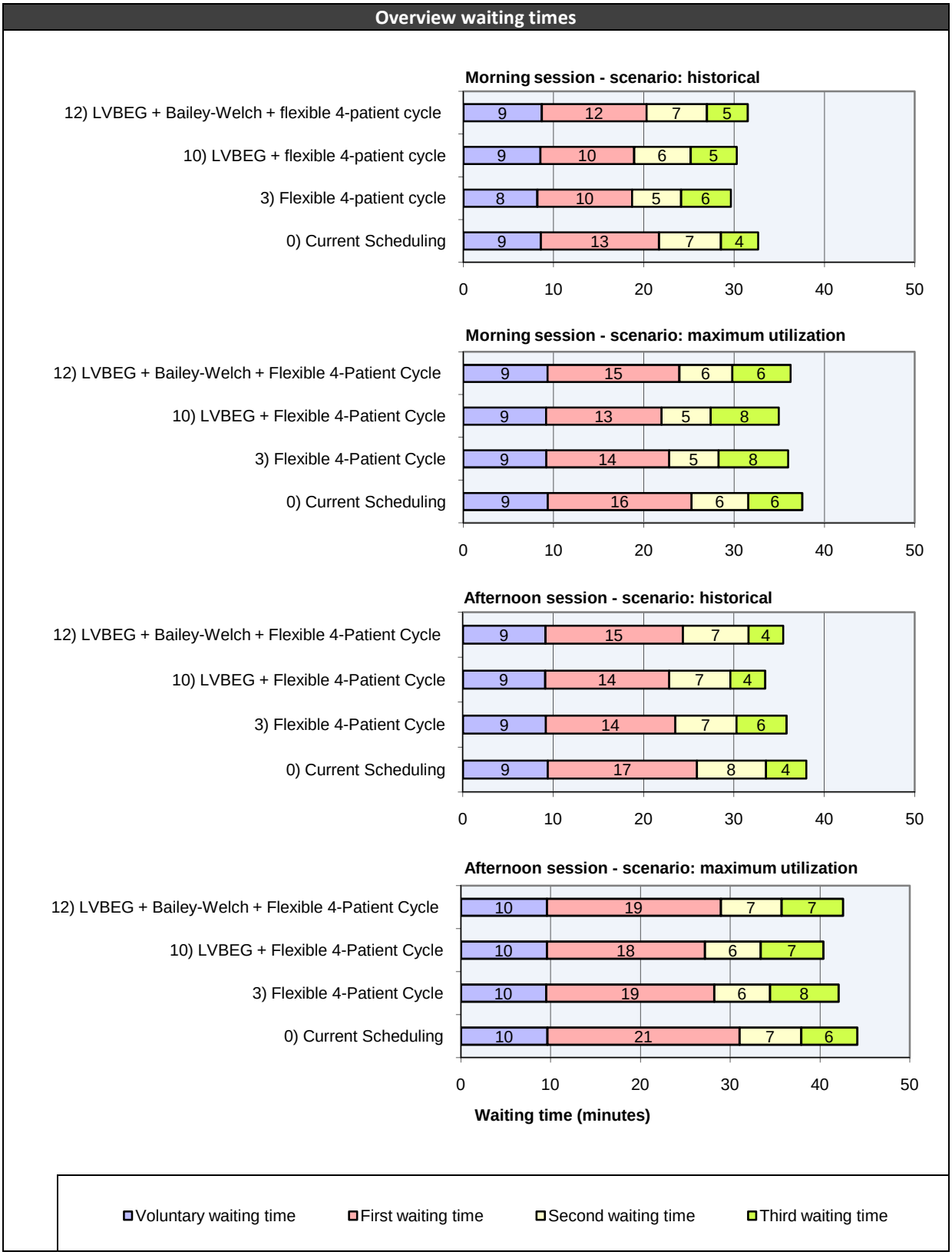


*Table 4.4 – Overview of the different waiting times caused by the interventions present on all efficient frontiers and the current scheduling for both morning and afternoon sessions and the scenarios historical and maximum utilization*

### 4.6.3 - Effects of Scenarios

The performance of the various interventions is measured and compared with the use of the most plausible scenarios historical and maximum utilization. Besides these two scenarios we also tested the effects of other scenarios on the current scheduling and/or the various interventions: accuracy, no interns and three 4-patient cycles.

***Accuracy***

With the scenario accuracy we measure the effect of the pediatrician and the intern showing up on time for their first consultation (see Table 4.9). Based on the results we can conclude that the accuracy of pediatricians and interns decreases both patient waiting time and pediatrician overtime by a small amount of two to three minutes. Since the amount of time that pediatricians have to arrive earlier to achieve this decrease is four to six minutes, the idle time of pediatrician must have been increased.

***No interns***

We measure the impact of no interns on the pediatrician overtime and patient waiting time by comparing it with the current scheduling under the historical scenario. The absence of interns shows both a decrease in pediatrician overtime and patient waiting time (see Table 4.9). Because of the absence of scheduling with the use of 4-patient cycles, the flexible 4-patient cycle does not appear on the efficient frontier. Instead the efficient frontiers are formed by the Bailey-Welch rule, the current scheduling and the variable slot rule. Therefore we conclude that scheduling with the use of the flexible 4-patient cycle is only applicable for the specific situation on the outpatient pediatric center.

***Three 4-patient cycles***

The scenario three 4-patient cycles is the opposite of scenario no interns: fully participation of interns vs. no participation of interns. We compare the performance of the current scheduling and all the interventions using this scenario (see Table 4.10). The two graphics show only significant difference in patient waiting time between the interventions. Pediatrician overtime stays quite constant but is ten to fifteen minutes more compared with the historical scenario of two 4-patient cycles. This is because of the extra new patient. Since this extra new patient is scheduled on the last appointment slot, a flexible 4-patient cycle can not be applied to decrease the pediatrician overtime: no follow-up patient is succeeding the last new patient. In order to decrease the pediatrician overtime, different interventions have to be applied (see Appendix G).

***Conclusion***

We analyzed the effects of the scenarios accuracy, no interns and three 4-patient cycles on the current scheduling and/or the various interventions. We found that pediatricians and interns arriving on time does lower the pediatrician overtime and patient waiting time but increases the pediatrician idle time. We also found that in case interns do not participate in consultation sessions, pediatrician overtime and patient waiting time decreases significantly and excludes the flexible 4-patient cycle from the best performing interventions. We also found significant changes in case consultation sessions are scheduled by three 4-patient cycles. In this situation the pediatrician overtime increases with ten to fifteen minutes and does no longer significantly differs between the various interventions. This is because of the extra 4-patient cycle which leads to an extra consultation by an intern.

| **The effect of scenario accuracy** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Scenario* | *Intervention* | | *Service -level* | | *Waiting time (minutes)* | | | | | *Overtime (minutes)* |
| | | | | | *Voluntary* | *First* | *Second* | *Third* | | |
| | | | | | | | | | | |
| *Morning sessions* | | | | | | | | | | |
| Historical | 0) Current scheduling | | 75 % | | 9 | 13 | 7 | 4 | | 34 |
| Accuracy | 0) Current scheduling | | 79 % | | 8 | 11 | 6 | 4 | | 32 |
| | | | | | | | | | | |
| *Afternoon sessions* | | | | | | | | | | |
| Historical | 0) Current scheduling | | 65 % | | 9 | 17 | 8 | 4 | | 32 |
| Accuracy | 0) Current scheduling | | 76 % | | 9 | 13 | 6 | 4 | | 29 |

*Table 4.9 – Overview of the effect of the scenario accuracy on the patient waiting times and pediatrician overtime*

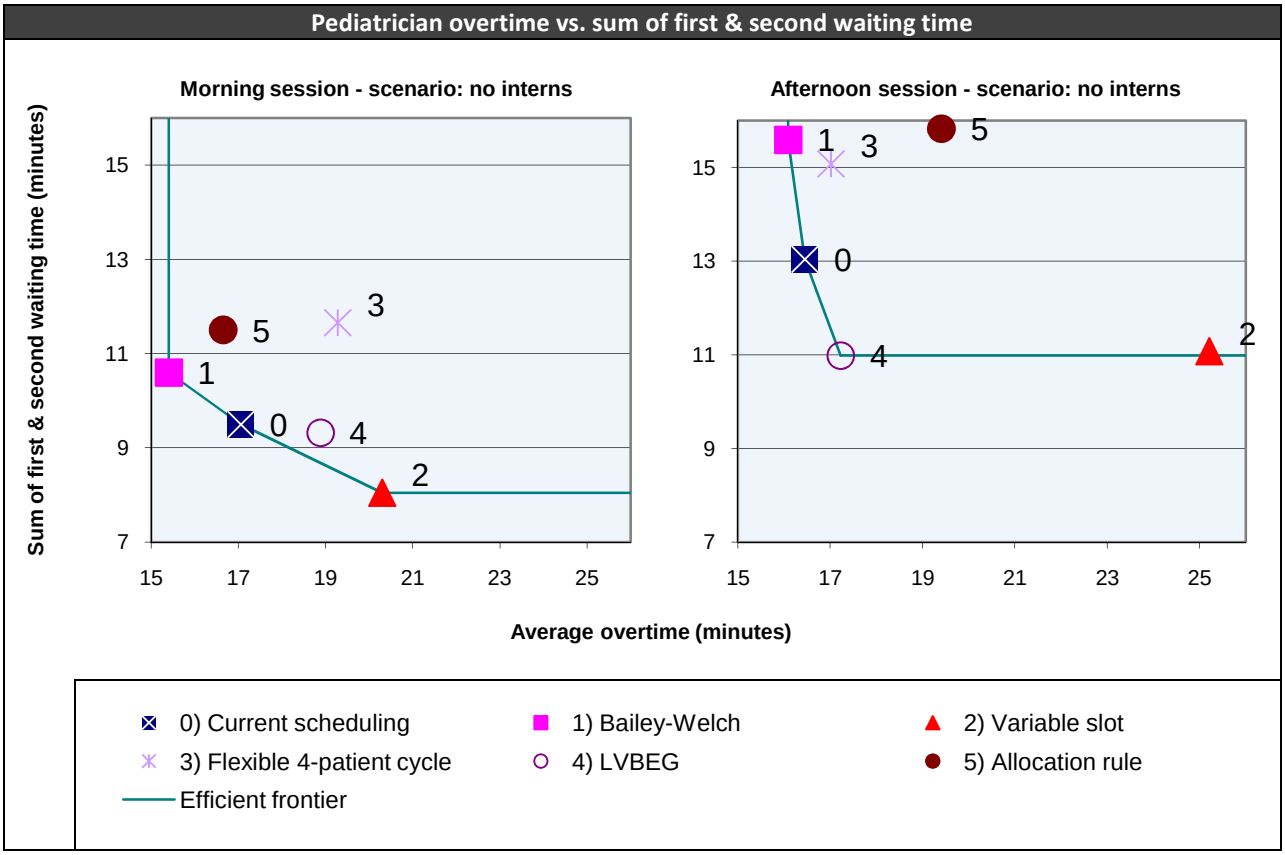


*Table 4.9 – Pediatrician overtime and the sum of first & second waiting time for the scenarios no interns for both morning and afternoon sessions*

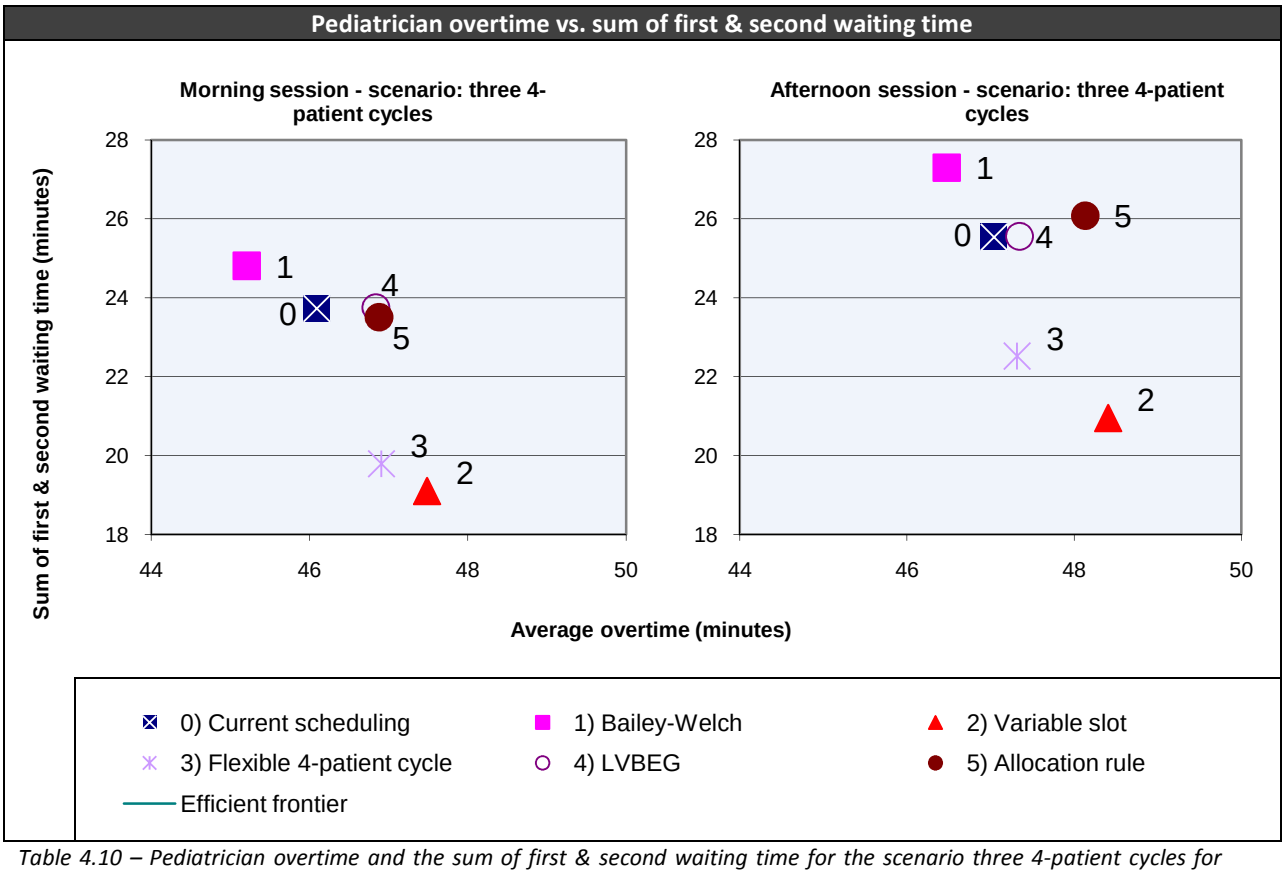


*Table 4.10 – Pediatrician overtime and the sum of first & second waiting time for the scenario three 4-patient cycles for both morning and afternoon sessions*

# 5 - Conclusions and Implementation

The purpose of this research is to increase the performance of the outpatient center of the pediatric department of the GHZ by improving its outpatient scheduling. The performance of this system is measured by the patient waiting time and pediatrician overtime.

***Current situation***
Our analysis of the currently used scheduling methods reveals different opportunities for improvement. We found that the currently used slot size of 15 minutes does not match the consultation duration of new patients. We also found that no allocation rule is used: a rule that depicts in what order appointment slots are filled. The biggest factor we found is the scheduling of consultations by an intern using a so-called 4-patient cycle. The 'consultations by an intern' are scheduled parallel with three consultations of follow-up patients by a pediatrician. Once both pediatrician and intern have finished their consultations they discus the new patient and the pediatrician consults the new patient accompanied by the intern. The imperfection of this scheduling rule is the waiting moment: the pediatrician or the intern has to wait until the other has finished consulting. The method increases the probability that the pediatrician experiences delays during the consultation session, which eventually increases the patient waiting time and the pediatrician overtime.

***Interventions***
We evaluate five interventions and combinations of these interventions to improve the current situation. (1) Bailey-Welch rule, i.e. scheduling of two patients on the initial slot. (2) Variable slot, i.e. increasing the slot size of new patients to 20 minutes. (3) Flexible 4-patient cycle, i.e. scheduling the follow-up patients succeeding the new patients 15 minutes earlier. (4) LVBEG rule, i.e. the scheduling of patients with low variance on consultation duration at the beginning of the consultation session and patients with a high variance at the end of the consultation session. (5) Allocation rule, i.e. introducing a rule that depicts how appointment slots have to be filled: starting with the first slot and continue with the successive slots. These interventions are tested with a simulation model of a consultation session with the use of two scenarios: historical and maximum utilization.

***Results***
Instead of appointing one of the interventions as the 'winner', we used an efficiency frontier to select a group of interventions that organize the consultation session most efficiently according to the patient waiting time and the pediatrician overtime. We found three interventions that represent the efficiency front in both of the scenarios historical and maximum utilization: (A) the flexible 4-patient cycle, (B) a combination of the LVBEG rule and the flexible 4-patient cycle and (C) a combination of the LVBEG rule, the Bailey-Welch rule and the flexible 4-patient cycle. The interventions have the ability to decrease the pediatrician overtime up to 20 % and the patient waiting time up to 10 %. Besides the historical and the maximum utilization, we tested the robustness of the interventions on different scenarios. We found that introducing an extra consultation by an intern would increase the pediatrician overtime and the different interventions would not differ significantly on pediatrician overtime anymore. We also found that excluding all consultations by an intern would exclude the flexible 4-patient cycle from the efficient frontier.

***Implementation***
Based on the environment in which the outpatient center offers pediatric health care, one of the three interventions should be chosen. In case the department strives to increase quality, it is more like to chose a configurations which leads to a lower patient waiting time. In case the cost of health care prevails, an intervention should be chosen that decreases the consultation end time and thereby increases the productivity. Implementing either one of the interventions comes down to changing the scheduling method. Since patients are scheduled with the use of the hospital information system, the scheduling application of this information system should allow scheduling of two patients on one slot. In case the scheduling application does not allow double bookings, assistance of the IT-department is necessary.

For the pediatric outpatient center the used method to schedule consultations by an intern has found to heavily influence its performance since altering the used scheduling with the use of the flexible 4-patient cycle decreases both pediatrician overtime and patient waiting time. Still no perfect configuration exists: combinations of other rules with the flexible 4-patient cycle result in shifts between the performance indicators overtime and waiting time, i.e. every configuration is a truce between different performance indicators. What combination must be chosen depends eventually on the environment of the outpatient center.

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# Appendix A - Summary of a Review on Outpatient Scheduling

Publications on outpatient scheduling are well covered in a review on this topic by Tugba Cayirli [Cayirli, 2003]. We therefore decide to summarize this review. The review discusses different variations in appointment scheduling as well as indicators to measure the performance of the appointment system (AS).

***Variations in appointment scheduling***

The used AS on the outpatient center can be classified as a static single-server system. Static because all the scheduled appointments do not change during the consultation session and single server since every patient has to queue before their appointed pediatrician for the service of a consultation. This is normal practice in outpatient centers where the one-to-one doctor-patient relationship is valued more than the efficiencies of a single common queue.

A more practical difference in AS is the number of appointments per consultation session. Other differences are the appointment interval, the block-size and the initial block, the queue discipline, patient classification and how the disruptive effect of no-shows is handled, differences which need more explanation.

Appointment interval

An appointment interval can either be fixed or variable. Recent studies indicate that increasing appointment intervals towards the middle of the consultation session and decreasing them from the middle of the consultation session equalizes waiting time among all patients.

Block-size and the initial block

The block size is the number of patients that are scheduled in the $i^{th}$ block. An AS can either use a single-block rule in which all patients are scheduled as a block at the start of the consultation session, an 'individual-block'-rule, in which every patient gets its own block or a 'multiple-block'-rule in which multiple patients are scheduled every block. The 'individual-block'-rule is used most frequently and the 'multiple-block'-rule is used when consultation times are very short. The *Bailey-Welch rule* is a variation of these two rules: it uses individual blocks with two patients on the initial block. This rule is found to be very effecting since it minimizes the risk of the physician staying idle (see Figure A.1).

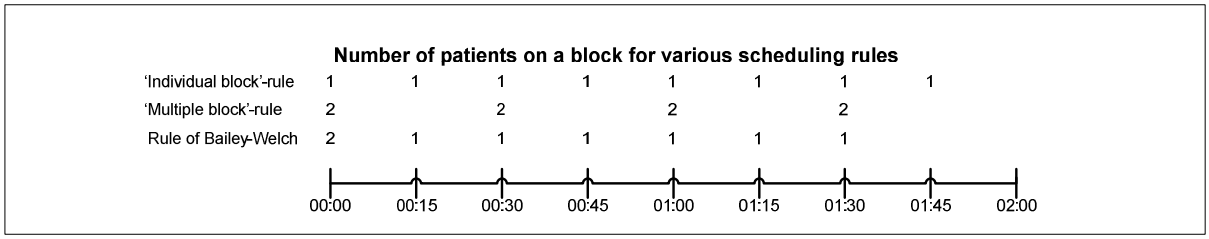



*Figure A.1 - Overview of the number of patients per block for various scheduling rules*

Queue discipline

An example of queue discipline is the first-come first-served rule (FCFS-rule) which is not the same as serving patients in the order in which they are scheduled. Nevertheless it isn't uncommon to use the FCFS-rule although this may result in patients ignoring appointments or patients coming earlier than necessary. The queue discipline defines which patient is served next, e.g. first urgent patients, second patients returning from an external examination, third scheduled patient and fourth walk-ins.

Patient classification

Patient classification is used to specify patients to specific appointment slots or define the size of the appointment slot. Examination time for example is influenced by factors as the patients' age or its physical mobility and could therefore be a reason to use different sizes of appointment slots. A negative side effect of classification is that it decreases the flexibility of the AS.

The disruptive effect of no-shows

Two ways of handling with no-shows are explained. The first approach is overbooking in which extra patients are planned during the consultation session and the second approach is shortening the appointment intervals proportionally.

***Performance indicators***

The performance of appointment systems is measured through time-based indicators and congestion-based indicators. The time-based indicators can also be used to measure the costs by multiplying the time with an hourly wage.

Time-based performance indicators

Performance measurements on a time-basis contain waiting, consultation and flow-time of the patient and idle and overtime of the pediatrician and the unpunctuality of the pediatrician. The presence of no-shows can also be seen as a time-based performance because of its influence on idle time pediatricians and waiting time of patients.

Waiting time seems to be insuperable since patients have the tendency to arrive more early than late. This unpunctuality is assumed to be independent of their scheduled appointment times. To some level, patients tolerate waiting time. This tolerance diminishes after about 30 minutes. The consultation time is the time in which the patient is claiming the doctor's attention. Although independence between the number of patients in the queue and the consultation duration is assumed, it could be that pediatricians raise their service level during peak hours. The flow-time of a patient is the total time a patient spends in the outpatient center.

The idle time of a pediatrician is the total time during a consultation session in which the pediatrician can not consult patients because there are no patients yet. The overtime is the time window between the scheduled and desired completion time of the consultation session and the actual end of the last consultation. The pediatricians' unpunctuality is defined as the lateness to the first appointment which has a major impact on the waiting time of patients.

Congestion-based performance indicators

Performance measurements on a congestion-basis contain the number of patients in a queue or system and the presence of companions which use (valuable) space.

***Motivation for differentiating appointment systems***

The review on outpatient scheduling in healthcare clearly describes the differences in outpatient scheduling. Although the review describes the impact of these differences, it does not describe the reasons for these differences. The obvious reason for differentiating appointment systems is the specific situation in which the appointment system operates. Specific lunch hours, opening and closing hours of the building, the value of the one-to-one doctor-patient relationship and specific deliberation hours, greatly depict the state of an appointment system. Therefore the lessons which can be distilled out of this review should be put into practice within the boundaries of these specific situations.

# Appendix B - Overview of Special Consultation Sessions

| Special consultation sessions | | |
|---|---|---|
| *Name* | *Description* | |
| 'Asthma and Lung'-session | Target group: | -Patients with Asthma or other Lung-problems |
| | Personnel: | -Pediatrician and pediatric nurse specialized in lungs |
| | Frequency: | -Daily |
| Cardio-session | Target group: | -Patients with a heart murmur |
| | Personnel: | -Pediatric cardiologist |
| | Frequency: | -Ones a month on a Wednesday |
| Diabetes-session | Target group: | -Patients with diabetes |
| | Personnel: | -Pediatrician, nurse specialized in diabetes and dietitian (and if necessary a psychologist) |
| | Frequency: | -Three or four times a year |
| Allergy-session | Target group: | -Patients with allergies |
| | Personnel: | -Pediatrician, dermatologist and/or dietitian |
| | Frequency: | -Ones every two weeks on a Monday afternoon |
| Immune-session | Target group: | -Patients with allergies, especially patients with hay fever |
| | Personnel: | -Pediatrician, nurse |
| | Frequency: | -Weekly |
| Baby-aftercare-session | Target group: | -Babies who experienced problems at birth |
| | Personnel: | -Nurse |
| | Frequency: | -Weekly on Thursday morning |
| GO-session | Target group: | -Patients with a deviating grow-curve |
| | Personnel: | -Pediatrician, physician of maternity center, physiotherapist and speech therapist |
| | | -Ones every two weeks on a Thursday afternoon |
| | Frequency: | |
| PIPO-session | Target group: | -Patient with pee and poop problems |
| | Personnel: | -Pediatrician, pediatric physiotherapist, dietitian, psychologist |
| | Frequency: | -Monthly |
| Down-team | Target group: | -Patients with the syndrome of Down |
| | Personnel: | -Pediatrician, physician specialized in rehabilitation, general practitioner, speech therapist , physiotherapist and social worker |
| | Frequency: | - Three or four times a year |
| Goldfish-session | Target group: | -Patients with developmental problems |
| | Personnel: | -Pediatrician, pediatric physician specialized in rehabilitation, medical psychologist |
| | | -Varies |
| | Frequency: | |
| Rehabilitation-session | Target group: | -Patients with motorial arrears/problems |
| | Personnel: | -Pediatrician, physician specialized in rehabilitation |
| | Frequency: | -Six until eight times a year |
| 'Language and Speech'-session | Target group: | -Patients with language and speech problems |
| | Personnel: | -Pediatrician and psychologist |
| | Frequency: | -Varies |

*Table B.1 - Overview of special consultation sessions*

# Appendix C1 - Time Registration System

The time registration of visiting patients started on the 11th of March 2008. Purpose of this registration system is to collect quantitative information on consultation sessions. Understanding the information based on this registration system demands an understanding on how the data is retrieved. What is registered and by whom this is registered, is explained in this section.

***The potential of the time registration system***

The visit of a patient can be explained by the various places the patient crosses during its visit or by the various services or treatments a patient retrieves. Explaining a visit by places comes down to waiting room, examination room and consultation room. Explaining a visit by services or treatments comes down to waiting, basic examination and consultation by the pediatrician.

The time registration system uses these two explanations to collect times. Sometimes a change in place, and sometimes a change in service is recorded. Table C1.2 gives an overview of the labels under which times are recorded. Together with the registration of a time a username is collected; the username is the name which is used to log on to the computer from which the registration is made.

The different collected times of a specific patient altogether is the route a patient takes. This route differs on the reason of visiting, whether the healthcare professional is a pediatrician or a pediatric resident and on the accuracy of the data collecting personnel. Table C1.3 gives an overview of the routes which are most registered.

The time registration system is build around the patient. Therefore patient specific information like the patient's pediatrician, the appointment times, kind of appointment and the diagnosis of the patient can be related to the recorded route. Table C1.1 gives an overview of the data that is recorded per visit.

***Execution of the time registration system***

The registration of the various times takes place for every patient visit. X/Care, the hospitals' information system, is used to record the various times: it just takes a couple of clicks and another time is recorded. The pitfall of this system is the recorded time. The question is whether or not the recorded time is equal to the actual time of the event it implies, this depends on the accuracy of the person recording the time. Every employee of the pediatric department contributes in recording the times, e.g. desk personnel record the entrance of patients and pediatricians record the start and end of a consultation. In most cases every 'label' is recorded by a specific type of employee (see Table C1.2).

| **Recorded data per patient visit** | | | | |
|---|---|---|---|---|
| *General information* | | *Time registration (example)* | | |
| - Patient identification number | - Number diagnose related group | Time | Label | Username |
| - Pediatrician | (DRG) | 09:02 | 2 | Front desk employee |
| - Date of consultation | - Start date of DRG | 09:05 | 3 | Secretary of the pediatrician |
| - Expected start time of consultation | - End date of DRG | 09:10 | 5 | Pediatrician |
| - Expected end time of consultation | - Diagnose | 09:25 | 7 | Pediatrician |
| - Consultation specification 1 | - Treatment | 09:31 | 8 | Front desk employee |
| - Consultation specification 2 | | | | |

*Table C1.1 - Overview of recorded data per patient visit*

| Time-labels | | | | |
|---|---|---|---|---|
| *Label* | | *Recording personnel* | *Place change description of label* | *Action decription of label* |
| *Code* | *Name* | | | |
| 1-N | Not arrived yet | | Time on which the patient has not yet arrived. | |
| 2-W | Waiting room | Front desk employee | Time on which the patient arrives and takes place in the waiting room. | |
| 3-O | Examination room | The secretary or the pediatrician | Time on which the patients enters the examination room. | Time on which the basic examination of weight and length starts. |
| 4-C | Intern | | | Time on which the Intern start with the consultation. |
| 5-S | Start consultation | Pediatrician | | Time on which the pediatrician start with the consultation. |
| 6-F | External examination. | | Time on which the patient leaves the pediatric department for an examination elsewhere. | |
| 7-E | End consultation | Pediatrician | | Time on which the pediatrician ends the consultation. |
| 8-V | Left with appointment | Front desk employee | Time of leaving of a patient which has just made another appointment. | |
| 9-B | Left without appointment | Front desk employee | Time of leaving of a patient that does not have to come back. | |
| 10-K | Left as inpatient | Front desk employee | Time of leaving of a patient that needs immediate medical attention. | |
| 11-X | No show | | Patient did not show up. | |

*Table C1.2 - Overview of labels under which times are recorded*

| Most frequent reported routes | | | |
|---|---|---|---|
| *Route* | *Route* | *Percentage* | *Percentage (cumulative)* |
| 2-3-5-7-8 | W-O-S-E-V | 34 % | 34 % |
| 5-7 | S-E | 11 % | 45 % |
| 2-3-4-5-7-8 | W-O-C-S-E-V | 7 % | 52 % |
| 2-3-5-7 | W-O-S-E | 5 % | 57 % |
| 2-2-3-3-5-5-7-7-8-8 | 2(W-O-S-E-V) | 3 % | 60 % |
| 3-5-7-8 | O-S-E-V | 3 % | 62 % |
| 5-7-8 | S-E-V | 2 % | 64 % |
| 7 | E | 2 % | 66 % |
| 11 | X | 2 % | 68 % |
| 2-5-7 | W-S-E | 2 % | 70 % |
| 2 | W | 1 % | 72 % |
| 2-5-7-8 | W-S-E-V | 1 % | 73 % |
| 2-3-5-7-9 | W-O-S-E-B | 1 % | 74 % |
| 2-3-7-8 | W-O-E-V | 1 % | 75 % |
| 2-3-5-8 | W-O-S-V | 1 % | 76 % |
| 2-3-4-5-7 | W-O-C-S-E | 1 % | 77 % |
| 5-5-7-7 | 2(S-E) | 1 % | 78 % |
| 2-3-5 | W-O-S | 1 % | 79 % |
| 2-2-3-3-5-5-7-7 | 2(W-O-S-E) | 1 % | 80 % |
| 2-5-8 | W-S-V | 1 % | 80 % |

*Table C1.3 - An overview of the most frequent reported routes (based on data gathered from March 11th 2008 until April 3rd 2009).*

# Appendix C2 - Inaccuracy of the Data

The data on the flow of a single patient is gathered in different steps (see Appendix C1). For a correct recording of the data, every involved employee has to record specific events. This has to be done on time and in the correct order. This recording system has found out to be very sensitive for human mistakes. Frequent mistakes are: forgetting to record a specific event, recording a false time for a specific event.

***Forgetting to record a specific event***

For every patient who visits the outpatient center of the pediatric department various steps are recorded. Some of these steps are only recorded for some patients, like the external examination, while the following steps should be recorded for all patients:

1. Entering outpatient center
2. Entering examination room
3. Start of consultation
4. End of consultation
5. Exit outpatient center

These steps are not always recorded (see Figure C2.1), which results in a percentage of 65 % of the consultations for which all of these obligatory five steps are present. Especially the moment of leaving the outpatient center (19,7 % not recorded) is worrying. A possible explanation is that patients, whom do not have to come back and are cleared of any other treatments, are not obliged to contact the front desk and can therefore leave without being noticed by the front desk personnel.

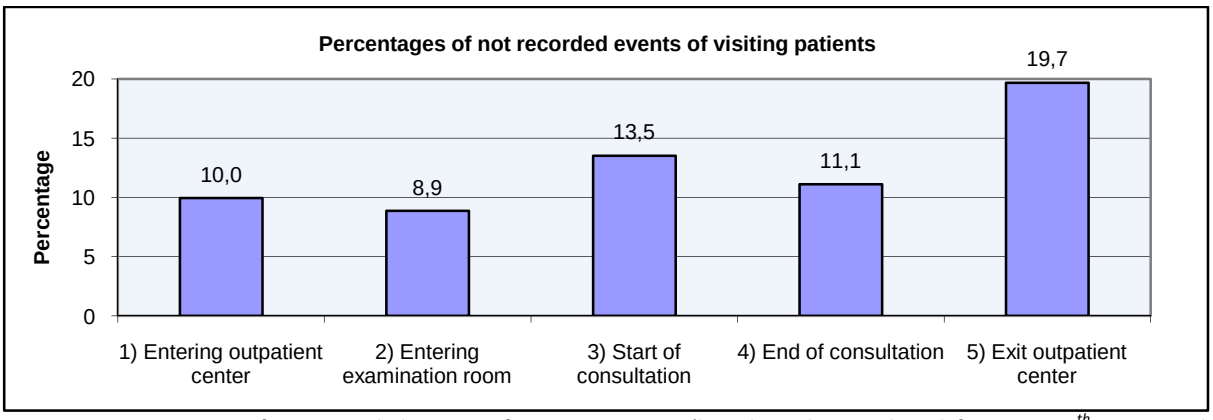



*Figure C2.1 - Overview of not recorded events of visiting patients (based on data gathered from May 6th 2008 until December 21th 2009).*

***Recording a false time***

The times that are recorded for patients in the outpatient center are the times of the actual recording of a specific step, i.e. the time at which the step is entered into the computer. If a specific step is entered into the computer long after it took place, the resulting time is an inaccurate representation of reality. In some cases it is possible to trace this mistake: by impossible routes, impossible time windows or overlapping consultation times. Nevertheless are these mistakes not always traceable, i.e. it can not be proven that a recorded time differentiates from reality in all cases. The following steps can be traced: impossible route, impossible time window and overlapping consultation times.

<u>A- Impossible route</u>

In case the route the patient takes is impossible, it can be stated that an event has been recorded at a different time than it took place. Table C2.1 gives an overview of recorded visits for which an impossible route is recorded.

B- Impossible time windows

Another case in which a mistake can be traced is when the resulting time windows is impossible, like in the case a consultation of zero minutes exists or consultation lasts more than a couple of hours (see Table C2.1).

C- Overlapping consultation times

Another case in which corrupt data can be traced is if the different consultation times overlap, which is the case for 8,61 percent of the cases in which this can be noticed (see Table C2.1).

| Percentages of corrupt recorded events of visiting patients | | |
|---|---|---|
| *Category* | *Mistake* | *Percentage* |
| A | Entering examination room before entering waiting room | 0,30 % |
| A | Starting consultation before entering examination room | 0,25 % |
| A | End of consultation before consultation has started | 0,39 % |
| A | Patient exits before consultation has ended | 1,68 % |
| B | Consultation takes zero minutes | 2,33 % |
| B | Consultation takes more than two hours | 0,19 % |
| B | Patient goes from waiting room to examination room in zero minutes | 4,97 % |
| C | Overlap of consultations | 8,61 % |

*Table C2.1 - Overview of the occurrence of mistakes (based on data gathered from May 6th 2008 until December 21th 2009).*

***Mistake-amplifiers***

In case of inaccurate data because of human mistakes it is plausible that these mistakes are more frequent for sporadic users and for sporadic registrations than for frequent users and frequent registrations. For this reason the percentages of mistakes are again calculated but than only for the seven pediatricians in their specific time slots. The results do support this hypothesis (see Figure C2.2).

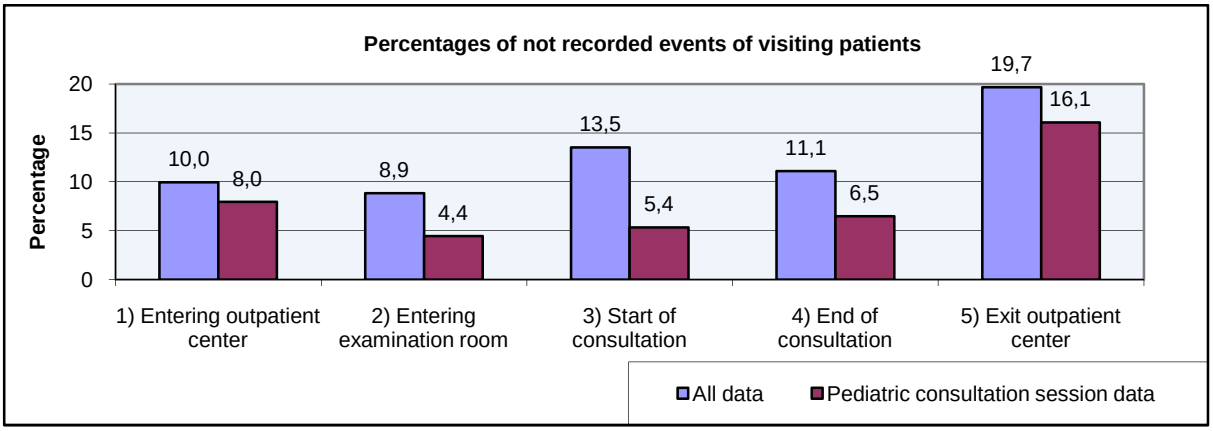



*Figure C2.2 - Overview of the accuracy of recording events which are applicable for every visiting patient (based on data gathered from May 6th 2008 until December 21th 2009).*

***Conclusion***

Since humans make mistakes and the existence of the data and the accuracy of the data depends on the data gathering employees of the pediatric department only, the data does and will contain mistakes. Because of this, the data which is used to determine parameters should be checked on traceable mistakes as explained in this section.

# Appendix C3 - Basic Selection Criteria

The dataset created by the time registration system (see Appendix C1) contains data on various patients on various consultation sessions by various health care professionals including the seven pediatricians. In order to create a comparable set of data, special consultation sessions and consultations by health care professionals other than the seven pediatricians needs to be filtered. This filtering is done by the use of Basic Selection Criteria. The basic selection depends on the various attributes every consultation has: the pediatrician and the time on which the consultations takes place, the kind of patient and the kind of consultation session. In this appendix the used criteria based on these attributes are explained.

***Pediatrician and the time on which the consultation takes place***

Consultations are selected when one of the seven pediatricians is involved. The consultation must be held in those specific half workdays at which the seven pediatricians have their regular consultation sessions (see Table C3.1). Workdays are split at 13:00 hours in morning (M) and afternoon (A).

| **Day and times of regular consultation sessions of the seven pediatricians** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pediatrician: | 2 | | 6 | | 1 | | 7 | | 4 | | 5 | | 3 | |
| M(orning)/A(fternoon): | M | A | M | A | M | A | M | A | M | A | M | A | M | A |
| Monday: | X | | X | | | X | | | | X | X | | | X |
| Tuesday: | | | | X | | X | | X | | | | X | | |
| Wednesday: | X | | | | | | X | | | | | X | | |
| Thursday: | | | | X | X | | | X | | | | | X | |
| Friday: | X | | | | | | | | X | | | | X | |

*Table C3.1 - Overview of half workdays on which the pediatricians have their consultation session, i.e. the shaded X.*

***Kind of Patient***

The visiting patients must be either new patients or follow-up patients only. This is done by filtering the consultations using the attribute 'kind of patient'. Consultations with the specific attribute new and follow-up patient are included (see Table C3.2).

| **Filtering using the attribute 'Kind of Patient'** | |
|---|---|
| *Include* | *Exclude* |
| Follow-up patient | Goldfish patient |
| New patient | PIPO patient |

*Table C3.2 - Overview of filtering using the attribute 'Kind of Patient'*

***Kind of Consultation Session***

The consultation session must be a general consultation session, i.e. it should not be a special consultation session. To exclude special consultation sessions, the attribute 'kind of consultation session' is used (see Table C3.3).

| **Filtering using the attribute 'kind of consultation'** | |
|---|---|
| *Include* | *Exclude* |
| Consultation by pediatric resident<br>Specially added consultation<br>Specially added consultation for new patients<br>Consultation by pediatrician | 'Allergy'-consultation<br>'Diabetes'-consultation<br>'Ultrasound'-consultation<br>'GO'-consultation<br>'Goldfish'-consultation<br>'PIPO'-consultation<br>'Physiotherapy'-consultation<br>'Cardio'-consultation<br>Consultation by phone<br>'Icat'-consultation |

*Table C3.3 - Overview of filtering using the attribute 'kind of session'*

***Conclusion***

Based on data gathered from March 11th 2008 until April 3rd 2009, the number of consultations decreased from 8332 to 5070 and the number of consultation sessions decreased from 968 to 609 by applying the basic selection criteria on the gathered data.

# Appendix D1 - Occurrence of Diagnoses

This appendix gives overviews of the size of various patient groups measured by the frequency of consultations for all pediatricians and for every single pediatrician. An overview of 80 % of the most frequent diagnoses present in a consultation can be found in Table D1.1. Overviews of 80 % of the most frequent diagnoses per pediatrician can be found in Table D1.2 to Table D1.8. Overviews are based on consultations selected with the use of the basic selection criteria (see Appendix C3).

| Occurrence of diagnoses | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 3202 | Asthma | 1663 | 1663 | 25,52 % | 25,52 % |
| 2 | 7601 | ADHD | 747 | 2410 | 11,46 % | 36,98 % |
| 3 | 3320 | Constipation (habitual) | 404 | 2814 | 6,20 % | 43,18 % |
| 4 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 273 | 3087 | 4,19 % | 47,37 % |
| 5 | 3203 | Atop syndrome | 250 | 3337 | 3,84 % | 51,20 % |
| 6 | 7110 | Small body height/ deviating growth curve | 213 | 3550 | 3,27 % | 54,47 % |
| 7 | 3327 | Food allergy (cow's milk among other things) | 141 | 3691 | 2,16 % | 56,64 % |
| 8 | 3310 | Gastro-esophageal reflux | 130 | 3821 | 1,99 % | 58,63 % |
| 9 | 8906 | Follow-up "neonatal intensive-care unit"-population | 106 | 3927 | 1,63 % | 60,26 % |
| 10 | 7611 | psychiatric disorders | 104 | 4031 | 1,60 % | 61,85 % |
| 11 | 7699 | Remaining psychosocial problems | 101 | 4132 | 1,55 % | 63,40 % |
| 12 | 3503 | Epilepsy | 98 | 4230 | 1,50 % | 64,91 % |
| 13 | 3520 | Mental and motorial retardation | 97 | 4327 | 1,49 % | 66,40 % |
| 14 | 7402 | Atop syndrome | 67 | 4394 | 1,03 % | 67,42 % |
| 15 | 3328 | Feeding problems/mistakes | 66 | 4460 | 1,01 % | 68,44 % |
| 16 | 4112 | Urinary tract infection, no anatomical deviation | 59 | 4519 | 0,91 % | 69,34 % |
| 17 | 7204 | Down syndrome | 58 | 4577 | 0,89 % | 70,23 % |
| 18 | 8911 | Depression/Fatigue (no chronic fatigue syndrome) | 58 | 4635 | 0,89 % | 71,12 % |
| 19 | 3104 | Upper respiratory infection | 56 | 4691 | 0,86 % | 71,98 % |
| 20 | 7108 | Hypothyroidism (CHT among other things) | 53 | 4744 | 0,81 % | 72,79 % |
| 21 | 3401 | Heart murmur, harmless | 50 | 4794 | 0,77 % | 73,56 % |
| 22 | 3303 | Abdominal pain, chronically recurrent | 48 | 4842 | 0,74 % | 74,30 % |
| 23 | 4113 | Urinary tract infection, anatomical deviation | 47 | 4889 | 0,72 % | 75,02 % |
| 24 | 7101 | Obesity | 46 | 4935 | 0,71 % | 75,73 % |
| 25 | 8904 | Failure-to-thrive eci | 44 | 4979 | 0,68 % | 76,40 % |
| 26 | 3208 | Lower respiratory infection | 41 | 5020 | 0,63 % | 77,03 % |
| 27 | 3506 | Headache (no migraine) | 40 | 5060 | 0,61 % | 77,64 % |
| | 3522 | Speech (developmental) impediment | 40 | 5100 | 0,61 % | 78,26 % |
| 28 | 6003 | Anemia, remaining | 40 | 5140 | 0,61 % | 78,87 % |
| 29 | 4101 | Dysfunctional voiding | 38 | 5178 | 0,58 % | 79,45 % |

*Table D1.1 - An overview of different diagnoses and the corresponding percentage of occupied consultations (based on data gathered from May 6$^{th}$ 2008 until August 31$^{st}$ 2009).*

| Occurrence of diagnoses of pediatrician 1 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 3202 | Asthma | 212 | 212 | 21,22 % | 21,22 % |
| 2 | 3203 | Atop syndrome | 204 | 416 | 20,42 % | 41,64 % |
| 3 | 7601 | ADHD | 100 | 516 | 10,01 % | 51,65 % |
| 4 | 3327 | Food allergy (cow's milk among other things) | 38 | 554 | 3,80 % | 55,46 % |
| 5 | 7402 | Atop syndrome | 33 | 587 | 3,30 % | 58,76 % |
| 6 | 7110 | Small body height/deviating growth curve | 29 | 616 | 2,90 % | 61,66 % |
| 7 | 3320 | Constipation (habitual) | 27 | 643 | 2,70 % | 64,36 % |
| 8 | 8911 | Depression/Fatigue (no chronic fatigue syndr.) | 22 | 665 | 2,20 % | 66,57 % |
| 9 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 21 | 686 | 2,10 % | 68,67 % |
| 10 | 3328 | Feeding problems/-mistakes | 16 | 702 | 1,60 % | 70,27 % |
| 11 | 3503 | Epilepsy | 15 | 717 | 1,50 % | 71,77 % |
| 12 | 8904 | Failure-to-thrive eci | 14 | 731 | 1,40 % | 73,17 % |
| 13 | 3103 | Atop syndrome | 13 | 744 | 1,30 % | 74,47 % |
| 14 | 3104 | Upper respiratory infection | 13 | 757 | 1,30 % | 75,78 % |
| 15 | 3310 | Gastro-esophageal reflux | 12 | 769 | 1,20 % | 76,98 % |
| 16 | 3303 | Abdominal pain, chronically recurrent | 11 | 780 | 1,10 % | 78,08 % |
| 17 | 4101 | Dysfunctional voiding | 10 | 790 | 1,00 % | 79,08 % |
| 18 | 7112 | Early puberty development | 10 | 800 | 1,00 % | 80,08 % |

*Table D1.2 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 1 (based on data gathered from May 6th 2008 until August 31st 2009).*

| Occurrence of diagnoses of pediatrician 6 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 3202 | Asthma | 262 | 262 | 25,02 % | 25,02 % |
| 2 | 7601 | ADHD | 104 | 366 | 9,93 % | 34,96 % |
| 3 | 3320 | Constipation (habitual) | 97 | 463 | 9,26 % | 44,22 % |
| 4 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 57 | 520 | 5,44 % | 49,67 % |
| 5 | 3327 | Food allergy (cow's milk among other things) | 33 | 553 | 3,15 % | 52,82 % |
| 6 | 7110 | Small body height/deviating growth curve | 33 | 586 | 3,15 % | 55,97 % |
| 7 | 8906 | Follow-up "neonatal intensive-care unit"-population | 33 | 619 | 3,15 % | 59,12 % |
| 8 | 3310 | Gastro-esophageal reflux | 28 | 647 | 2,67 % | 61,80 % |
| 9 | 3503 | Epilepsy | 27 | 674 | 2,58 % | 64,37 % |
| 10 | 3520 | Mental and motorial retardation | 18 | 692 | 1,72 % | 66,09 % |
| 11 | 3328 | Feeding problems/-mistakes | 13 | 705 | 1,24 % | 67,34 % |
| 12 | 4112 | Urinary tract infection, no anatomical deviation | 13 | 718 | 1,24 % | 68,58 % |
| 13 | 4101 | Dysfunctional voiding | 12 | 730 | 1,15 % | 69,72 % |
| 14 | 7611 | Psychiatric disorders | 11 | 741 | 1,05 % | 70,77 % |
| 15 | 7499 | Remaining skin diseases | 10 | 751 | 0,96 % | 71,73 % |
| 16 | 7699 | Remaining psychosocial problems | 10 | 761 | 0,96 % | 72,68 % |
| 17 | 5199 | Remaining orthopedic disorder | 9 | 770 | 0,86 % | 73,54 % |
| 18 | 3208 | Lower respiratory infection | 8 | 778 | 0,76 % | 74,31 % |
| 19 | 3513 | Migraine | 8 | 786 | 0,76 % | 75,07 % |
| 20 | 3517 | Mental retardation | 8 | 794 | 0,76 % | 75,84 % |
| 21 | 3522 | Speech (developmental) impediment | 8 | 802 | 0,76 % | 76,60 % |
| 22 | 6001 | Anemia, iron deficiency | 8 | 810 | 0,76 % | 77,36 % |
| 23 | 7105 | Tall body height | 8 | 818 | 0,76 % | 78,13 % |
| 24 | 7112 | Early puberty development | 8 | 826 | 0,76 % | 78,89 % |
| 25 | 3104 | Upper respiratory infection | 7 | 833 | 0,67 % | 79,56 % |

*Table D1.7 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 6 (based on data gathered from May 6th 2008 until August 31st 2009).*

| Occurrence of diagnoses of pediatrician 4 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 3202 | Asthma | 100 | 100 | 18,73 % | 18,73 % |
| 2 | 7601 | ADHD | 49 | 149 | 9,18 % | 27,90 % |
| 3 | 3401 | Heart murmur, harmless | 37 | 186 | 6,93 % | 34,83 % |
| 4 | 3320 | Constipation (habitual) | 33 | 219 | 6,18 % | 41,01 % |
| 5 | 7110 | Small body height/deviating growth curve | 32 | 251 | 5,99 % | 47,00 % |
| 6 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 30 | 281 | 5,62 % | 52,62 % |
| 7 | 3310 | Gastro-esophageal reflux | 17 | 298 | 3,18 % | 55,81 % |
| 8 | 3410 | Cardiac arrhythmia | 12 | 310 | 2,25 % | 58,05 % |
| 9 | 3520 | Mental and motorial retardation | 11 | 321 | 2,06 % | 60,11 % |
| 10 | 3328 | Feeding problems/-mistakes | 10 | 331 | 1,87 % | 61,99 % |
| 11 | 4113 | Urinary tract infection, anatomical deviation | 10 | 341 | 1,87 % | 63,86 % |
| 12 | 3404 | Cor Vitium, no Cyanosis, hemodynamical unimportant | 8 | 349 | 1,50 % | 65,36 % |
| 13 | 3405 | Cor Vitium, after cardiac surgery | 8 | 357 | 1,50 % | 66,85 % |
| 14 | 3499 | Remaining cardiological syndromes | 8 | 365 | 1,50 % | 68,35 % |
| 15 | 7502 | Inborn error with retardation | 8 | 373 | 1,50 % | 69,85 % |
| 16 | 7611 | Psychiatric disorders | 8 | 381 | 1,50 % | 71,35 % |
| 17 | 8906 | Follow-up "neonatal intensive-care unit"-population | 8 | 389 | 1,50 % | 72,85 % |
| 18 | 3503 | Epilepsy | 7 | 396 | 1,31 % | 74,16 % |
| 19 | 7699 | Remaining psychosocial problems | 7 | 403 | 1,31 % | 75,47 % |
| 20 | 7204 | Down syndrome | 6 | 409 | 1,12 % | 76,59 % |
| 21 | 8910 | Fever (FUO) | 6 | 415 | 1,12 % | 77,72 % |
| 22 | 8911 | Depression/Fatigue (no chronic fatigue syndr.) | 6 | 421 | 1,12 % | 78,84 % |
| 23 | 3104 | Upper respiratory infection | 5 | 426 | 0,94 % | 79,78 % |

*Table D1.3 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 4 (based on data gathered from May 6th 2008 until August 31st 2009).*

| Occurrence of diagnoses of pediatrician 2 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 3202 | Asthma | 317 | 317 | 32,95 % | 32,95 % |
| 2 | 7601 | ADHD | 144 | 461 | 14,97 % | 47,92 % |
| 3 | 3320 | Constipation (habitual) | 59 | 520 | 6,13 % | 54,05 % |
| 4 | 7110 | Small body height/deviating growth curve | 39 | 559 | 4,05 % | 58,11 % |
| 5 | 3520 | Mental and motorial retardation | 29 | 588 | 3,01 % | 61,12 % |
| 6 | 3503 | Epilepsy | 18 | 606 | 1,87 % | 62,99 % |
| 7 | 7611 | Psychiatric disorders | 17 | 623 | 1,77 % | 64,76 % |
| 8 | 3203 | Atop syndrome | 15 | 638 | 1,56 % | 66,32 % |
| 9 | 7104 | Diabetes mellitus | 15 | 653 | 1,56 % | 67,88 % |
| 10 | 7108 | Hypothyroidism (CHT among other things) | 13 | 666 | 1,35 % | 69,23 % |
| 11 | 7199 | Remaining endocrinology | 13 | 679 | 1,35 % | 70,58 % |
| 12 | 7204 | Down syndrome | 13 | 692 | 1,35 % | 71,93 % |
| 13 | 3103 | Atop syndrome | 11 | 703 | 1,14 % | 73,08 % |
| 14 | 5199 | remaining orthopedic disorder | 10 | 713 | 1,04 % | 74,12 % |
| 15 | 7604 | Eating disorder | 10 | 723 | 1,04 % | 75,16 % |
| 16 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 10 | 733 | 1,04 % | 76,20 % |
| 17 | 3104 | Upper respiratory infection | 9 | 742 | 0,94 % | 77,13 % |
| 18 | 3506 | Headache (no migraine) | 9 | 751 | 0,94 % | 78,07 % |
| 19 | 7101 | Obesity | 9 | 760 | 0,94 % | 79,00 % |
| 20 | 7105 | Tall body height | 9 | 769 | 0,94 % | 79,94 % |

*Table D1.4 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 2 (based on data gathered from May 6th 2008 until August 31st 2009).*

| Occurrence of diagnoses of pediatrician 3 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 3202 | Asthma | 425 | 425 | 41,63 % | 41,63 % |
| 2 | 7601 | ADHD | 73 | 498 | 7,15 % | 48,78 % |
| 3 | 3320 | Constipation (habitual) | 43 | 541 | 4,21 % | 52,99 % |
| 4 | 7110 | Small body height/deviating growth curve | 33 | 574 | 3,23 % | 56,22 % |
| 5 | 3310 | Gastro-esophageal reflux | 27 | 601 | 2,64 % | 58,86 % |
| 6 | 6003 | Anemia, remaining | 24 | 625 | 2,35 % | 61,21 % |
| 7 | 7402 | Atop syndrome | 23 | 648 | 2,25 % | 63,47 % |
| 8 | 3327 | Food allergy (cow's milk among other things) | 21 | 669 | 2,06 % | 65,52 % |
| 9 | 3304 | Coeliac disease | 16 | 685 | 1,57 % | 67,09 % |
| 10 | 7611 | Psychiatric disorders | 16 | 701 | 1,57 % | 68,66 % |
| 11 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 16 | 717 | 1,57 % | 70,23 % |
| 12 | 3328 | Feeding problems/-mistakes | 14 | 731 | 1,37 % | 71,60 % |
| 13 | 3203 | Atop syndrome | 11 | 742 | 1,08 % | 72,67 % |
| 14 | 3520 | Mental and motorial retardation | 11 | 753 | 1,08 % | 73,75 % |
| 15 | 7204 | Down syndrome | 10 | 763 | 0,98 % | 74,73 % |
| 16 | 8911 | Depression/Fatigue (no chronic fatigue syndrome) | 10 | 773 | 0,98 % | 75,71 % |
| 17 | 3523 | Syncope/no epileptic attack | 9 | 782 | 0,88 % | 76,59 % |
| 18 | 7108 | Hypothyroidism (CHT among other things) | 9 | 791 | 0,88 % | 77,47 % |
| 19 | 7112 | Early puberty development | 9 | 800 | 0,88 % | 78,35 % |
| 20 | 3104 | Upper respiratory infection | 8 | 808 | 0,78 % | 79,14 % |
| 21 | 3208 | Lower respiratory infection | 8 | 816 | 0,78 % | 79,92 % |

*Table D1.5 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 3 (based on data gathered from May 6th 2008 until August 31st 2009).*

| Occurrence of diagnoses of pediatrician 5 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 7601 | ADHD | 254 | 254 | 22,62 % | 22,62 % |
| 2 | 3202 | Asthma | 242 | 496 | 21,55 % | 44,17 % |
| 3 | 3320 | Constipation (habitual) | 52 | 548 | 4,63 % | 48,80 % |
| 4 | 7611 | Psychiatric disorders | 41 | 589 | 3,65 % | 52,45 % |
| 5 | 7699 | Remaining psychosocial problems | 39 | 628 | 3,47 % | 55,92 % |
| 6 | 7110 | small body height/deviating growth curve | 30 | 658 | 2,67 % | 58,59 % |
| 7 | 3327 | Food allergy (cow's milk among other things) | 20 | 678 | 1,78 % | 60,37 % |
| 8 | 3517 | Mental retardation | 17 | 695 | 1,51 % | 61,89 % |
| 9 | 3522 | Speech (developmental) impediment | 17 | 712 | 1,51 % | 63,40 % |
| 10 | 7204 | Down syndrome | 17 | 729 | 1,51 % | 64,92 % |
| 11 | 7610 | Learning disorders | 17 | 746 | 1,51 % | 66,43 % |
| 12 | 3503 | Epilepsy | 16 | 762 | 1,42 % | 67,85 % |
| 13 | 3520 | Mental and motorial retardation | 16 | 778 | 1,42 % | 69,28 % |
| 14 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 16 | 794 | 1,42 % | 70,70 % |
| 15 | 4112 | Urinary tract infection, no anatomical deviation | 13 | 807 | 1,16 % | 71,86 % |
| 16 | 7108 | Hypothyroidism (CHT among other things) | 13 | 820 | 1,16 % | 73,02 % |
| 17 | 7105 | Tall body height | 12 | 832 | 1,07 % | 74,09 % |
| 18 | 7101 | Obesity | 11 | 843 | 0,98 % | 75,07 % |
| 19 | 3303 | Abdominal pain, chronically recurrent | 10 | 853 | 0,89 % | 75,96 % |
| 20 | 3399 | Remaining gastro-enterol ailments | 10 | 863 | 0,89 % | 76,85 % |
| 21 | 4102 | Nocturnal enuresis | 10 | 873 | 0,89 % | 77,74 % |
| 22 | 4113 | Urinary tract infection, anatomical deviation | 9 | 882 | 0,80 % | 78,54 % |
| 23 | 6003 | Anemia, remaining | 9 | 891 | 0,80 % | 79,34 % |
| 24 | 3518 | Motorial retardation | 8 | 899 | 0,71 % | 80,05 % |

*Table D1.6 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 5 (based on data gathered from May 6th 2008 until August 31st 2009).*

| Occurrence of diagnoses of pediatrician 7 | | | | | | |
|---|---|---|---|---|---|---|
| *Rank* | *Diagnose number* | *Diagnose* | *Number of consultations* | *Number of consultations cumulative* | *Percentage* | *Percentage cumulative* |
| 1 | 8905 | Follow-up neonatal problems (no neonatal intensive-care unit) | 123 | 123 | 14,80 % | 14,80 % |
| 2 | 3202 | Asthma | 105 | 228 | 12,64 % | 27,44 % |
| 3 | 3320 | Constipation (habitual) | 93 | 321 | 11,19 % | 38,63 % |
| 4 | 8906 | Follow-up "neonatal intensive-care unit"-population | 50 | 371 | 6,02 % | 44,65 % |
| 5 | 3310 | Gastro-esophageal reflux | 36 | 407 | 4,33 % | 48,98 % |
| 6 | 7601 | ADHD | 23 | 430 | 2,77 % | 51,74 % |
| 7 | 8904 | Failure-to-thrive eci | 23 | 453 | 2,77 % | 54,51 % |
| 8 | 3327 | Food allergy (cow's milk among other things) | 21 | 474 | 2,53 % | 57,04 % |
| 9 | 7699 | Remaining psychosocial problems | 20 | 494 | 2,41 % | 59,45 % |
| 10 | 7110 | Small body height/deviating growth curve | 17 | 511 | 2,05 % | 61,49 % |
| 11 | 4112 | Urinary tract infection, no anatomical deviation | 15 | 526 | 1,81 % | 63,30 % |
| 12 | 3506 | Headache (no migraine) | 11 | 537 | 1,32 % | 64,62 % |
| 13 | 7101 | Obesity | 11 | 548 | 1,32 % | 65,94 % |
| 14 | 8911 | Depression/Fatigue (no chronic fatigue syndrome) | 11 | 559 | 1,32 % | 67,27 % |
| 15 | 3303 | Abdominal pain, chronically recurrent | 10 | 569 | 1,20 % | 68,47 % |
| 16 | 7199 | Remaining endocrinology | 10 | 579 | 1,20 % | 69,68 % |
| 17 | 3104 | Upper respiratory infection | 9 | 588 | 1,08 % | 70,76 % |
| 18 | 4113 | Urinary tract infection, anatomical deviation | 9 | 597 | 1,08 % | 71,84 % |
| 19 | 4101 | Dysfunctional voiding | 8 | 605 | 0,96 % | 72,80 % |
| 20 | 7805 | Lymphadenopathy | 8 | 613 | 0,96 % | 73,77 % |
| 21 | 3503 | Epilepsy | 7 | 620 | 0,84 % | 74,61 % |
| 22 | 3518 | Motorial retardation | 7 | 627 | 0,84 % | 75,45 % |
| 23 | 7604 | Eating disorder | 7 | 634 | 0,84 % | 76,29 % |
| 24 | 7611 | Psychiatric disorders | 7 | 641 | 0,84 % | 77,14 % |
| 25 | 7204 | Down syndrome | 6 | 647 | 0,72 % | 77,86 % |
| 26 | 7401 | Eczema | 6 | 653 | 0,72 % | 78,58 % |
| 27 | 7402 | Atop syndrome | 6 | 659 | 0,72 % | 79,30 % |
| 28 | 9902 | Basic care infants | 6 | 665 | 0,72 % | 80,02 % |

*Table D1.8 - Overview of the occurrence of 80 % of the most frequent diagnoses present in consultations of pediatrician 7 (based on data gathered from May 6$^{th}$ 2008 until August 31$^{st}$ 2009).*

# Appendix D2 - Utilization of Appointment Slots

This appendix describes the utilization of appointment slots and the necessary data selection. The utilization of appointment slots is described by the number of new and follow-up patients that are scheduled and how these patients are allocated on the available appointment slots.

In order to calculate this utilization, consultation sessions are collected using the basic selection criteria (see Appendix C3). This resulted in 676 consultation sessions. From the 676 consultation sessions seven sessions are excluded: for every pediatrician the first recorded consultation session is deleted since the possibility exist that these consultation sessions do not contain all consultations. From these 669 consultation sessions, another eleven sessions are excluded because the sessions contained consultations excluded through the basic selection. Another twelve sessions are excluded because of containing consultations by phone and finally, six more sessions are excluded because of containing only new patients.

Table D2.1, D2.2 and D2.3 show an overview of the number of patients per consultation session. Table D2.4 shows an example of the distribution of patients among appointment slots. Figure D2.1 visualizes this consultation session filling, showing a peak at eleven/twelve patients per consultation sessions. It also shows the share of fragmented sessions, fragmented because of other duties of the pediatrician. The average number of new patients in a consultation session is 1,8 and the average number of follow-up patients in a consultation session is 7,8.

| Number of patients on a consultation session | | |
|---|---|---|
| *Number of patients* | *Number of consultation sessions* | *Percentage of consultation sessions* |
| 1 | 16 | 2,5 % |
| 2 | 11 | 1,7 % |
| 3 | 18 | 2,8 % |
| 4 | 21 | 3,3 % |
| 5 | 22 | 3,4 % |
| 6 | 25 | 3,9 % |
| 7 | 31 | 4,8 % |
| 8 | 43 | 6,7 % |
| 9 | 54 | 8,4 % |
| 10 | 84 | 13,1 % |
| 11 | 110 | 17,2 % |
| 12 | 108 | 16,9 % |
| 13 | 60 | 9,4 % |
| 14 | 29 | 4,5 % |
| 15 | 8 | 1,3 % |
| **Total:** | **640** | **100,0 %** |

*Table D2.1 - Number of patients per consultation session (based on data gathered from May 6th 2008 until August 31th 2009)*

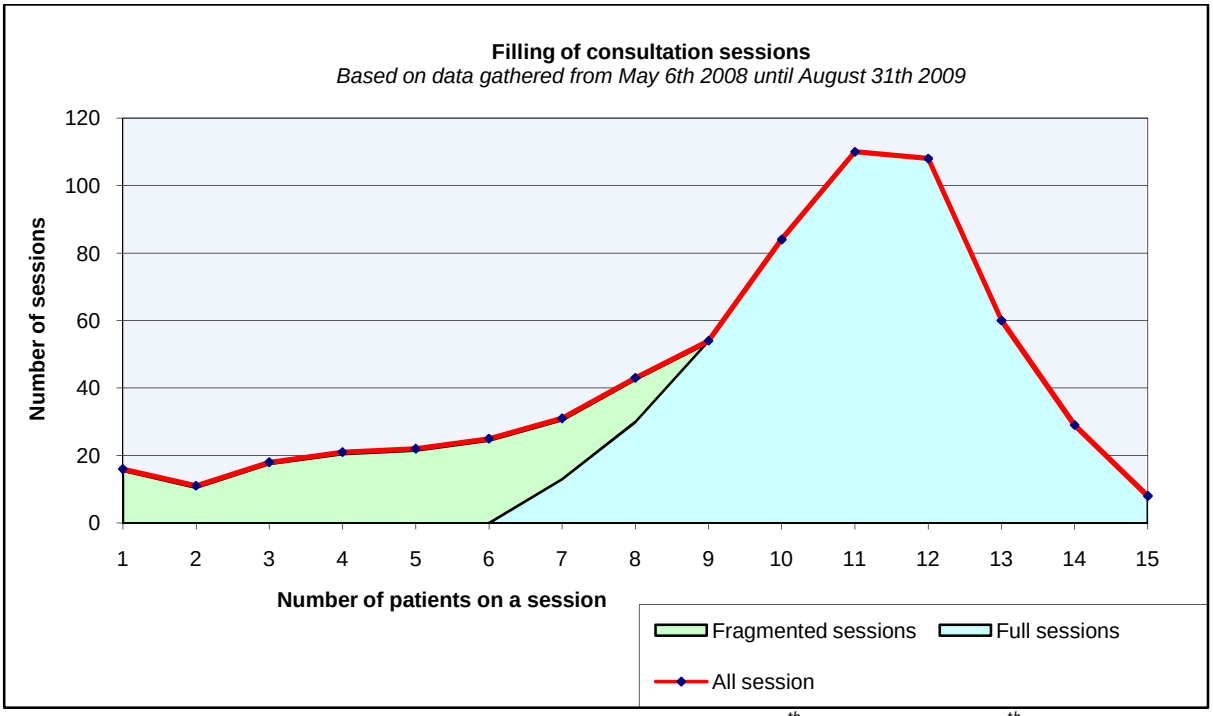



*Figure D2.1 - Filling of consultation sessions (based on data gathered from May 6th 2008 until August 31th 2009)*

| Number of patients on a consultation session in the morning | | | | | |
|---|---|---|---|---|---|
| *Number of follow-up patients* | *Number of consultation sessions* | *Percentage of consultation sessions* | *Number of new patients* | *Number of consultation sessions* | *Percentage of consultation sessions* |
| 0 | 6 | 2,0 % | 1 | 3 | 50,0 % |
| | | | 3 | 2 | 33,3 % |
| | | | 4 | 1 | 16,7 % |
| 1 | 5 | 1,7 % | 0 | 4 | 80,0 % |
| | | | 3 | 1 | 20,0 % |
| 2 | 4 | 1,3 % | 0 | 2 | 50,0 % |
| | | | 1 | 1 | 25,0 % |
| | | | 2 | 1 | 25,0 % |
| 3 | 12 | 4,0 % | 0 | 1 | 8,3 % |
| | | | 1 | 4 | 33,3 % |
| | | | 2 | 6 | 50,0 % |
| | | | 3 | 1 | 8,3 % |
| 4 | 11 | 3,6 % | 0 | 2 | 18,2 % |
| | | | 1 | 2 | 18,2 % |
| | | | 2 | 7 | 63,6 % |
| 5 | 18 | 5,9 % | 0 | 1 | 5,6 % |
| | | | 1 | 3 | 16,7 % |
| | | | 2 | 12 | 66,7 % |
| | | | 3 | 2 | 11,1 % |
| 6 | 22 | 7,3 % | 1 | 3 | 13,6 % |
| | | | 2 | 16 | 72,7 % |
| | | | 3 | 3 | 13,6 % |
| 7 | 33 | 10,9 % | 0 | 1 | 3,0 % |
| | | | 1 | 4 | 12,1 % |
| | | | 2 | 20 | 60,6 % |
| | | | 3 | 7 | 21,2 % |
| | | | 4 | 1 | 3,0 % |
| 8 | 43 | 14,2 % | 0 | 1 | 2,3 % |
| | | | 1 | 4 | 9,3 % |
| | | | 2 | 36 | 83,7 % |
| | | | 3 | 2 | 4,7 % |
| 9 | 41 | 13,5 % | 0 | 1 | 2,4 % |
| | | | 1 | 2 | 4,9 % |
| | | | 2 | 34 | 82,9 % |
| | | | 3 | 4 | 9,8 % |
| 10 | 45 | 14,9 % | 0 | 1 | 2,2 % |
| | | | 1 | 2 | 4,4 % |
| | | | 2 | 34 | 75,6 % |
| | | | 3 | 8 | 17,8 % |
| 11 | 31 | 10,2 % | 1 | 2 | 6,5 % |
| | | | 2 | 28 | 90,3 % |
| | | | 3 | 1 | 3,2 % |
| 12 | 23 | 7,6 % | 1 | 1 | 4,3 % |
| | | | 2 | 21 | 91,3 % |
| | | | 3 | 1 | 4,3 % |
| 13 | 9 | 3,0 % | 1 | 2 | 22,2 % |
| | | | 2 | 7 | 77,8 % |
| **Total:** | **303** | **100,0 %** | | **303** | |

*Table D2.2 - Number of follow-up patients in a consultation session and the number of new patients in a consultation session with x follow-up patients for sessions in the morning (based on data gathered from May 6th 2008 until August 31th 2009)*

| Number of patients on a consultation session in the afternoon | | | | | |
|---|---|---|---|---|---|
| *Number of follow-up patients* | *Number of consultation sessions* | *Percentage of consultation sessions* | *Number of new patients* | *Number of consultation sessions* | *Percentage of consultation sessions* |
| 0 | 6 | 1,8 % | 1 | 3 | 50,0 % |
| | | | 2 | 2 | 33,3 % |
| | | | 3 | 1 | 16,7 % |
| 1 | 13 | 3,9 % | 0 | 6 | 46,2 % |
| | | | 1 | 2 | 15,4 % |
| | | | 2 | 3 | 23,1 % |
| | | | 3 | 2 | 15,4 % |
| 2 | 12 | 3,6 % | 0 | 5 | 41,7 % |
| | | | 1 | 2 | 16,7 % |
| | | | 2 | 4 | 33,3 % |
| | | | 3 | 1 | 8,3 % |
| 3 | 21 | 6,2 % | 0 | 8 | 38,1 % |
| | | | 1 | 3 | 14,3 % |
| | | | 2 | 8 | 38,1 % |
| | | | 3 | 2 | 9,5 % |
| 4 | 14 | 4,2 % | 0 | 3 | 21,4 % |
| | | | 1 | 2 | 14,3 % |
| | | | 2 | 8 | 57,1 % |
| | | | 3 | 1 | 7,1 % |
| 5 | 20 | 5,9 % | 0 | 2 | 10,0 % |
| | | | 1 | 4 | 20,0 % |
| | | | 2 | 11 | 55,0 % |
| | | | 3 | 3 | 15,0 % |
| 6 | 13 | 3,9 % | 1 | 2 | 15,4 % |
| | | | 2 | 11 | 84,6 % |
| 7 | 21 | 6,2 % | 0 | 1 | 4,8 % |
| | | | 1 | 5 | 23,8 % |
| | | | 2 | 13 | 61,9 % |
| | | | 3 | 2 | 9,5 % |
| 8 | 44 | 13,1 % | 0 | 1 | 2,3 % |
| | | | 1 | 9 | 20,5 % |
| | | | 2 | 28 | 63,6 % |
| | | | 3 | 6 | 13,6 % |
| 9 | 71 | 21,1 % | 0 | 4 | 5,6 % |
| | | | 1 | 7 | 9,9 % |
| | | | 2 | 55 | 77,5 % |
| | | | 3 | 5 | 7,0 % |
| 10 | 70 | 20,8 % | 0 | 1 | 1,4 % |
| | | | 1 | 9 | 12,9 % |
| | | | 2 | 60 | 85,7 % |
| 11 | 26 | 7,7 % | 0 | 1 | 3,8 % |
| | | | 1 | 2 | 7,7 % |
| | | | 2 | 23 | 88,5 % |
| 12 | 6 | 1,8 % | 0 | 1 | 16,7 % |
| | | | 2 | 5 | 83,3 % |
| **Total:** | **337** | **100,0 %** | | **337** | |

*Table D2.3 - Number of follow-up patients in a consultation session and the number of new patients in a consultation session with x follow-up patients for sessions in the afternoon (based on data gathered from May 6th 2008 until August 31th 2009)*

| Distributions of patients overtime slots (percentage of AT-slot filled) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Distribution of patients overtime slots in case four follow-up patients visit the consultation session* | | | | | | | | | | | | | | | |
| Number of follow-up patients: 4 (3,6 %)<br>Number of new patients: 0 (18,2 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 25 |
| New: | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Number of follow-up patients: 4 (3,6 %)<br>Number of new patients: 1 (18,2 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 0 | 0 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| New: | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of follow-up patients: 4 (3,6 %)<br>Number of new patients: 2 (63,6 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 0 | 0 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| New: | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Distribution of patients overtime slots in case seven follow-up patients visit the consultation session* | | | | | | | | | | | | | | | |
| Number of follow-up patients: 7 (10,9 %)<br>Number of new patients: 0 (3,0 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 0 | 0 | 14 | 14 | 14 | 0 | 14 | 14 | 14 | 0 | 14 | 0 | 0 | 0 |
| New: | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Number of follow-up patients: 7 (10,9 %)<br>Number of new patients: 1 (12,1 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 11 | 11 | 14 | 11 | 11 | 4 | 14 | 4 | 11 | 0 | 4 | 7 | 0 | 0 |
| New: | 0 | 25 | 0 | 25 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of follow-up patients: 7 (10,9 %)<br>Number of new patients: 2 (60,6 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 4 | 3 | 13 | 14 | 14 | 0 | 14 | 13 | 12 | 0 | 9 | 5 | 0 | 0 |
| New: | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of follow-up patients: 7 (10,9 %)<br>Number of new patients: 3 (21,2 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 6 | 8 | 14 | 6 | 12 | 6 | 12 | 6 | 6 | 8 | 6 | 6 | 2 | 0 |
| New: | 0 | 29 | 0 | 14 | 0 | 19 | 0 | 14 | 0 | 24 | 0 | 0 | 0 | 0 | 0 |
| Number of follow-up patients: 7 (10,9 %)<br>Number of new patients: 4 (3,0 %) | | | | | | | | | | | | | | | |
| | 8:45 | 9:00 | 9:15 | 9:30 | 9:45 | 10:00 | 10:15 | 10:30 | 10:45 | 11:00 | 11:15 | 11:30 | 11:45 | 12:00 | 12:15 |
| FUP: | 0 | 0 | 0 | 14 | 14 | 14 | 0 | 14 | 14 | 0 | 0 | 14 | 14 | 0 | 0 |
| New: | 0 | 25 | 0 | 25 | 0 | 0 | 0 | 25 | 0 | 25 | 0 | 0 | 0 | 0 | 0 |

*Table D2.4 - Example of the distribution of patients overtime slots (based on data gathered from May 6th 2008 until August 31th 2009)*

# Appendix D3 - Basic Examination

This appendix describes the data selection and the calculation of the basic examination. Basic examination is the time window in which the secretary measures the weight and length of the patient before the patient enters the examination room.

To calculate the average length of the basic examination, a time window must be recorded which is caused by the basic examination only. For example, the time window between the arrival of the first patient and entering the examination room of that same patient is caused by the basic examination and the accuracy of the secretary to invite the patient from the waiting room. Therefore this specific time window can not be seen as the length of the basic examination only. For every consultation session, four possible time windows exist which are only caused by the length of the basic examination: the so-called basic examination measuring points. In those cases both examination rooms are filled with patients. If one of the patients leaves and the next patient enters the empty examination room, the window between leaving the examination room of a patient and entering the same examination room by the next patients, is caused by the basic examination.

To collect these time windows, the basic selection criteria (see Appendix C3) are used which results in 609 consultation sessions which results is 2436 possible time windows from which 862 exists. These time windows are checked on double times: a situation in which for example a twin is scheduled on two neighboring appointment slots and for whom identically consultation start and end times are recorded. After this selection, 660 possible times windows are left. From these 660 possible time windows, 553 had the following necessary information to calculate the time window:

- Time at which the consultation for the last patient ends
- Arrival time of the patient next patient
- Time of entry into the examination room of the next patient

In only 16,8 % of the measuring points, an basic examination can be calculated. In those cases, the basic examination has an average of 5:54 minutes and a median of 3 minutes (see Table D3.1).

| **Basic examination measuring points** | | |
|---|---|---|
| | *Number of measuring points* | *Percentage of measuring points* |
| The number of 'basic examination measuring points' for which the next patient is entering the examination room before the previous consultation has ended. | 388 | 70.16 % |
| The number of 'basic examination measuring points' in which the next patient did not yet arrived in the five minutes before the previous consultation ended. | 72 | 13.02 % |
| The number of 'basic examination measuring points' in which the basic examination can be measured. | 93 | 16.82 % |
| **Length of basic examination** | | |
| Average (minutes) | 5:54 | |
| Median (minutes) | 3 | |

*Table D3.1 - Overview of the basic examination measuring points (based on data gathered from March 11th 2008 until April 3rd 2009)*

# Appendix D4 - Accuracy of Pediatricians

This appendix describes the procedure used to determine the accuracy of pediatricians and the outcomes of this procedure. The accuracy of pediatricians is the time window between the scheduled start of the consultation session and the time at which the pediatrician actually starts the consultation session.

Consultation sessions are collected using the basic selection criteria (see Appendix C3) resulting in 676 consultation session. Since the basic data selection excludes consultations instead of consultation sessions, the first consultation of a consultation session after the basic selection, does not have to be the real first consultation, i.e. the real first consultation could be excluded in the basic selection. This is the case for 117 consultation sessions, resulting in 559 session usable to calculate the accuracy of pediatricians.

The remaining 559 consultation sessions should have the following data:

- The arrival time of the patient
- The time of entering the examination room
- The start time of the consultation

The consultation should also have no involvement of an intern since involvement of an intern in the first consultation results in misleading start times of pediatricians. Because of these specific criteria only 314 consultations are collected (see Table D4.1).

| **Overview of the frequencies of start times** | | | | | | |
|---|---|---|---|---|---|---|
| *Consultation sessions in the morning:* | | | | | | |
| Start time consultation session | 8:30 | 8:45 | 9:00 | 9:15 | 9:30 | 10:30 |
| Number of consultations | 1 | 23 | 112 | 15 | 52 | 1 |
| *Consultation sessions in the afternoon:* | | | | | | |
| Start time consultation session | 13:30 | 13:45 | 13:50 | 14:00 | 14:15 | 14:30 |
| Number of consultations | 1 | 12 | 1 | 90 | 5 | 1 |

*Table D4.1 - Overview of the frequencies of consultation session start times (based on data gathered from May 6th 2008 until August 31st 2009)*

To calculate the start time of a pediatrician independent of the arrival of the patient only those first consultations are included in which the patient arrives 10 minutes early. The consultation session should also take a minimum of 5 minutes to eliminate the possibility of a start time which is recorded too late. In order to calculate a realistic start time only the most frequent start times are included: 9:00 hour, 9:15 hour, 9:30 hour and 14:00 hour. The collected 83 consultations resulted in four different values for the accuracy of pediatricians for four different start times of a consultation session (see Table D4.2).

| **Arrival time of pediatricians** | | | |
|---|---|---|---|
| *Start time consultation* | *Number of consultations* | *Difference between appointment time and start time (minutes after start time consultation)* | |
| | | *Average* | *Median* |
| 9:00 | 35 | 3:51 | 5 |
| 9:15 | 7 | 1:17 | 0 |
| 9:30 | 20 | 1:36 | 3 |
| 14:00 | 37 | 5:55 | 6 |

*Table D4.2 - Accuracy of pediatricians for different consultation session start times (based on data gathered from May 6th 2008 until August 31st 2009)*

# Appendix D5 - Idle Time of Pediatricians

This appendix describes the procedure used to determine the idle time of pediatricians and the outcomes of this procedure. The idle time of the pediatrician is the sum of the time windows in which the pediatrician does not consult patients.

To calculate the idle time, data is selected using basic selection criteria (see Appendix C3) on the data gathered from May 6th 2008 until August 31st 2009. This resulted in 676 consultation sessions. 14 sessions are excluded because these could be fragmented. This resulted in 662 sessions. The total idle time per consultation session is calculated by taking the sum of the times between the actual end of consultation X and the actual beginning of consultation X+1, in case these actual start and end times are available. This calculation resulted in an average idle time of 41:28 minutes.

To calculate the percentage of idle time, the average consultation length is calculated with the use of the actual start and end of the consultation session. The average consultation length is 2:32:59 hours which makes the percentage of idle time 27,10 %.

# Appendix D6 - Overtime of Pediatricians & Consultation Session End Time

This appendix describes the procedure used to determine the overtime of pediatricians and the consultation session end time as well as the outcomes of this procedure. The overtime of pediatricians is the average of the time windows between the scheduled end of the last consultations and the actual end of the last consultation. For example, if the last consultation is scheduled to end at 12.00 and actually ends at 12:25, the overtime is 25 minutes.

To calculate these indicators, data is selected using basic selection criteria (see Appendix C3) on the data gathered from May 6th 2008 until August 31st 2009. This resulted in 676 consultation sessions. From these 676 sessions, 588 sessions had an actual recorded end time of the last consultation. The average overtime of the 588 selected sessions is 23:57 minutes.

From the 588 sessions, 252 are consultation session in the morning with an average consultation session end time of 12:19 hours and 336 are consultation session in the afternoon with an average consultation session end time of 16:53 hours.

# Appendix D7 - Accuracy of Interns

This appendix describes the procedure used to determine the accuracy of interns and the outcomes of this procedure. The accuracy of interns is the time window between the scheduled start of the first consultation involving an intern and the actual start of this consultation.

The basic selection criteria (see Appendix C3) resulted in 676 consultations. 615 consultation sessions have a consultation involving an intern from which 531 have the following necessary information in the correct order:

- The arrival time of the patient
- The time of entering the examination room and
- The start time of the consultation by an intern

To calculate the start time of an intern independent of the arrival of the patient only those first consultations are included in which the patient arrives 10 minutes early. The consultation by an intern should also take a minimum of 20 minutes to eliminate the possibility of start time which is recorded to late. According to these criteria, 272 of the 531 consultations are collected.

56 % of the first consultations by an intern begin on time while the other 44 % begin too late with an average of 5:41 minutes and a median of 4 minutes (see Table D7.1).

| **Accuracy of interns** | | |
|---|---|---|
| *Intern is on time* | *Number of consultations* | *Percentage of consultations* |
| Consultation by an intern starts earlier than the appointment time | 131 | 56 % |
| Consultation by an intern starts within 3 minutes after the patient has entered the examination room (the time of the basic examination, see Appendix D3) | 22 | |
| *Intern is too late* | | |
| Consultation by an intern starts more than 3 minutes after the start of the appointment time | 119 | 44 % |
| **Arrival time of interns in case the intern starts more than 3 minutes after the start of the appointment time** | | |
| Average (minutes) | 5:41 | |
| Median (minutes) | 4 | |

*Table D7.1 - Accuracy of interns (based on data gathered from May 6th 2008 until August 31st 2009)*

# Appendix D8 - Duration of Consultation by an Intern

This appendix describes the procedure that is used to determine the distribution which describes the duration of a consultation by an intern. The 'duration of a consultation by an intern' is the difference between the start of a consultation by an intern and the start of the consultation by a pediatrician. The steps in calculating the distribution fit are: data selection, data correction, hypothesizing distribution, parameter estimation and determining the representativeness of the fitted distributions. The methods used to hypothesize distributions, estimate parameters and determine representativeness are based on methods describes by Averill Law and David Kelton [Law, 2000].

***Data Selection***

Consultations are collected using the basic selection criteria (see Appendix C3) on the data gathered from March 11th 2008 to April 3rd 2009 which resulted in 5070 consultations. From these consultations, 23 consultations are excluded because of faulty recording of times, i.e. the start time of the consultation is after the end time of the consultation. This leaves 5047 consultations from which another 879 consultations are excluded because of faulty recording of times, i.e. the end time of consultation A is after the start time of consultation B in which case both consultations are excluded because of indefinable consultation times. From these 4168 consultations, another 648 consultations are excluded because no start or end time of the consultation is recorded, leaving 3520 consultations for defining the consultation duration.

From these 3520 consultation, 699 are preceded by a consultation by an intern from which 2 are excluded because of negative duration of the consultation by an Intern. From these 697 consultations, the following information is gathered:

- Start time of consultation by an intern
- Start time of consultation by a pediatrician

***Data Correction***

The data selection that is conducted, does not exclude all faulty consultation durations, i.e. it does not exclude unrealistic small consultation durations. Therefore a data correction is necessary: excluding too small consultation durations based on a visual inspection of the histogram, i.e. if the length of the consultation durations goes up, the number of consultations should also go up, if the number of consultations goes down, wrong times have been recorded which have to be excluded (for small durations, see Figure D8.1).

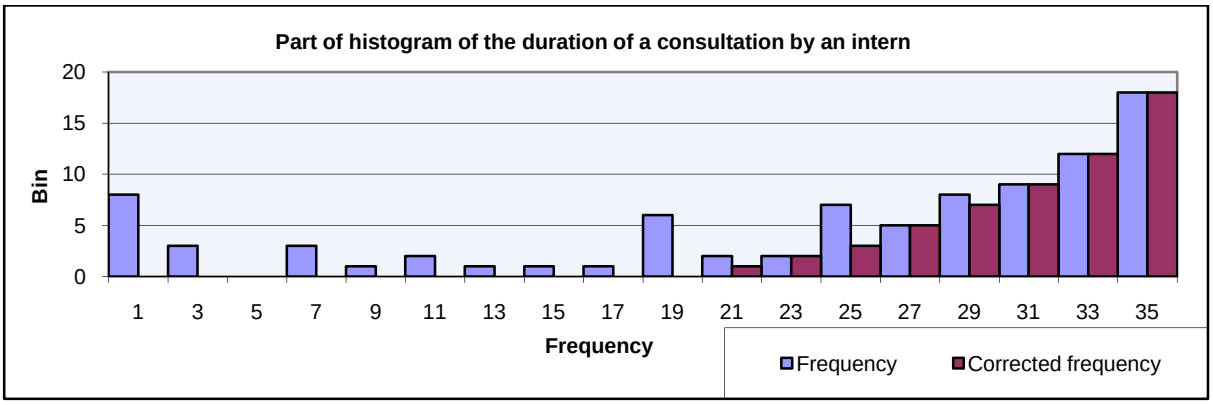
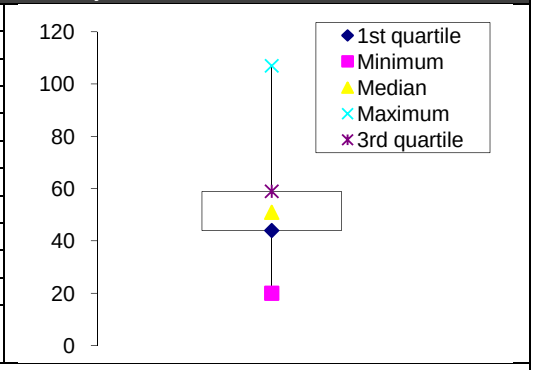



*Figure D8.1 - Frequency vs. corrected frequency of duration of a consultation by an intern (based on data gathered from March 11th 2008 until April 3rd 2009)*

***Hypothesizing Distribution***

Based on the summary statistics, the box plot and the histogram (see Table D8.1), a normal-distribution is most likely.

| Summary statistics, box plot and histogram of durations of consultations by an intern | |
|---|---|
| Mean | 51,90 |
| Median | 51 |
| Mode | 47 |
| Standard deviation | 12,81 |
| Sample variance | 164,20 |
| Kurtosis | 0,79 |
| Skewness | 0,55 |
| Range | 87 |
| Minimum | 20 |
| Maximum | 107 |
| Count | 665 |
| | |



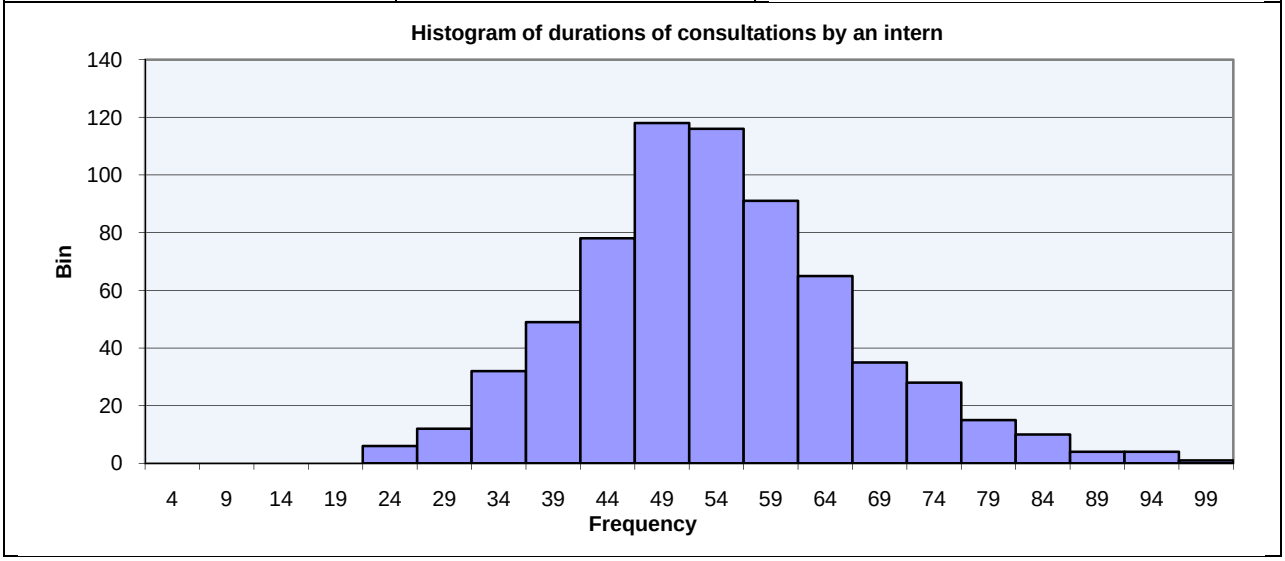




*Table D8.1 - Summary statistics, box plot and histogram of duration of consultations by an intern (based on data gathered from March 11th 2008 until April 3rd 2009)*

***Parameter Estimation***

The parameters of a normal distribution are the mean and the standard deviation (see Table D8.2).

| Defining parameters for normal(α,β) | |
|---|---|
| $\alpha = Mean$ | $\beta = Standard\ deviation$ |

*Table D8.2 - Used formulas to determine the parameters for a normal-distribution.*

***Determining the representativeness of the fitted distributions***

The found normal-distribution is found out to represent the consultation durations by interns correctly. This is confirmed by a histogram over plot, a Q-Q Plot (see Figure D8.2 and D8.3) and a chi-square test (chi-square = 17,11, 12 d.f., p=0,15).

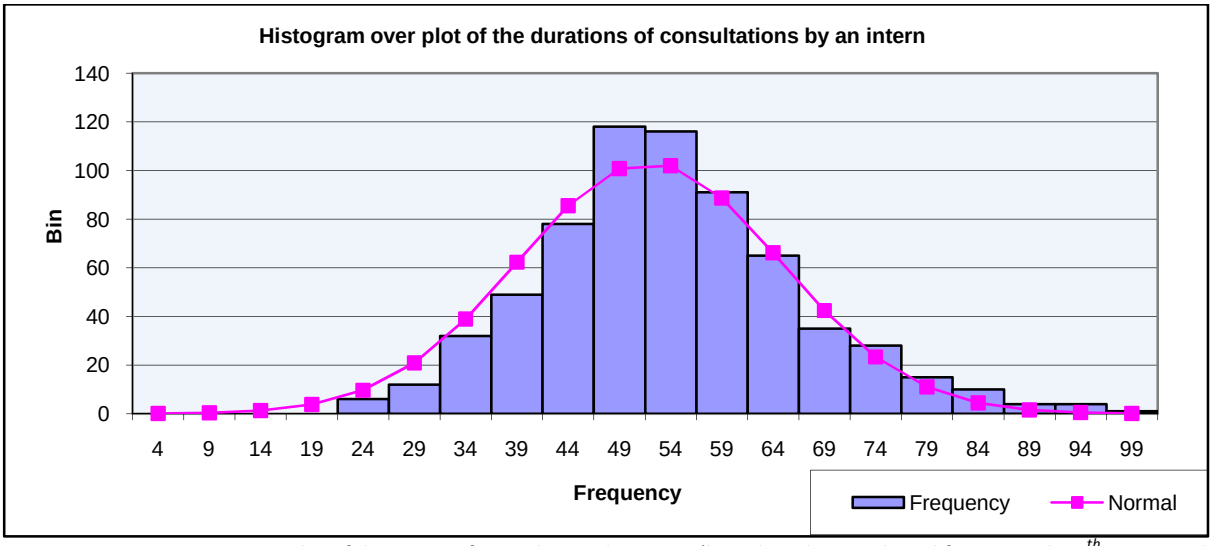



*Figure D8.2 - Histogram over plot of durations of consultation by intern (based on data gathered from March 11th 2008 until April 3rd 2009)*

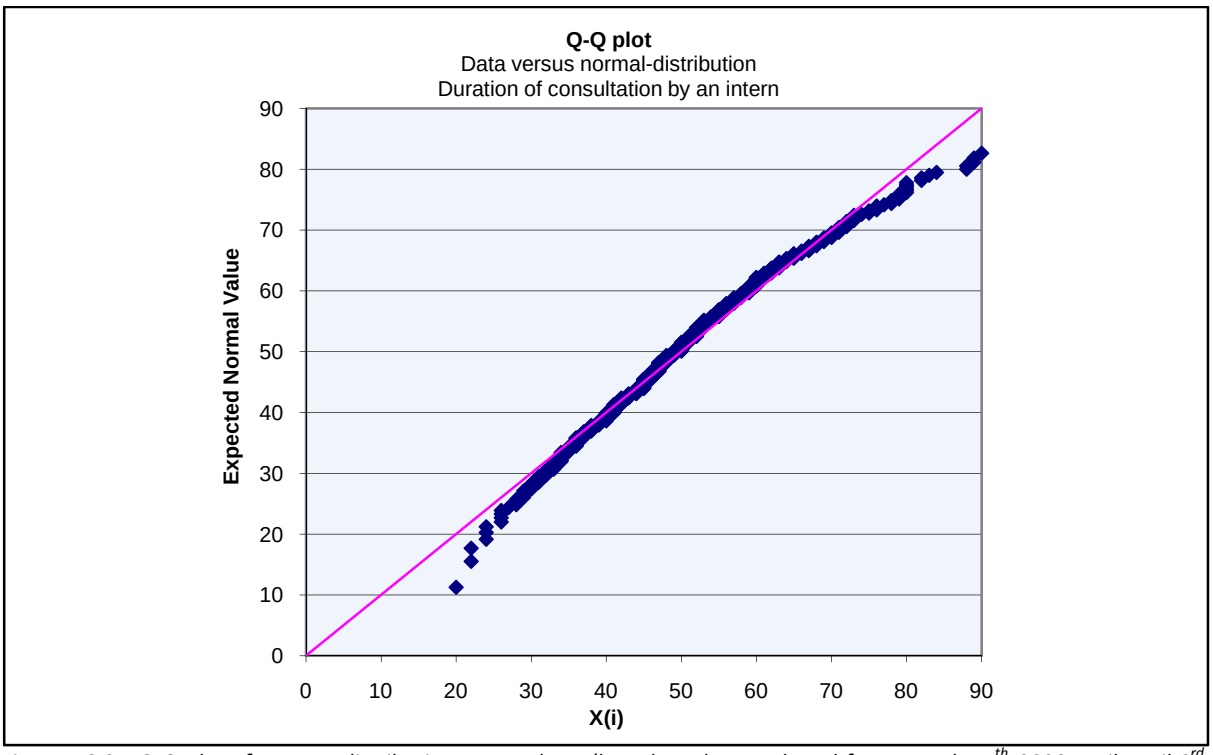



*Figure D8.3 - Q-Q plot of gamma-distribution versus data. (based on data gathered from March 11th 2008 until April 3rd 2009)*

***Conclusion***

The duration of the consultation by an intern can be described by a normal(52,13)-distribution.

# Appendix D9 - No-Shows

This appendix gives information of the number of no-shows. No-shows are described by the percentage of consultations for which the patient did not show up. To calculate this parameter, consultations are selected using 'basic selection criteria' (see Appendix C3). From the 140 consultations for which the patient did not show up, 139 are follow-up patients and 1 is a new patient, which corresponds with percentages of 3,44 % and 0,10 % (see Table D9.1).

| Kind of patient | Number of consultations | Number of no-shows | Percentage |
|---|---|---|---|
| All patients | 5070 | 140 | 2,76 % |
| New patients | 1024 | 1 | 0,10 % |
| Follow-up patients | 4046 | 139 | 3,44 % |

*Table D9.1 - Overview of ratios of no-shows (based on data gathered from March 11th 2008 until April 3rd 2009)*

# Appendix D10 - Second Consultations and External Examination

This appendix gives more information of the number of second consultations and the length of the external examination. Second consultations are described by the percentage of consultations in which the patients leaves the pediatric department for an external examination. A selection of these patients returns to finish the consultation with the pediatrician, i.e. the second consultation. The external examination is the time window between the end of the first consultation and the start of the second consultation.

The basic selection criteria (see Appendix C3) resulted in 7877 consultations. From these consultations, 272 patients (3,45 %) get an external referral. The ratio between new and follow-up patients is slightly more for new patients (see Table D10.1).

From the 272 consultations with a referral to an external examination, 57 returned to the outpatient center for a second consultation (0,72 % of the consultations). The average and the median of the length of the external examination are 35:27 and 33 minutes.

| Percentage of second consultations | | | |
|---|---|---|---|
| | *Number of consultations* | *Percentage new patient* | *Percentage follow-up patients* |
| All consultations | 7877 | 19,65 % | 80,35 % |
| Consults with external examination | 272 | 25,00 % | 75,00 % |

*Table D10.1 - Overview of second consultations (based on data gathered from May 6th 2008 until December 21th 2009)*

# Appendix D11 - Arrival Times of Patients

An arrival time of a patient is defined as the difference between the arrival time and the appointment time. This appendix describes the procedure used to define different arrival patterns and to find distribution fits for these arrival patterns. The different steps in the used procedure are: data selection, determination of different arrival patterns, data correction, hypothesizing distributions, parameter estimation and determining the representativeness of the fitted distributions, which have to take place for every consultation deviating group of arrival times. The methods used to hypothesize distributions, estimate parameters and determining representativeness are based on methods describes by Averill Law and David Kelton [Law, 2000].

***Data Selection***

After the basic selection criteria are applied on the data gathered from March 11th 2008 until April 3rd 2009, 5070 consultation are left. From these consultations, 4541 had a recorded arrival time of the patient.

***Defining deviating groups***

The groups of arrival times for every appointment time are compared using a t-test with an alpha of 0,01. The following groups differed significantly in consultation duration and had enough data to depict a distribution of consultation times (see Figure D11.1 and D11.1):

- Patients from 8:45 until 16:00 hour - 4077 consultations
- Patients from 16:15 until 17:00 hour - 464 consultations

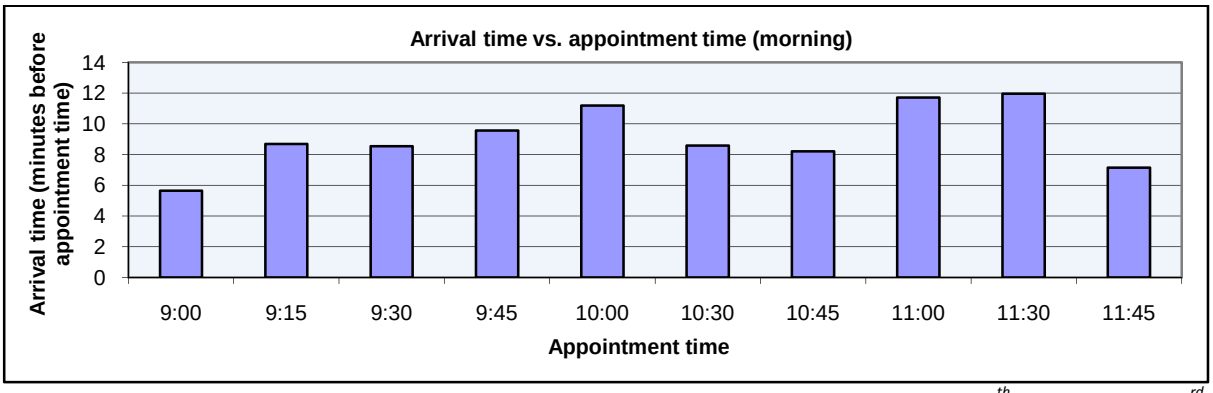



*Figure D11.1 - Arrival time vs. appointment time (morning) (based on data gathered from March 11th 2008 until April 3rd 2009)*

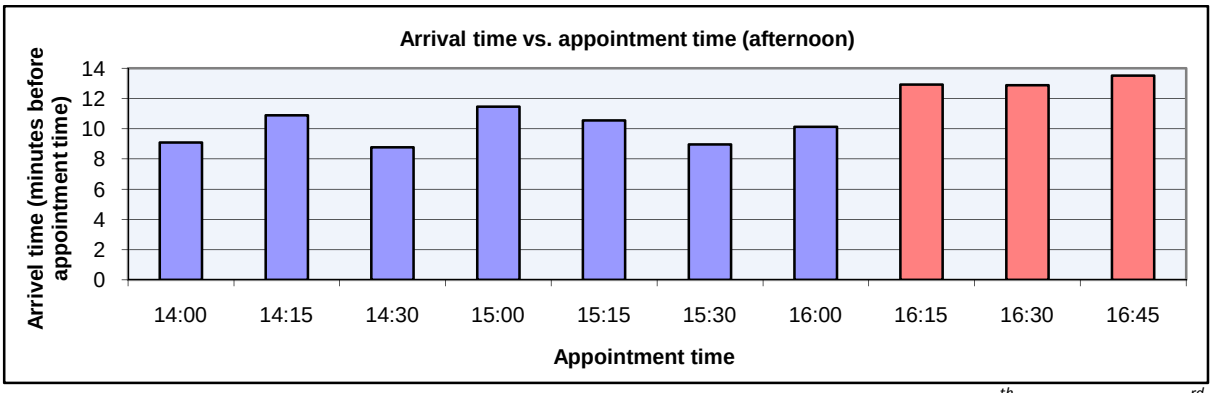



*Figure D11.2 - Arrival time vs. appointment time (afternoon) (based on data gathered from March 11th 2008 until April 3rd 2009)*

***Data Correction***

Arrival times of patients with appointment times from 8:45 until 16:00

19 arrival times are excluded because of unrealistic arrival times.

Arrival times of patients with appointment times from 16:15 until 17:00

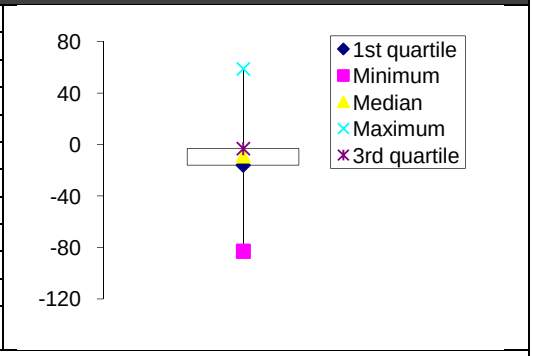
11 arrival times are excluded because of unrealistic arrival times.

***Hypothesizing Distributions***

Based on the summary statistics, the box plot and the histogram (see Table D11.1 and Table D11.2), normal-distributions are most likely.

**Summary statistics, box plot and histogram for arrival times of patients with appointment times from 8:45 until 16:00**

| | |
|---|---|
| Mean | -9,815 |
| Median | -9 |
| Mode | -9 |
| Standard deviation | 13,00 |
| Sample variance | 169,0 |
| Kurtosis | 4,417 |
| Skewness | -0,6487 |
| Range | 142 |
| Minimum | -83 |
| Maximum | 59 |
| Count | 4057 |
| | |



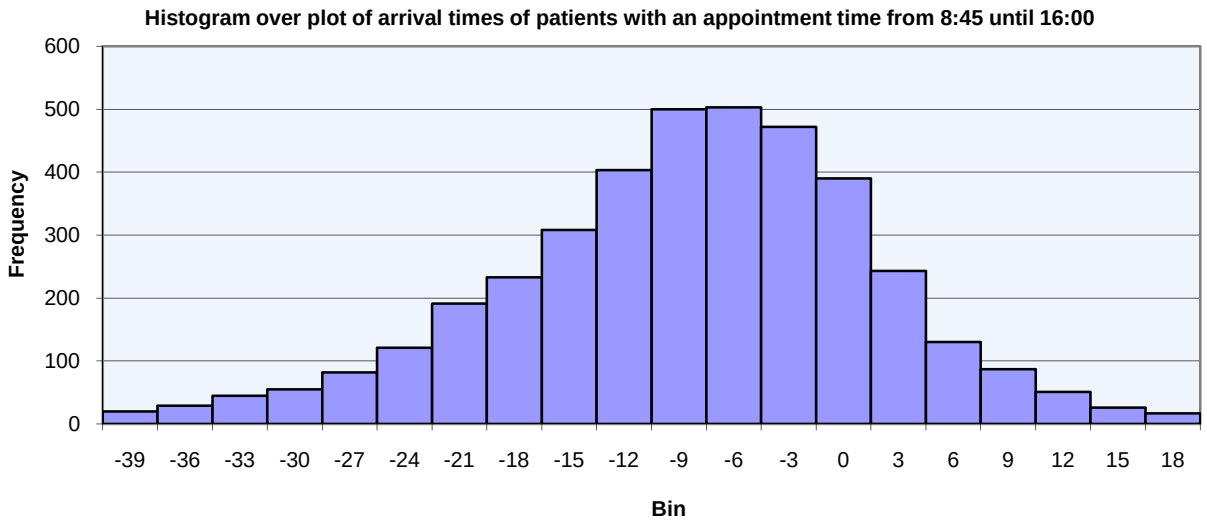
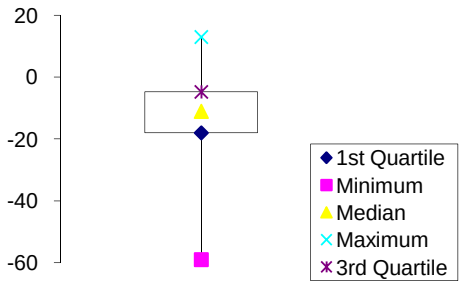




*Table D11.1 - Summary statistics, box plot and histogram of arrival times of patients with an appointment time from 8:45 until 16:00 (based on data gathered from March 11th 2008 until April 3rd 2009)*

| Summary statistics, box plot and histogram of patients with appointment times from 16:15 until 17:00 | |
|---|---|
| Mean | -12,79 |
| Median | -11 |
| Mode | -8 |
| Standard deviation | 12,03 |
| Sample variance | 144,7 |
| Kurtosis | 1,177 |
| Skewness | -0,9421 |
| Range | 72 |
| Minimum | -59 |
| Maximum | 13 |
| Count | 452 |
| | |



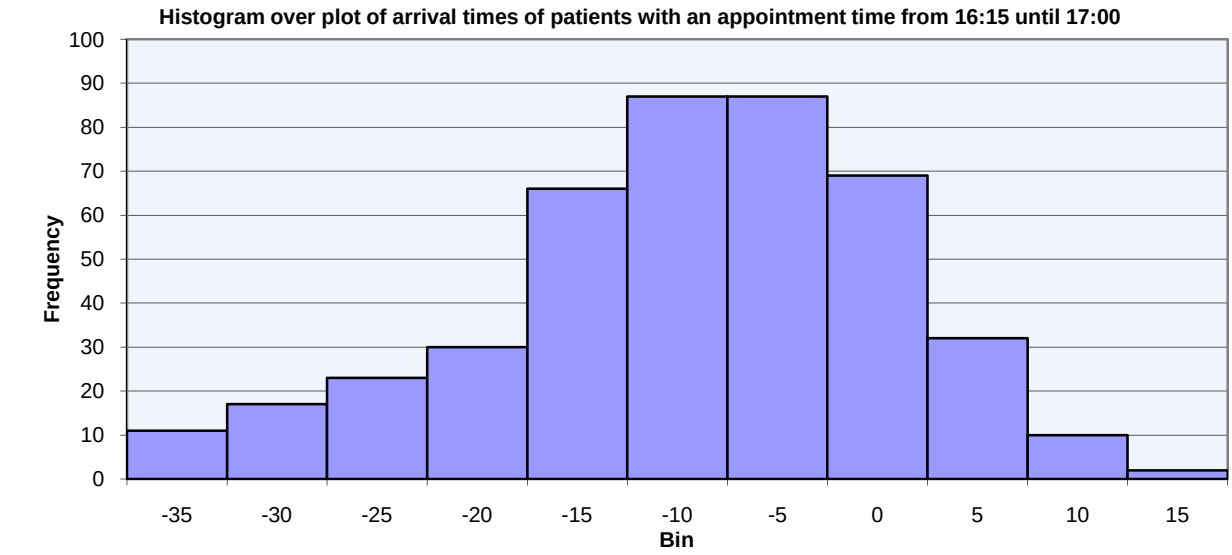




*Table D11.2 - Summary statistics, box plot and histogram of arrival times of patients with an appointment time from 16:15 until 17:00 (based on data gathered from March 11th 2008 until April 3rd 2009)*

***Conclusion: Parameter Estimation and determining the representativeness of the fitted distributions***

The parameters of normal distributions are the mean and the standard deviation. We found that these parameters do not represent the arrival time of patients, i.e. the histogram over plot does not confirm this normal distribution nor does this normal distribution comply with the chi-square test. Other distributions, the weibull, gamma and lognormal-distributions are also found not to represent the arrival of patients. Therefore, parameters of the normal-distribution are determined manually, taking the histogram over plot and the critical value of the chi-square test as well as the representativeness of the arrivals after the appointment time into account (see Table D11.3 and Figure D11.3 and Figure D11.4).

| Parameter estimation | α | β |
|---|---|---|
| *Arrival times of patients with an appointment time from 8:45 until 16:00* | | |
| Mean and standard deviation: | -9,8 | 13,0 |
| Manually determined parameters: | -8,0 | 10,0 |
| *Arrival times of patients with an appointment time from 16:15 until 17:00* | | |
| Mean and standard deviation: | -12,8 | 12,0 |
| Manually determined parameters: | -10,7 | 10,0 |

*Table D13.6 - Parameter estimation for normal(α,β)-distribution (based on data gathered from March 11th 2008 until April 3rd 2009)*

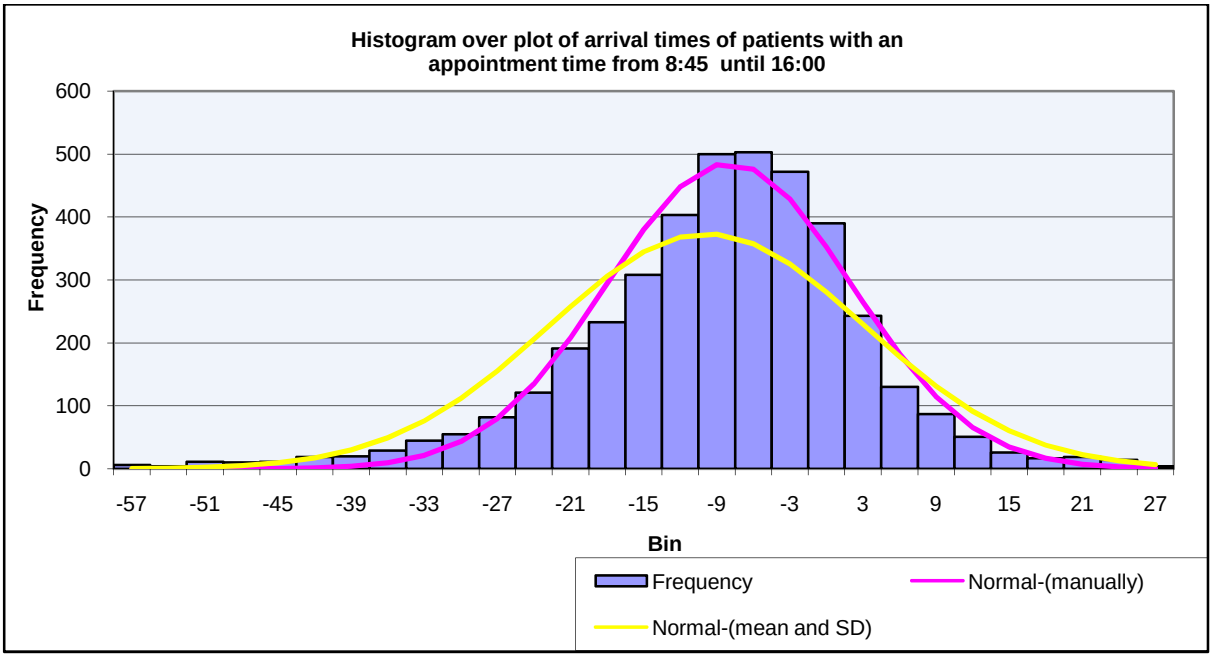



*Figure D11.3 - Histogram over plot of arrival times of patients with an appointment time between 8:45 and 16:15. (based on data gathered from March 11th 2008 until April 3rd 2009)*

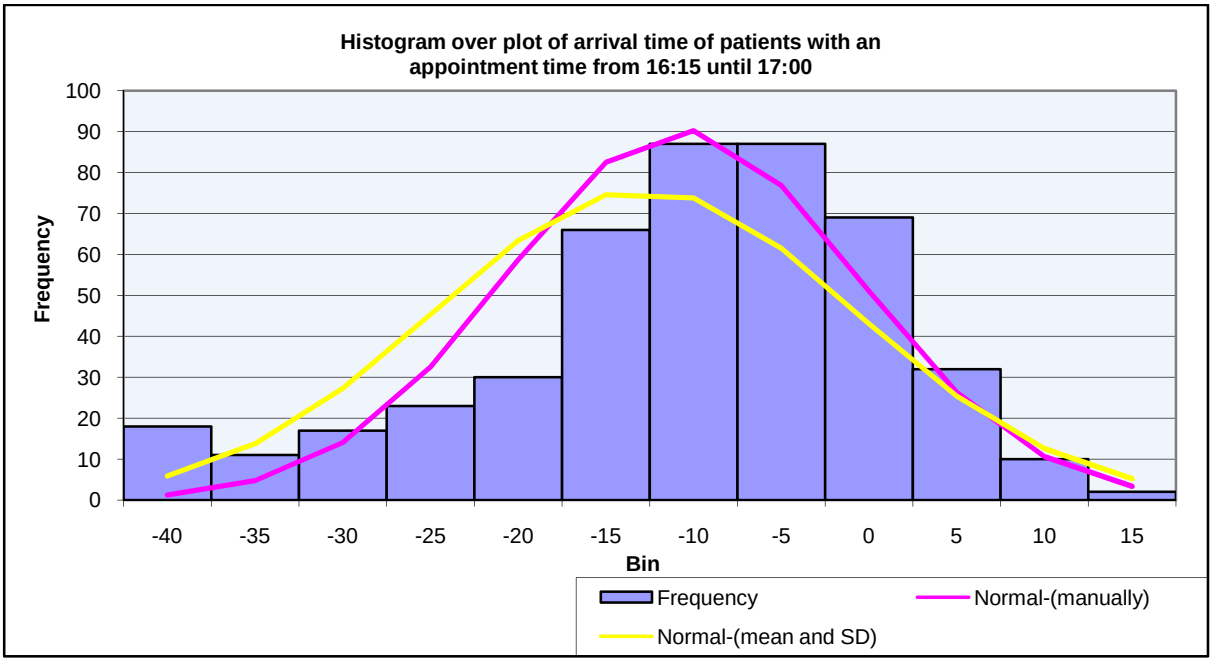



*Figure D11.4 - Histogram over plot of arrival times of patients with an appointment time between 16:30 and 17:00. (based on data gathered from March 11th 2008 until April 3rd 2009)*

# Appendix D12 - Waiting Time of Patients

This appendix gives information on the waiting time of patients. The total waiting time of patients can be split into three different time windows: the voluntary waiting time, the first waiting time and the second waiting time. The voluntary waiting time is the window between the arrival of the patient and the scheduled start time of the appointment, in case the patient arrives before the scheduled start time of the appointment. The first waiting time is the window between the scheduled appointment time and the time at which the patient enters the examination room or, in case the patient arrives after the scheduled appointment time, the window between the arrival of the patient and the time at which the patient enters the examination room. The second waiting time is the window between entering the examination room and the start of the consultation by either an intern or a pediatrician minus the duration of the basic examination of 3 minutes (see Appendix D3).

To calculate these waiting times, consultations are selected using the basic selection criteria (see Appendix C3). From these 7877 consultations, 4217 consultations had all the necessary information in the right order. An overview of the different waiting times is shown in Table D12.1.

| Overview of waiting times of patients | |
|---|---|
| Voluntary waiting time: | 7:54 minutes |
| First waiting time: | 6:37 minutes |
| Second waiting time: | 5:53 minutes |
| **Total waiting time:** | **20:24 minutes** |

*Table D12.1 - Overview of waiting times of patients (based on data gathered from May 6th 2008 until August 31st 2009).*

# Appendix D13 - Consultation Duration

The consultation duration is difference between the start of a consultation by a pediatrician and its end. This appendix describes the procedure used to define deviating consultation durations and to find distribution fits for these durations. The steps in the used procedure are: data selection, determination of deviating groups, data correction, hypothesizing distributions, parameter estimation and determining the representativeness of the fitted distributions, which have to take place for every deviating group of consultations. The methods used to hypothesize distributions, estimate parameters and determining representativeness are based on methods described by Averill Law and David Kelton [Law, 2000].

***Data Selection***

Consultations are collected by applying the basic selection criteria (see Appendix C3) on the data gathered from March 11th 2008 until April 3rd 2009, which resulted in 5070 consultations. From these consultations, 23 consultations are excluded because of faulty recording of times, i.e. the start time of the consultation is later than the end time of the consultation. This leaves 5047 consultations from which another 879 consultations are excluded because of faulty recording of times, i.e. the end time of consultation A is after the start time of consultation B in which case both consultations are excluded because of indefinable consultation times. From these 4168 consultations, another 648 consultations are excluded because no start or end time of the consultation is recorded, leaving 3520 consultations for defining the consultation duration.

From these 3520 consultations, the following information is gathered:

- Start time of consultation
- End time of consultation
- Diagnosis of the patient
- Patient type

***Defining Deviating Groups***

Before defining one consultation duration for all consultations, the groups of 3520 consultation durations is investigated on deviating consultation times for specific diagnoses and new versus follow-up patients. This is done by answering the following questions:

- Do new patients and follow-up patients of the same diagnose differ significantly in consultation duration?
- Do new patients of diagnose X and new patients without diagnose X significantly differ in consultation duration?
- Do follow-up patients of diagnose X and follow-up patients without diagnose X significantly differ in consultation duration?

The different groups of consultation durations are compared using a t-test with an alpha of 0,01. The following groups differed significantly in consultation duration and had enough data to depict a distribution of consultation times:

- Follow-up patients with diagnose ‘Asthma’ (3202) - 807 consultations
- New and follow-up patients with diagnose ‘Depression/Fatigue (no chronic fatigue syndrome)’ (8911) - 39 consultations

The resulting group of 2779 consultations is investigated on deviating consultation times for new versus follow-up patients using a t-test with an alpha of 0,01. The consultation duration of new patients is found out to deviate significantly from the consultation durations of follow-up patients. For each of the following groups a distribution of consultation times is determined:

- Remaining new patients: new patients except new patient of diagnose ‘Depression/Fatigue (no chronic fatigue syndrome)’ (8911) - 731 consultations
- Remaining follow-up patients: follow-up patients except follow-up patients of diagnose ‘Depression/Fatigue (no chronic fatigue syndrome)’ (8911) and of diagnose ‘Asthma’ (3202) - 1943 consultations

***Data Correction***

The data selection that is conducted, does not exclude all faulty consultation durations, i.e. it does not exclude consultation durations which are too small to be true. Therefore a data correction is necessary: excluding too small consultation durations based on a visual inspection of the histogram, i.e. if the length of the consultation durations goes up, the number of consultations should also go up, if the number of consultations goes down, wrong times have been recorded which have to be excluded (see Figure D13.1, D13.2, D13.3 and D13.4).

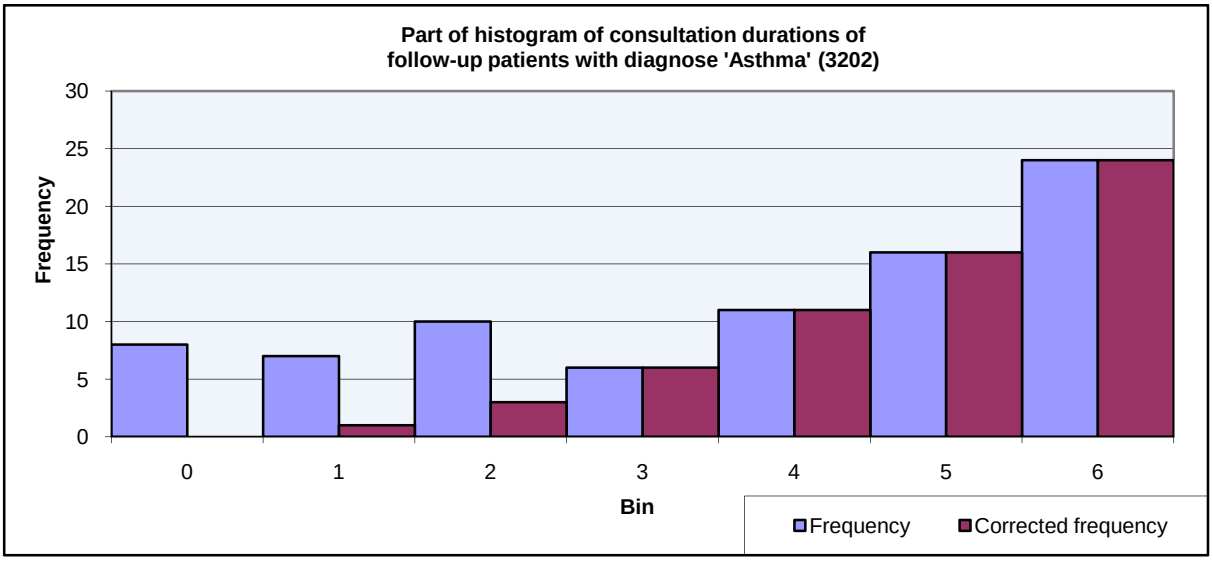



*Figure D13.1 - Frequency vs. corrected frequency of follow-up patients with diagnose 'Asthma' (3202) (based on data gathered from March 11th 2008 until April 3rd 2009).*

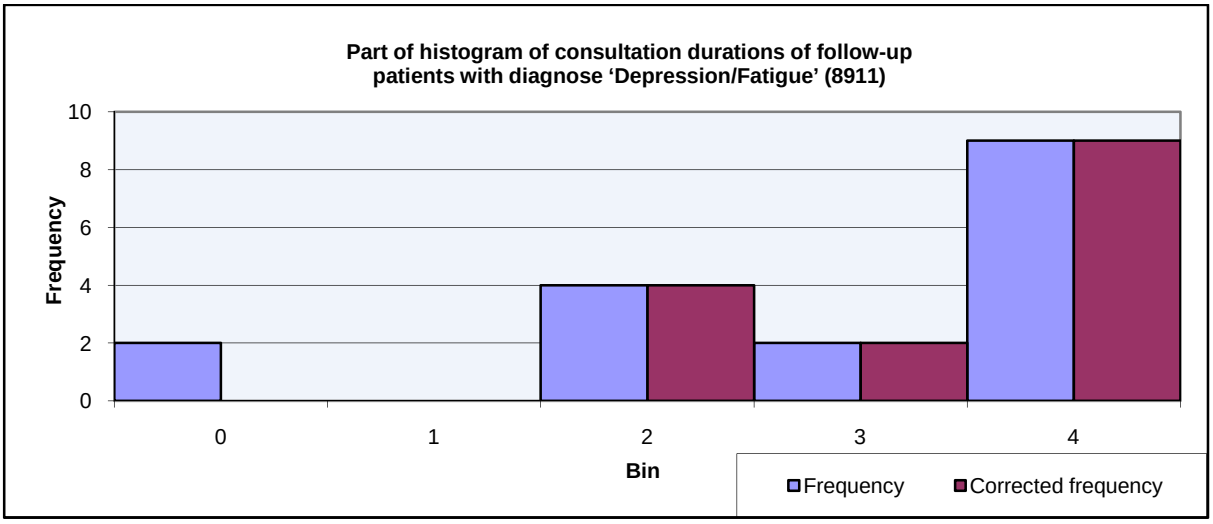



*Figure D13.2 - Frequency vs. corrected frequency of patients with diagnose 'Depression/Fatigue' (8911) (based on data gathered from March 11th 2008 until April 3rd 2009).*

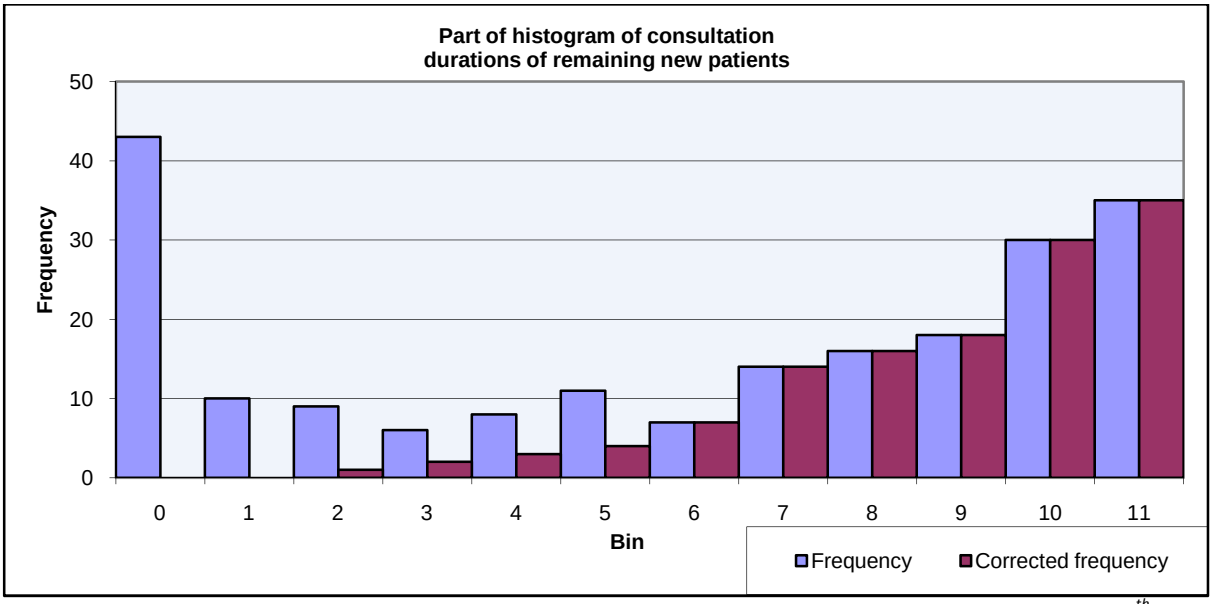



*Figure D13.3 - Frequency vs. corrected frequency of remaining new patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

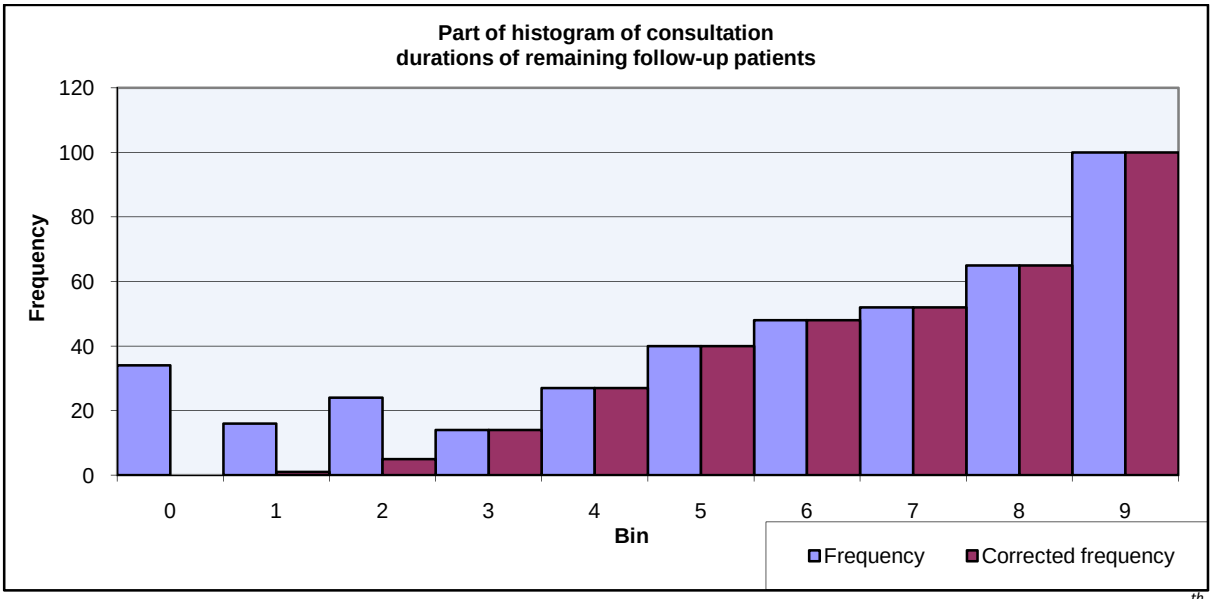
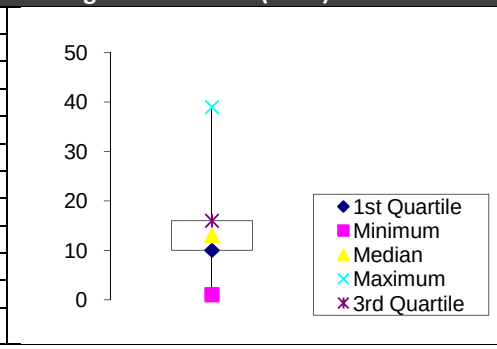



*Figure D13.4 - Frequency vs. corrected frequency of remaining follow-up patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

***Hypothesizing Distribution***

Based on the summary statistics, the box plot and the histogram (see Table D13.1, D13.2, D13.3 and D13.4), gamma-distributions are most likely.

| Summary statistics, box plot and histogram of follow-up patients with diagnose 'Asthma' (3202) | |
|---|---|
| Mean | 13,61 |
| Median | 13 |
| Mode | 11 |
| Standard deviation | 5,775 |
| Sample variance | 33,35 |
| Kurtosis | 1,006 |
| Skewness | 0,8451 |
| Range | 38 |
| Minimum | 1 |
| Maximum | 39 |
| Count | 787 |
| | |



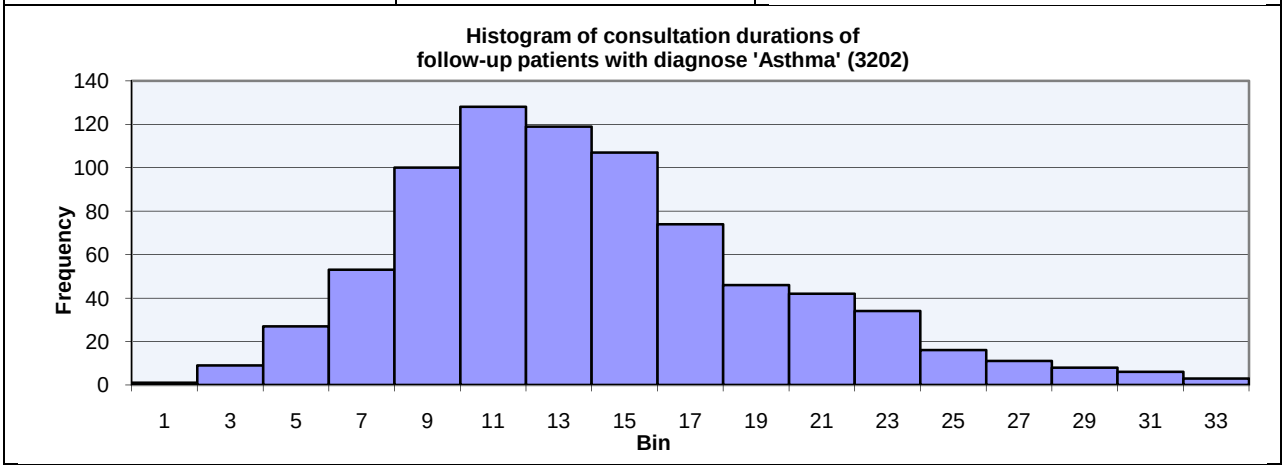
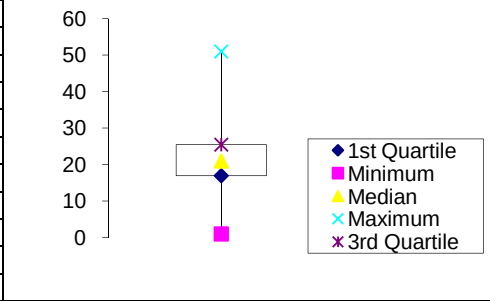




*Table D13.1 - Summary statistics, box plot and histogram of follow-up patients with diagnose 'Asthma' (3202) (based on data gathered from March 11th 2008 until April 3rd 2009).*

| Summary statistics, box plot and histogram of follow-up patients with diagnose 'Depression/Fatigue' (8911) | |
|---|---|
| Mean | 20,49 |
| Median | 21 |
| Mode | 17 |
| Standard deviation | 8,528 |
| Sample variance | 72,73 |
| Kurtosis | 3,682 |
| Skewness | 0,6341 |
| Range | 50 |
| Minimum | 1 |
| Maximum | 51 |
| Count | 39 |
| | |



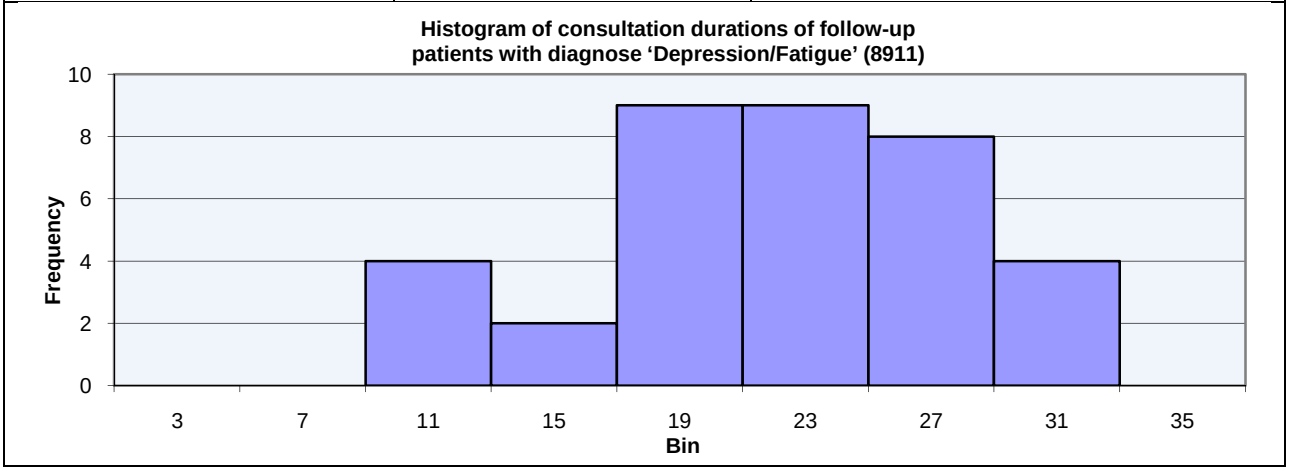
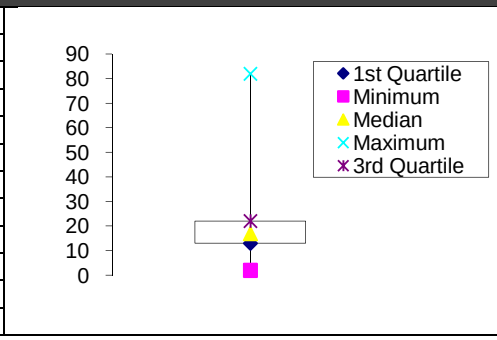




*Table D13.2 - Summary statistics, box plot and histogram of patients with diagnose 'Depression/Fatigue' (8911) (based on data gathered from March 11th 2008 until April 3rd 2009).*

| Summary statistics, box plot and histogram of remaining new patients | |
|---|---|
| Mean | 17,95 |
| Median | 17 |
| Mode | 14 |
| Standard deviation | 8,159 |
| Sample variance | 66,58 |
| Kurtosis | 8,576 |
| Skewness | 1,859 |
| Range | 80 |
| Minimum | 2 |
| Maximum | 82 |
| Count | 654 |
| | |



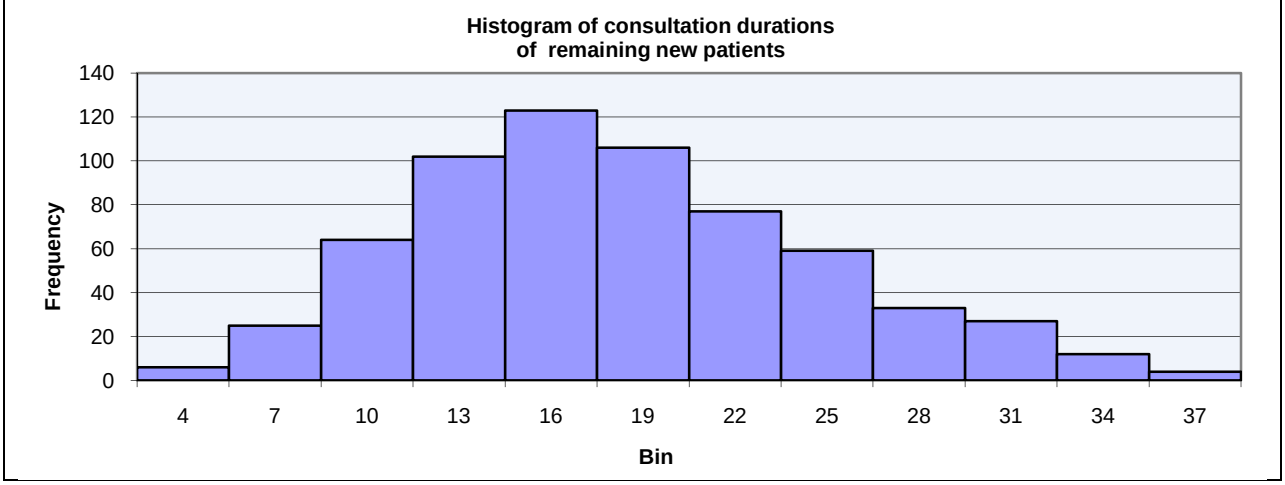
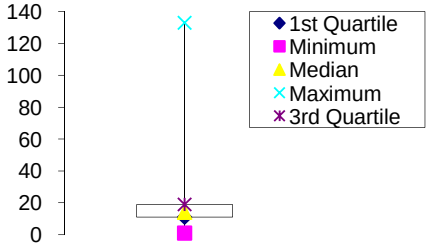




*Table D13.3 - Summary statistics, box plot and histogram of remaining new patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

| Summary statistics, box plot and histogram or remaining follow-up patients | |
|---|---|
| Mean | 15,57 |
| Median | 14 |
| Mode | 13 |
| Standard deviation | 8,119 |
| Sample variance | 65,92 |
| Kurtosis | 29,14 |
| Skewness | 3,145 |
| Range | 132 |
| Minimum | 1 |
| Maximum | 133 |
| Count | 1875 |
| | |



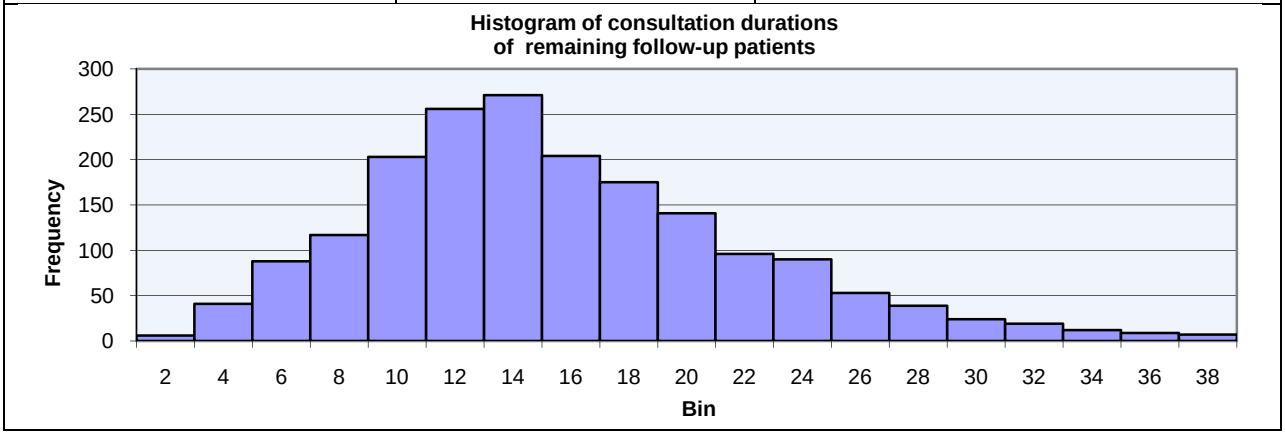




*Table D13.4 - Summary statistics, box plot and histogram of remaining follow-up patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

***Parameter Estimation***

The parameters are estimated using maximum likelihood parameter (see Table D13.5 and D13.6).

| Defining parameters for gamma(α,β) | |
|---|---|
| $\alpha = \frac{Mean}{\beta}$ | $\beta = \frac{Standard\ deviation}{Mean}$ |

*Table D13.5 - Uses formulas to determine the parameters for a gamma-distribution*

| | α | β |
|---|---|---|
| Follow-up patients with 'Asthma' (3202) | 5,6 | 2,4 |
| Patients with 'Depression/Fatigue' (8911) | 5,8 | 3,6 |
| Remaining new patients | 4,8 | 3,7 |
| Remaining follow-up patients | 3,7 | 4,2 |

*Table D13.6 - Parameter estimation for gamma(α,β)-distribution*

***Determining the representativeness of the fitted distributions***

For follow-up patients with asthma, patients with depression/fatigue and remaining new patients, the gamma-distribution is found out to represent the consultation durations correctly. This is confirmed by a histogram over plot, a Q-Q plot (see Figure D13.5 until D13.10) and the chi-square tests of these three groups of patients (see table D13.7).

For the remaining follow-up patients, the chi-square test does not confirm the gamma-distribution as representative for the consultation durations of this group, i.e. the result of the chi-square test is bigger than the critical value for the chi-square distribution at 30 degrees of freedom and an alpha of 0,1 which is 43,77. Neither does the chi-square test confirm a lognormal or a weibull distribution as representative.

Since the consultation duration of the other patients groups is best described by a gamma-distribution, the gamma-parameters for the distribution of the remaining follow-up patients are manually altered in order to comply as much as possible with the chi-square test. This resulted in an alpha of 5,2 and a beta of 3,0. The histogram over plot and the Q-Q Plot of this gamma(5,2;3,0)-distribution is shown in Figure D13.11 and Figure D13.12.

| Outcomes chi-square tests | |
|---|---|
| Follow-up patients with 'Asthma' (3202) | Chi-square = 34,72, 25 d.f., p=0,09 |
| Patients with 'Depression/Fatigue' (8911) | Chi-square = 9,91, 5 d.f., p=0,08 |
| Remaining new patients | Chi-square = 35,54, 30 d.f., p=0,22 |
| Remaining follow-up patients | Chi-square = 50,17, 30 d.f., p= 0,01 |

*Table D13.7 - Outcomes of the chi-square tests*

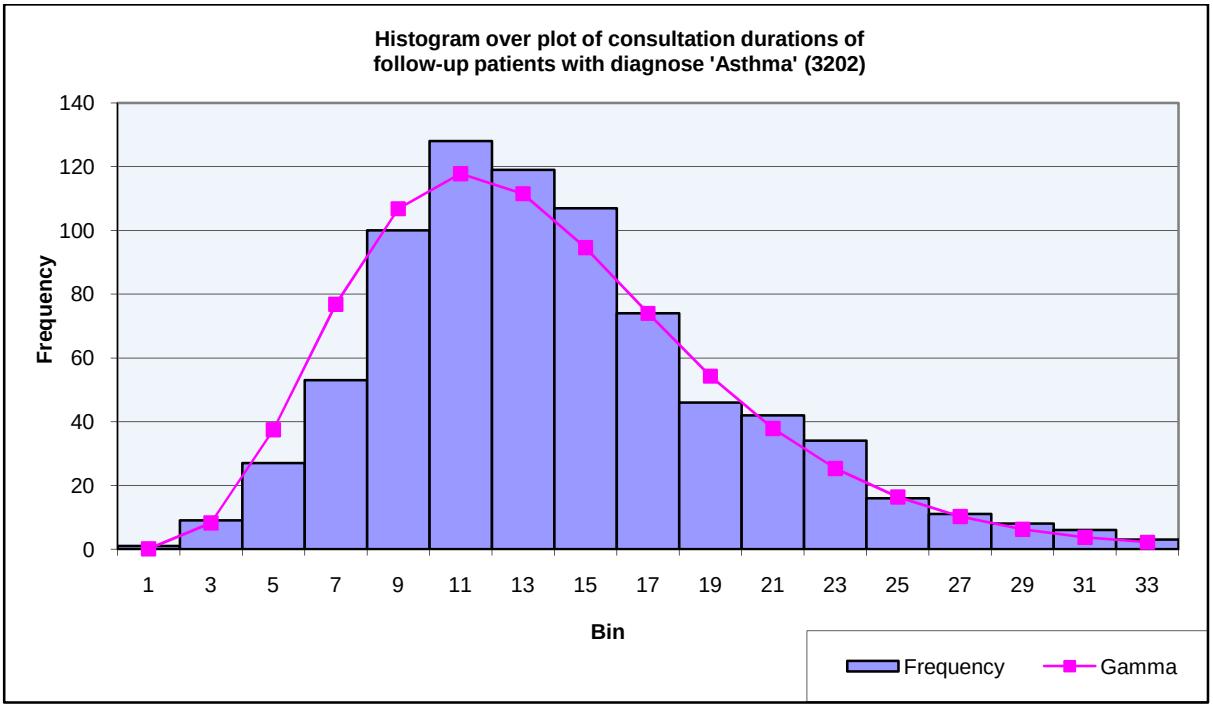



*Figure D13.5 - Histogram over plot of consultation durations of follow-up patients with diagnose Asthma (3202) (based on data gathered from March 11th 2008 until April 3rd 2009).*

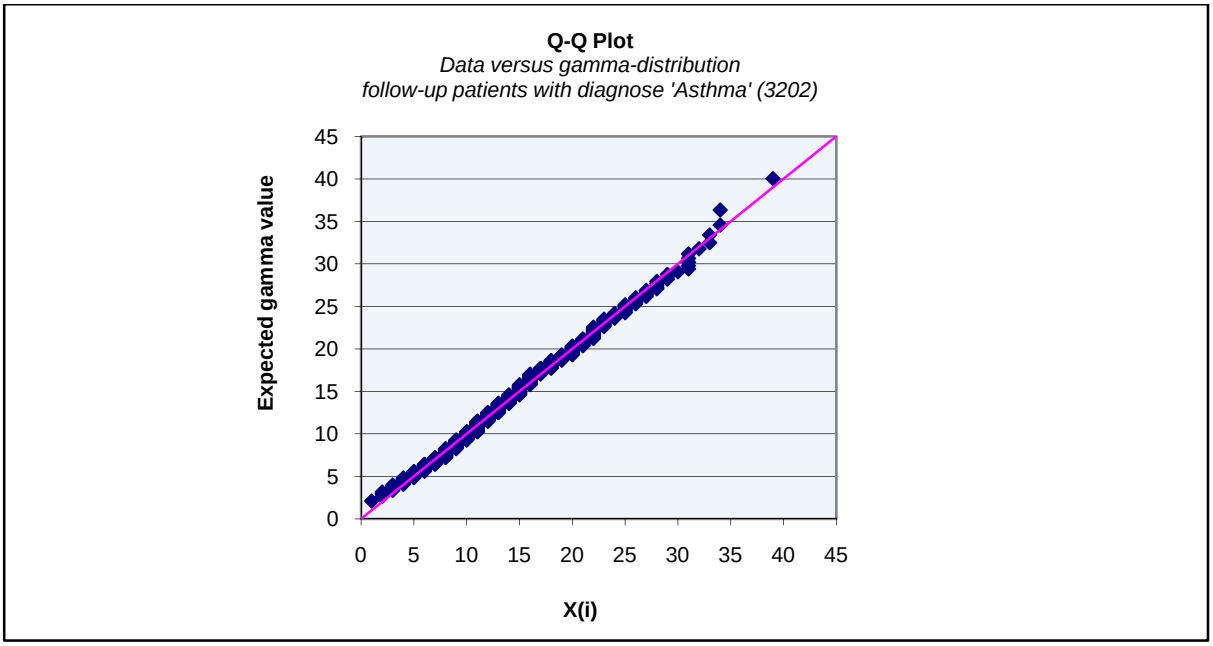



*Figure D13.6 - Q-Q plot of gamma-distribution versus data follow-up patients with diagnose Asthma (3202) (based on data gathered from March 11th 2008 until April 3rd 2009).*

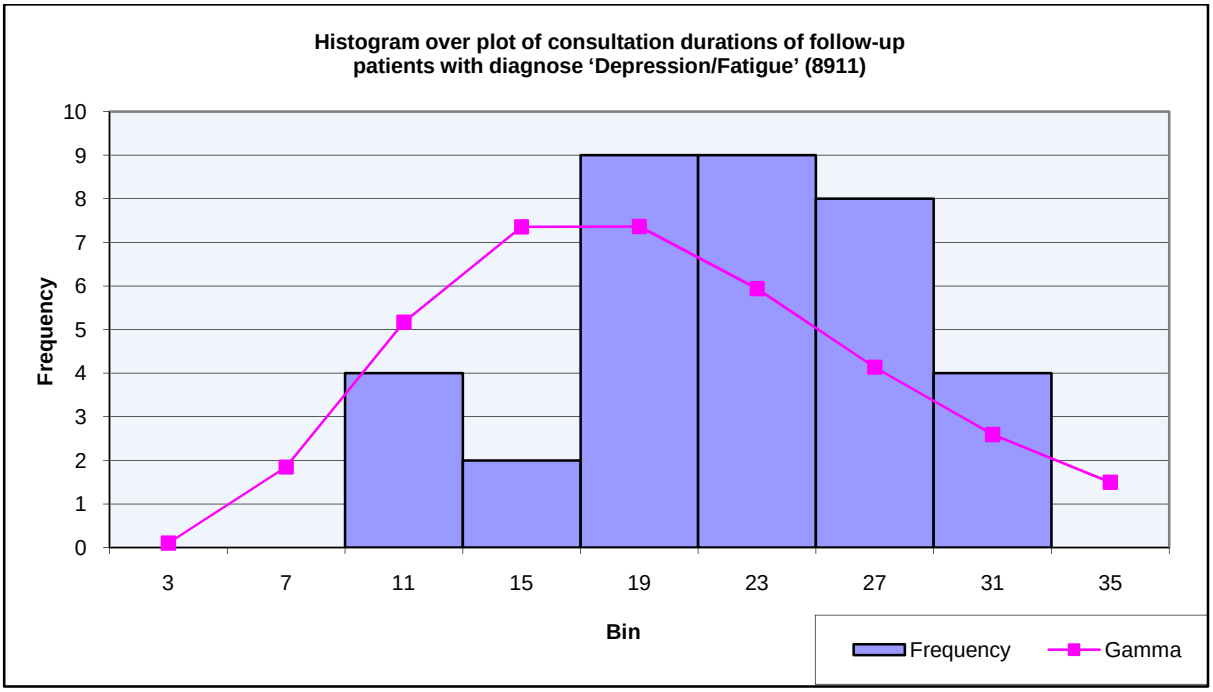



*Figure D13.7 - Histogram over plot of consultation durations of patients with diagnose 'Depression/Fatigue' (8911) (based on data gathered from March 11th 2008 until April 3rd 2009).*

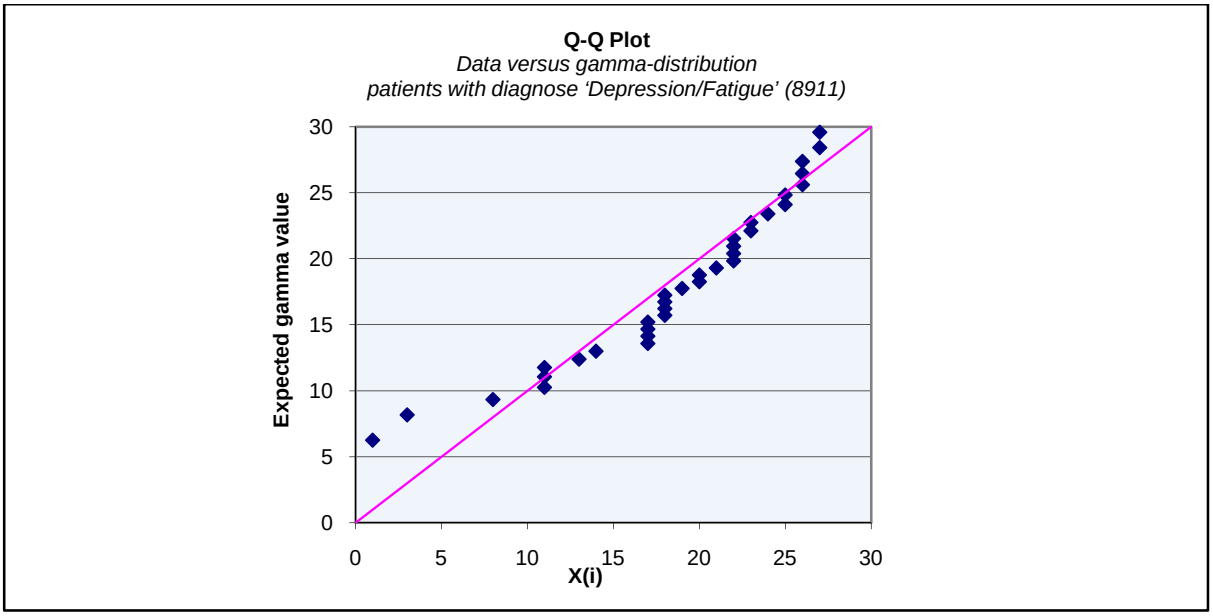



*Figure D13.8 - Q-Q plot of gamma-distribution versus data of patients with diagnose 'Depression/Fatigue' (8911) (based on data gathered from March 11th 2008 until April 3rd 2009).*

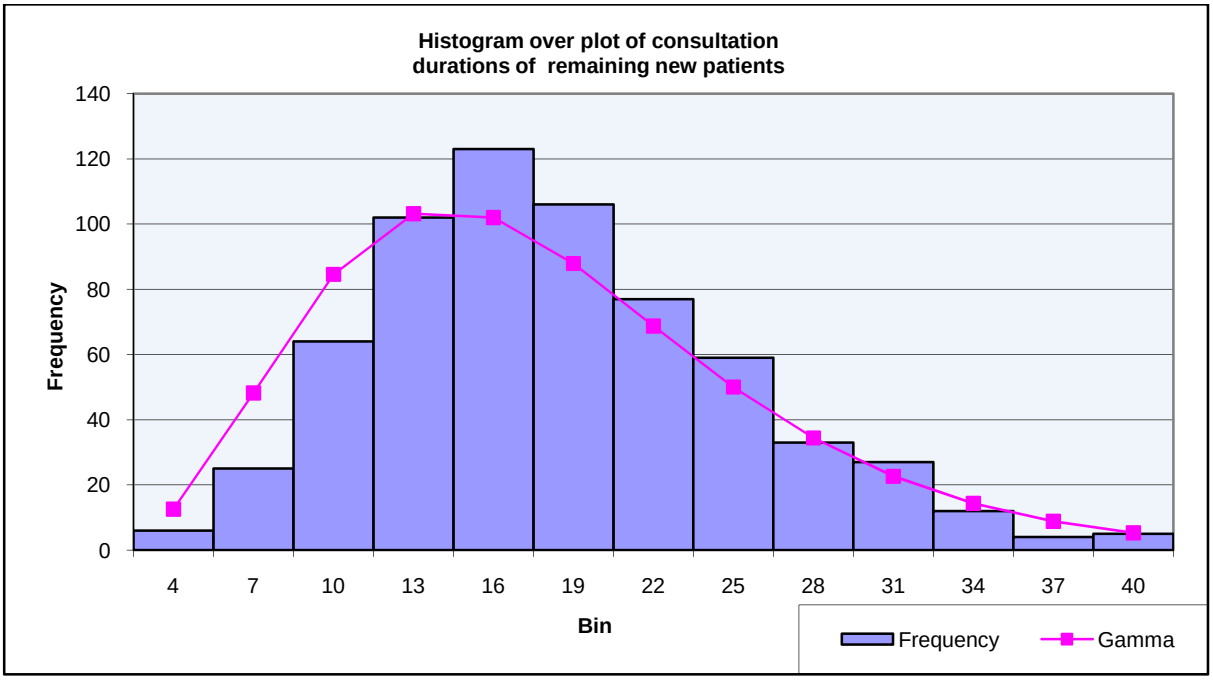



*Figure D13.9 - Histogram over plot of consultation durations of remaining new patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

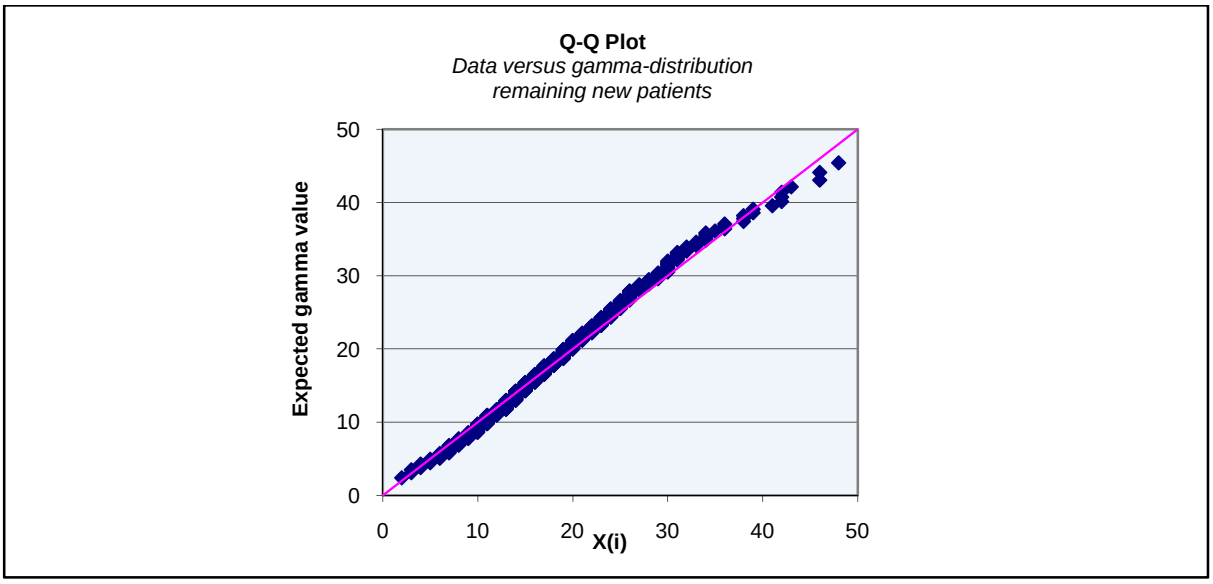



*Figure D13.10 - Q-Q plot of gamma-distribution versus data of remaining new patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

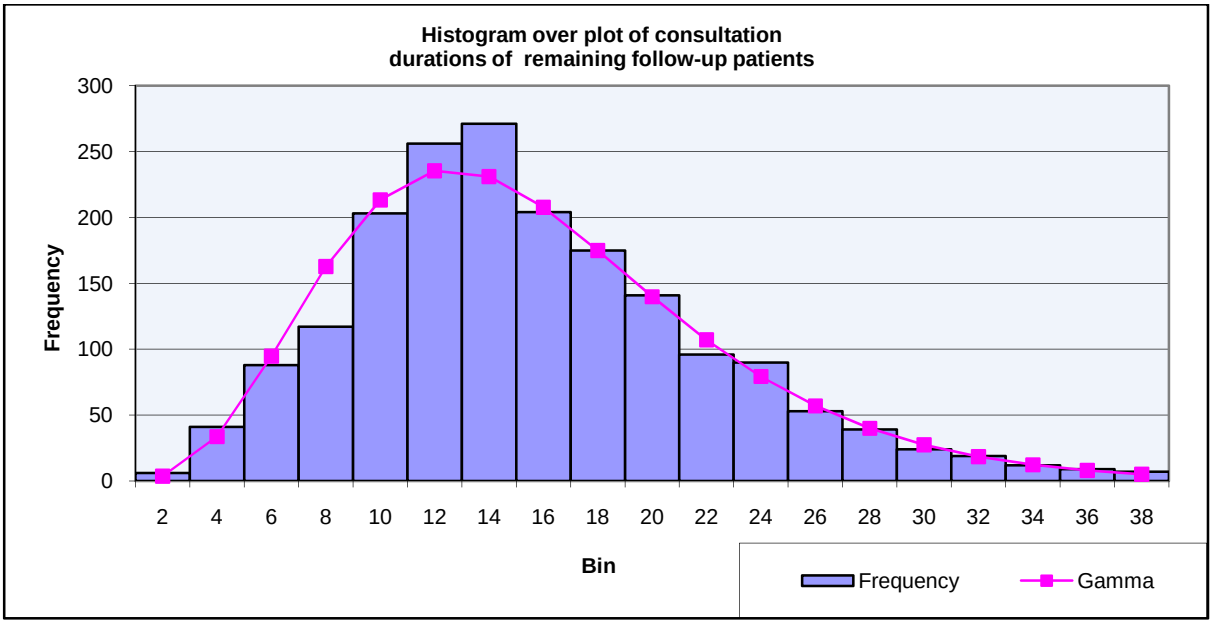



*Figure D13.11 - Histogram over plot of consultation durations of remaining follow-up patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

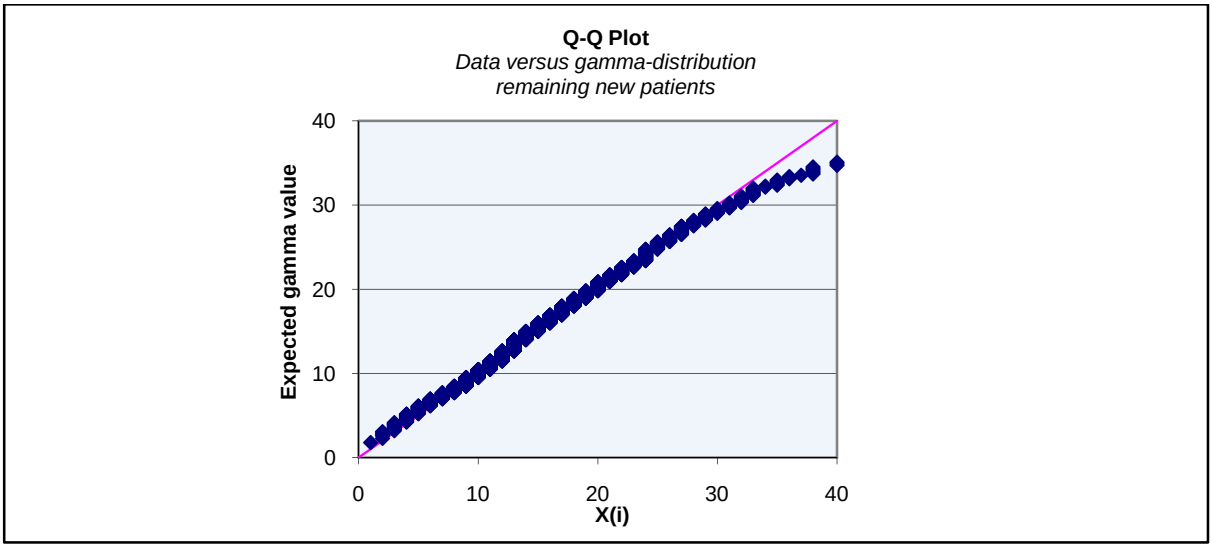



*Figure D13.12 - Q-Q plot of gamma-distribution versus data of remaining follow-up patients (based on data gathered from March 11th 2008 until April 3rd 2009).*

***Conclusions***

For the four groups, we found the gamma-distribution to be representative.

# Appendix E - Technical Model

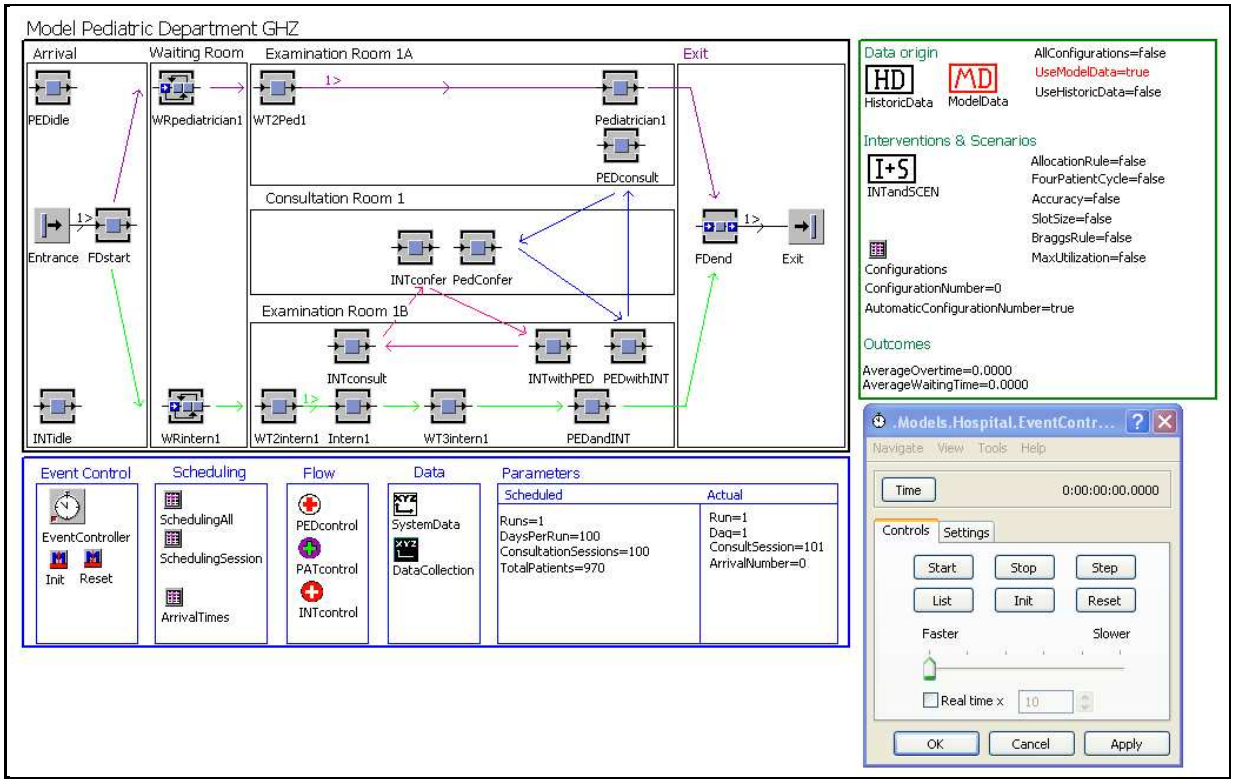



*Figure E.1 - Screenshot of the computer simulation model*

# Appendix F - Sensitivity Analysis

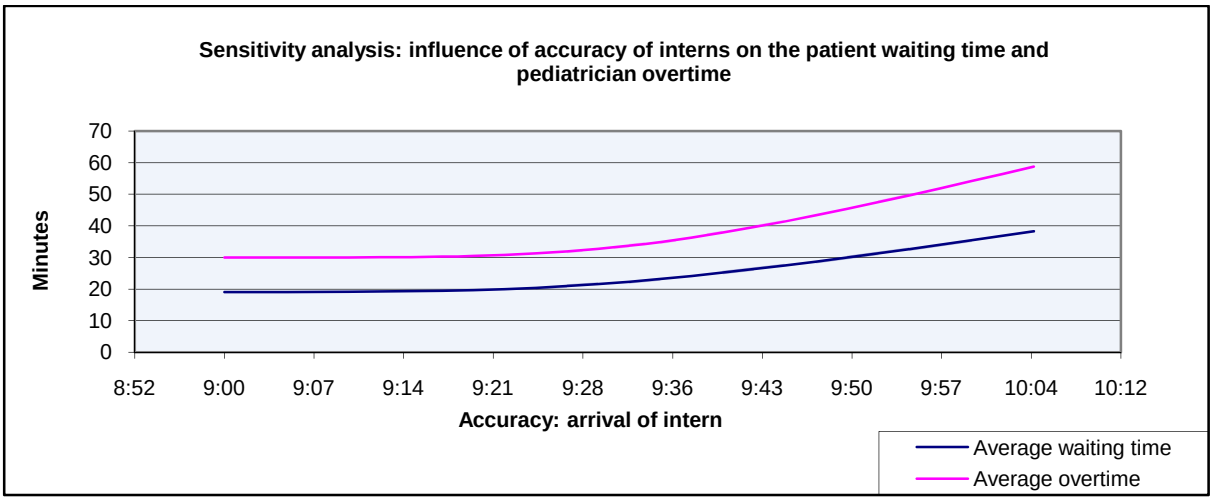



*Figure F.1 - Results of the sensitivity analysis on the accuracy of interns*

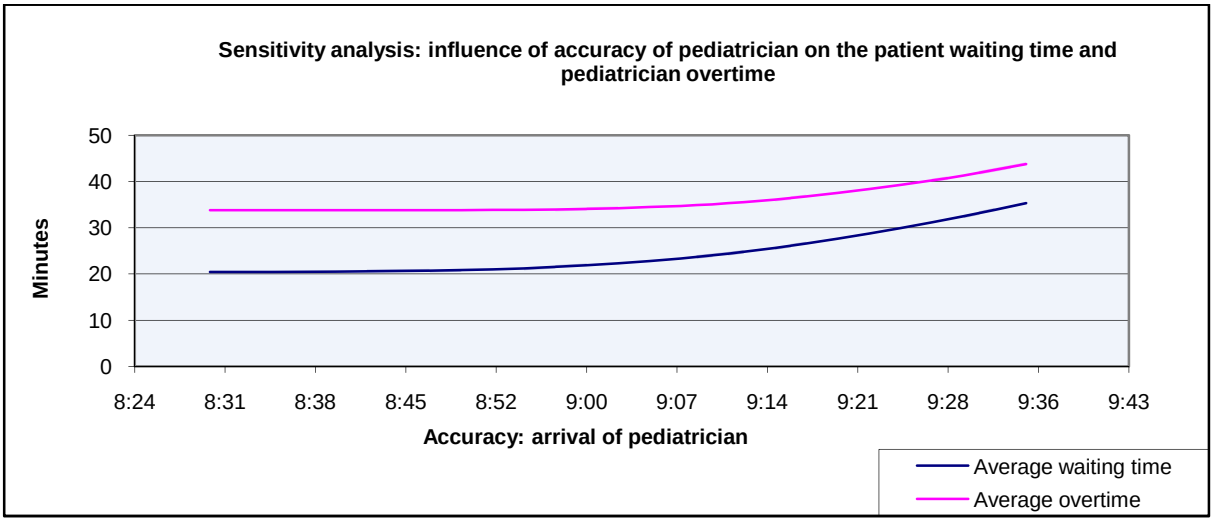



*Figure F.2 - Results of the sensitivity analysis on the accuracy of pediatricians*

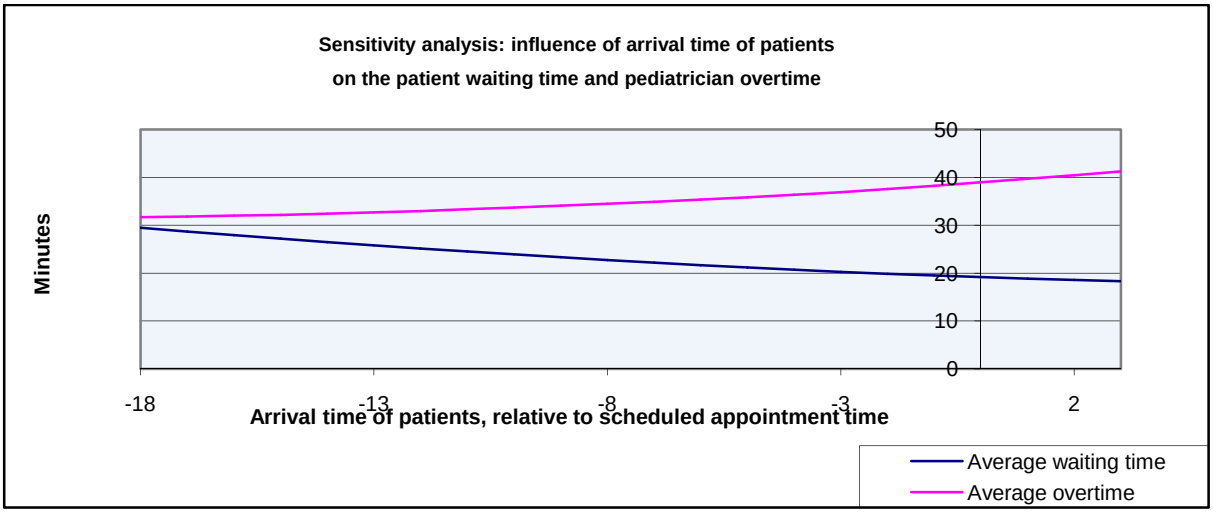



*Figure F.3 - Results of the sensitivity analysis on the patient arrival times*

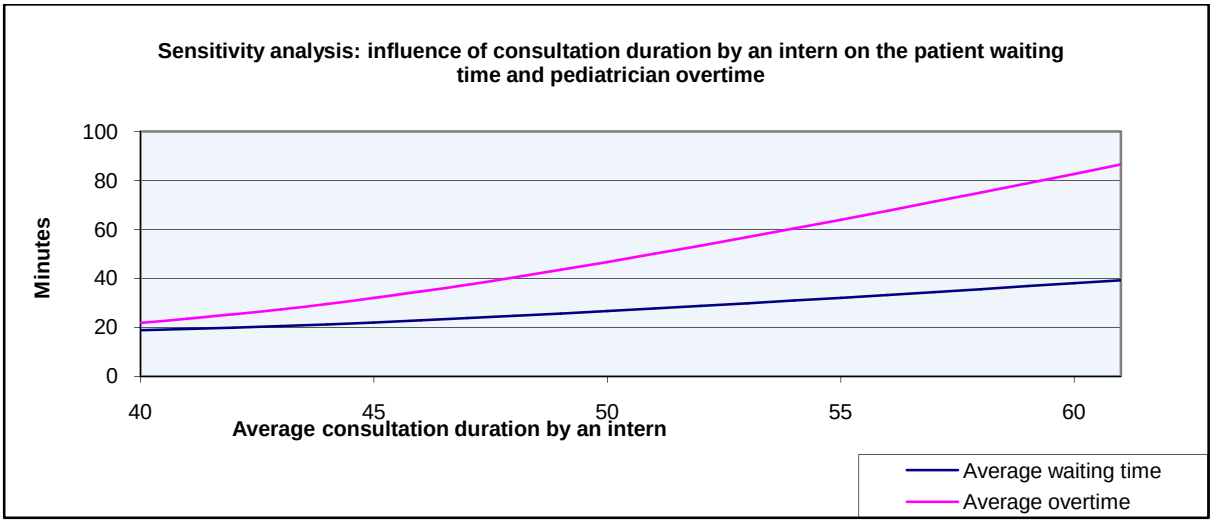



*Figure F.4 - Results of the sensitivity analysis on the durations of consultations by interns*

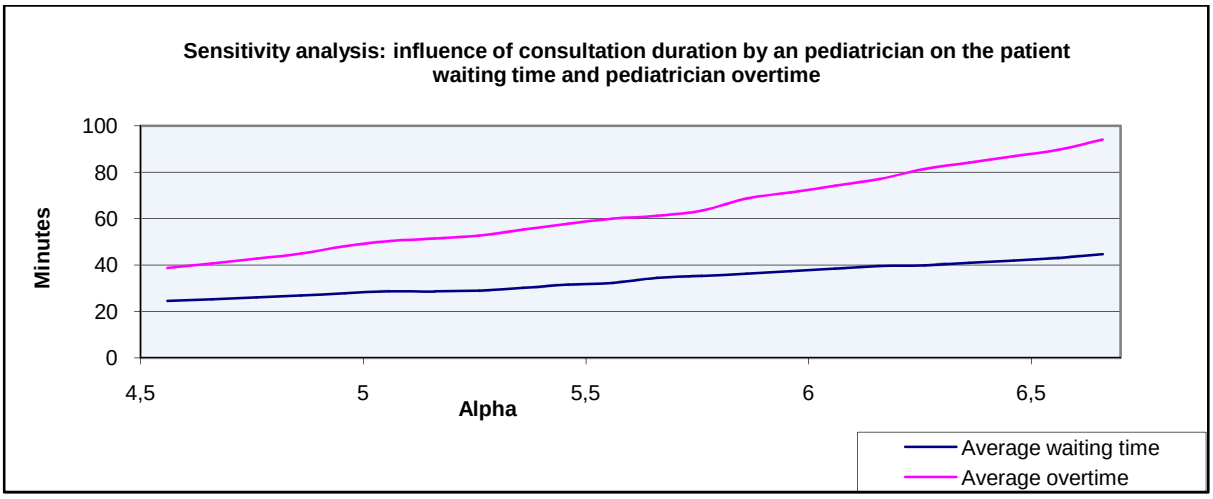



*Figure F.5 - Results of the sensitivity analysis on the durations of consultations of pediatricians*

# Appendix G - Outpatient Scheduling in Case of an Increase in the Number of New Patients per Consultation Session

## G1 - Introduction

The performance of the different interventions explained in Section 4.6 is only appropriate for the specific context explained in Chapter 2. In this appendix a slightly different context is used: instead of two new patients per consultation session, a pediatrician consults three new patients per consultation session, a change that is recently implemented on the pediatric outpatient center. This different situation results in different interventions and different results. This appendix uses the same composition as the report. First the context is described (Section G2) followed by an explanation of the various interventions (Section G3) and their performances (Section G4). The appendix ends with a conclusion (Section G5).

## G2 - Context Analysis

In case the outpatient center is faced with more new patients, it increases the number of new patients a pediatrician consults during a consultation session. Instead of two new patients and ten follow-up patients, a consultation session contains three new patients and nine follow-up patients. The scheduling is done with three instead of two 4-patient cycles (see Figure G2.1).

The new situation does not change but amplifies the conclusions from the context analysis (Section 2.4). Three instead of two new patients means more insufficient slot sizes and three instead of two 4-patient cycles means more possible delays of pediatrician and intern causing more pediatrician overtime.

## G3 - Interventions

The different interventions explained in Chapter 3 do not differ on overtime in case scheduling is done with the use of three 4-patient cycles (see Section 4.6.3). In order to decrease the pediatrician overtime, different interventions have to be created. We use two strategies to create interventions: (1) altering the current scheduling in order to gain the positive effect of the flexible 4-patient cycle or (2) separating new from follow-up patients. These two strategies are explained in this section. An overview of the interventions to be analyzed is given in Table G3.1.

***Flexible 4-patient cycle with alterations***

The flexible 4-patient cycle rule reduces the pediatrician overtime and the patient waiting time by reducing the probability that the pediatrician has to wait for the intern to finish his or her consultation. The rule states that the follow-up patients which are scheduled after the consultations of new patients arrive 15 minutes early giving the pediatrician the opportunity to keep on consulting. In case consultation sessions are scheduled with the use of three 4-patient cycles, the last cycle can not be made flexible since no follow-up patient can be scheduled 15 minutes early, i.e. the last patient is a new patient (see Figure G3.1).

In order to regain the positive effect of the flexible 4-patient cycle, the last patient of a consultation session should be a follow-up patient that can be scheduled 15 minutes earlier. We therefore create the following interventions in which the three 4-patient cycles are shifted 15 minuets forwards and the first follow-up patients is scheduled on the last appointment slot:

> *Intervention 18, flexible 4-patient cycle rule with intern starting earlier: schedule the patient succeeding the new patient 15 minutes earlier & let the intern start 15 minutes earlier (Figure G3.2)*

Another method to regain the effect of the flexible 4-patient cycle is by cancelling the third consultation by an intern:

> *Intervention 19, flexible 4-patient cycle rule and no consultation by an intern for the last new patient: schedule the patient succeeding the new patient 15 minutes earlier and cancel the third consultation by an intern (see Figure G3.3).*

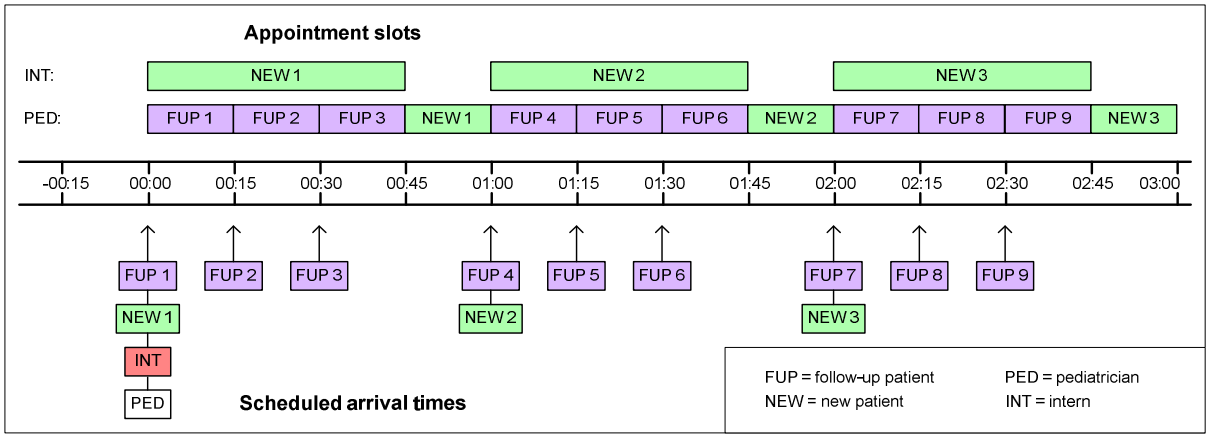



*Figure G2.1 - An overview of appointment slots and arrival times of a schedule with three 4-patient cycles.*

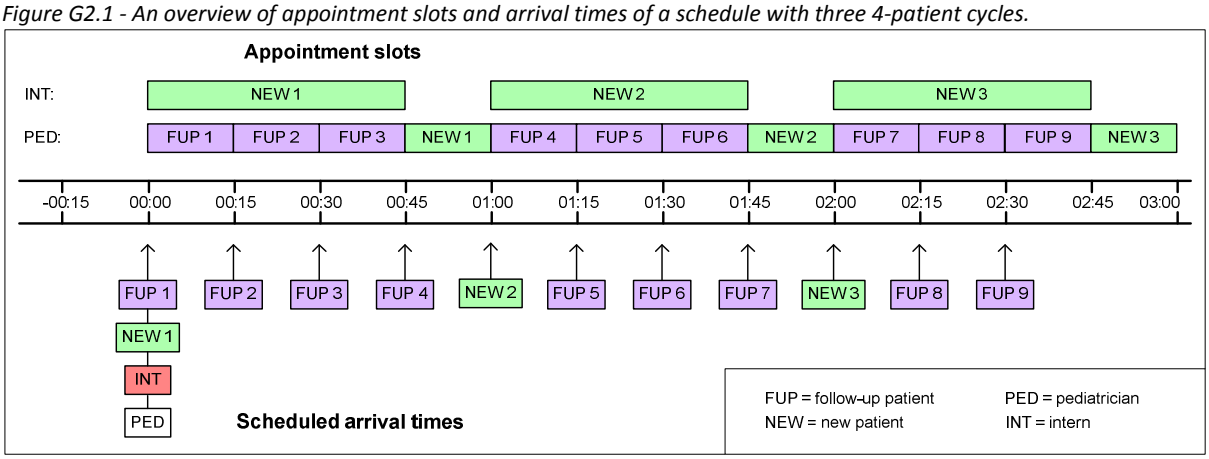



*Figure G3.1 - An overview of appointment slots and arrival times of a schedule with three flexible 4-patient cycles.*

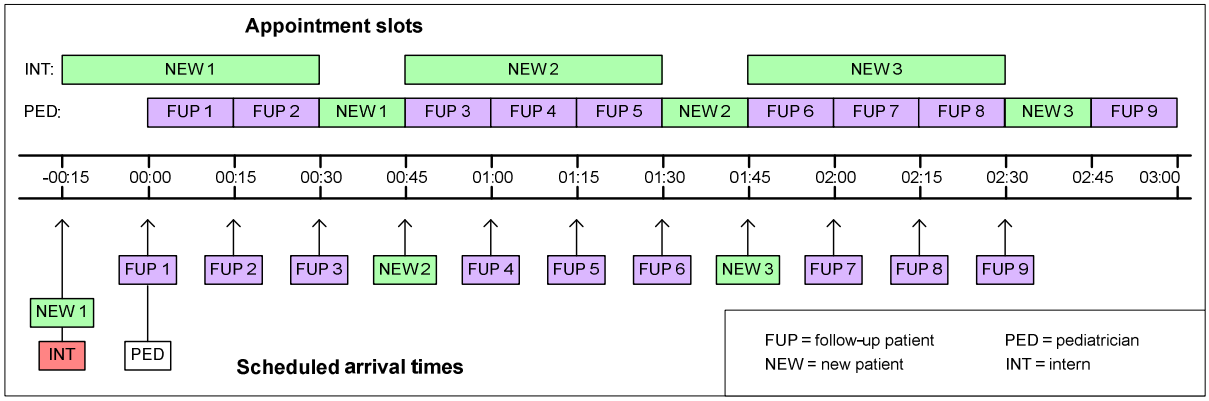



*Figure G3.2 - An overview of appointment slots and arrival times of a schedule with three flexible 4-patient cycles and the intern starting early.*

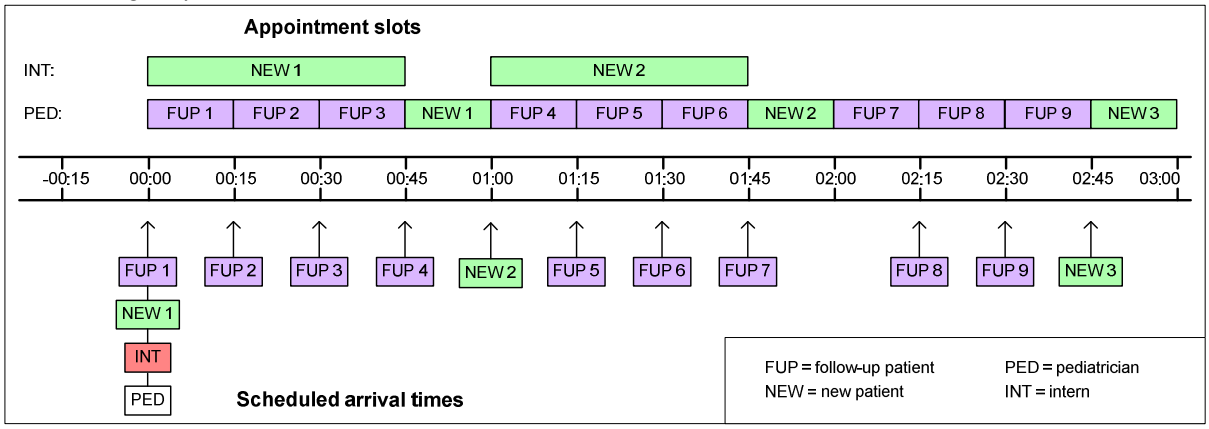



*Figure G3.3 - An overview of appointment slots and arrival times of a schedule with three flexible 4-patient cycles and without the intern consulting the last new patient.*

***Separating new and follow-up patients***

The increase in the number of new patients on a consultations session gives the possibility to create a consultation session for new patients only, i.e. since every pediatrician has three consultation sessions per week, the number of new patients per week changes from six to nine: enough new patients to fill an entire consultation session. In order to consult the same amount of follow-up patients, the two sessions devoted to follow-up patients should be able to contain 27 follow-up patients. We therefore create the following intervention:

> *Intervention 20, separating new and follow-up patients: create two consultation sessions for a maximum of 27 follow-up patients (see Figure G3.4 and G3.5) and one consultation session for new patient only (see Figure G3.6). The consultation session for new patients is accompanied by four interns.*

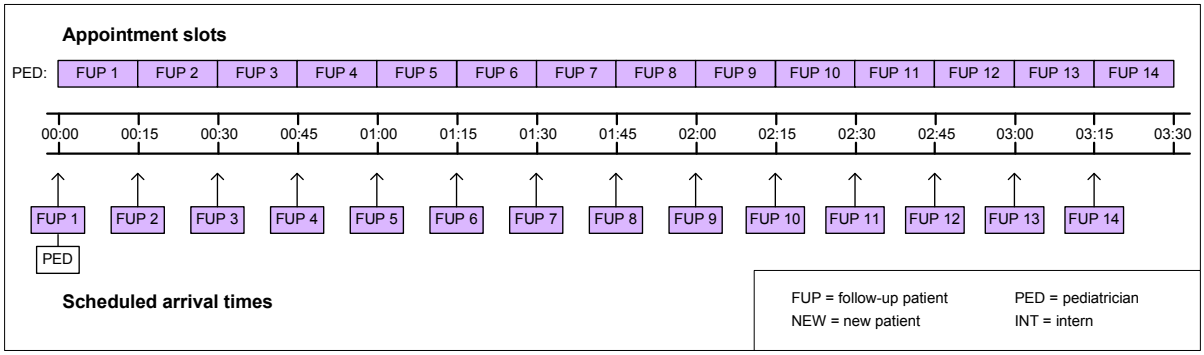



*Figure G3.4 – An overview consultation session one: 14 follow-up patients*

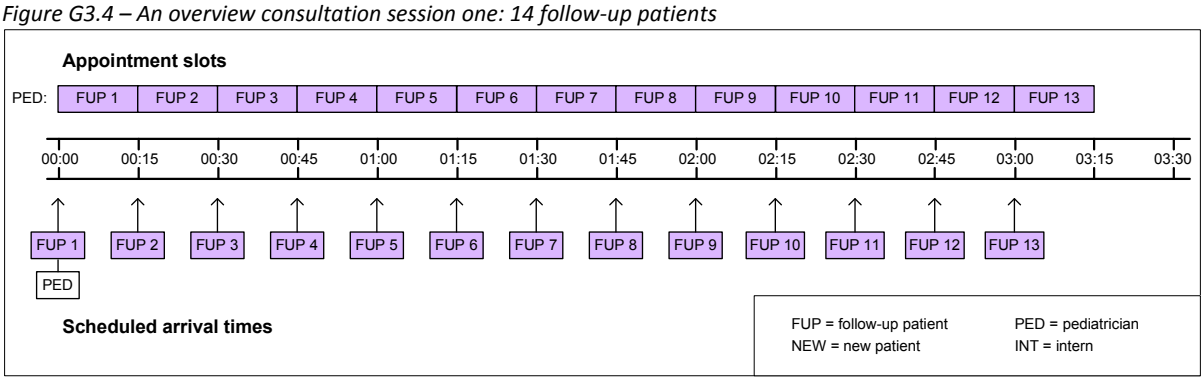



*Figure G3.5 – An overview consultation session two: 13 follow-up patients*

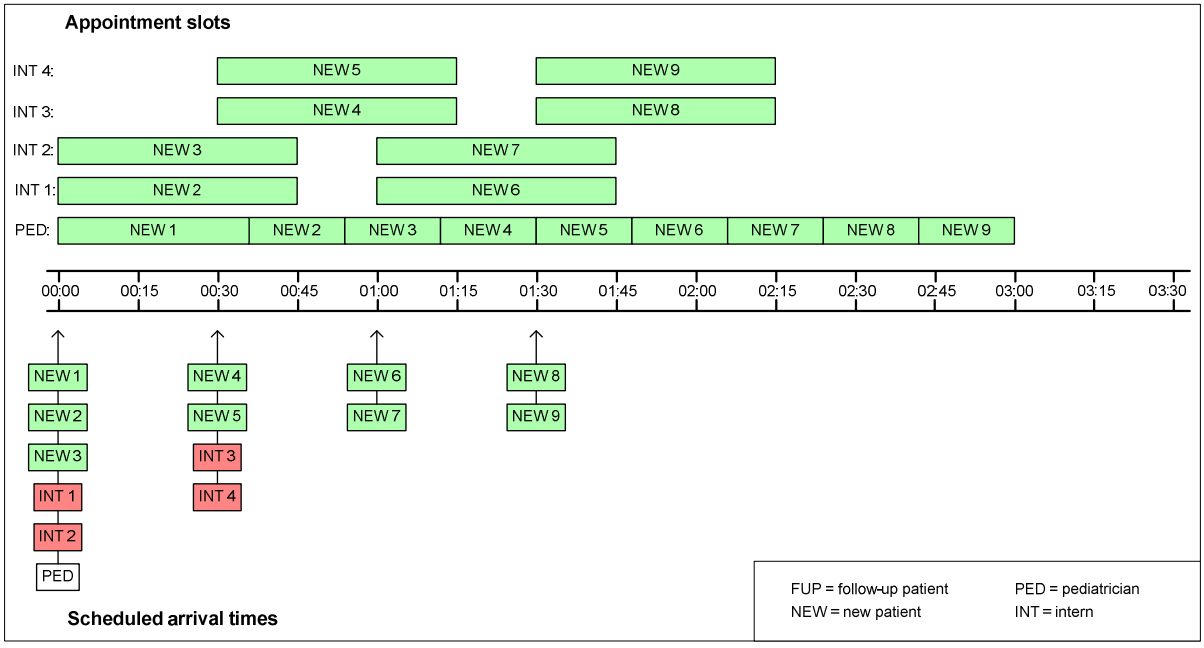



*Figure G3.6 – An overview consultation session three: 9 new patients*

| Overview of Interventions | | |
|---|---|---|
| 1) Bailey-Welch rule | : | Schedule of two patients on the initial slot and none on the slot preceding the first new patient |
| 2) Variable slot | : | Schedule new patients in slots sizes of 20 minutes |
| 3) Flexible 4-patient cycle | : | Schedule the patient succeeding the new patient one slot earlier |
| 4) LVBEG rule | : | Schedule low variance patients at the beginning of the consultation session and high variance patients at the end of the consultation session |
| 5) Allocation rule | : | Start scheduling appointment slots with the initial slot and continue with the successive slots |
| 10) LVBEG + Flexible 4-patient cycle | : | Combination of LVBEG and flexible 4-patient cycle |
| 12) LVBEG + Bailey-Welch + Flexible 4-patient cycle | : | Combination of LVBEG, Bailey-Welch and flexible 4-patient cycle |
| 18) Flexible 4-patient cycle + early start intern | : | Schedule the patient succeeding the new patient 15 minutes earlier & let the intern start 15 minutes earlier |
| 19) Flexible 4-patient cycle + last new patient no intern consultation | : | Schedule the patient succeeding the new patient 15 minutes earlier and cancel the third consultation by an intern. |
| 20) Seperating new and follow-up patients | : | Create two consultation sessions for a maximum of 27 follow-up patients and one consultation session for new patient only. The consultation session for new patients is accompanied by four interns. |

*Table G3.1 - Overview of the basic interventions (1-5), the best performing interventions in case of two new patients per consultation session (3, 10 and 12) and the interventions for a situation with three new patients (18-20)*

# G4 - Analysis of Interventions

We analyze the new interventions 18, 19 and 20 (see Section G3) together with the current scheduling and the basic interventions 1, 2, 3, 4, 5 and the best performing interventions 10 and 12 (see Chapter 3), using the methods explained in Chapter 4 with the following exceptions:

- Conceptual model, session model - We do not discriminate between consultation sessions in the morning and the afternoon. Scheduling with the use of three 4-patient cycles removes the difference in scheduling between morning and afternoon sessions, i.e. the place of the three cycles is the same in both sessions.
- Data collection - In case of intervention 20, the separation of new and follow-up patients, the first new patient is consulted by the pediatrician only. In case of intervention 19, the last new patient is consulted by the pediatrician only. In these cases the preparatory work of the intern is absent, causing the consultation to take more time. We describe these 'consultations of new patients by pediatricians only' by a normal distribution with an average of 37 minutes and a standard deviation of 18 minutes (see Section G6).
- Experiments, scenarios - We only use maximum utilization to compare the different interventions. The historic scenario is not used since no data on the allocation of appointment slots can be retrieved for all the proposed interventions. This is especially the case for separating new and follow-up patients.

***Results***

Figure G4.1 shows the performance of the various interventions. Interventions 18 and 20 are the 'winners', both reduce the pediatrician overtime by 20 % compared with the current scheduling. Intervention 20, the separation of new and follow-up patients performs the best in decreasing the patient waiting time by more that 30 % compared with the current scheduling. The downside to this intervention is the increase in the third waiting time for new patients (see Figure G4.2).

The basic and best performing interventions in case of two 4-patient cycles do not differ on overtime as already stated in Section 4.6.3. The new intervention 19 does also not differ on overtime. The reduction in overtime by cancelling the last consultation by an intern is compensated by longer consultation duration of the new patient by the pediatrician.

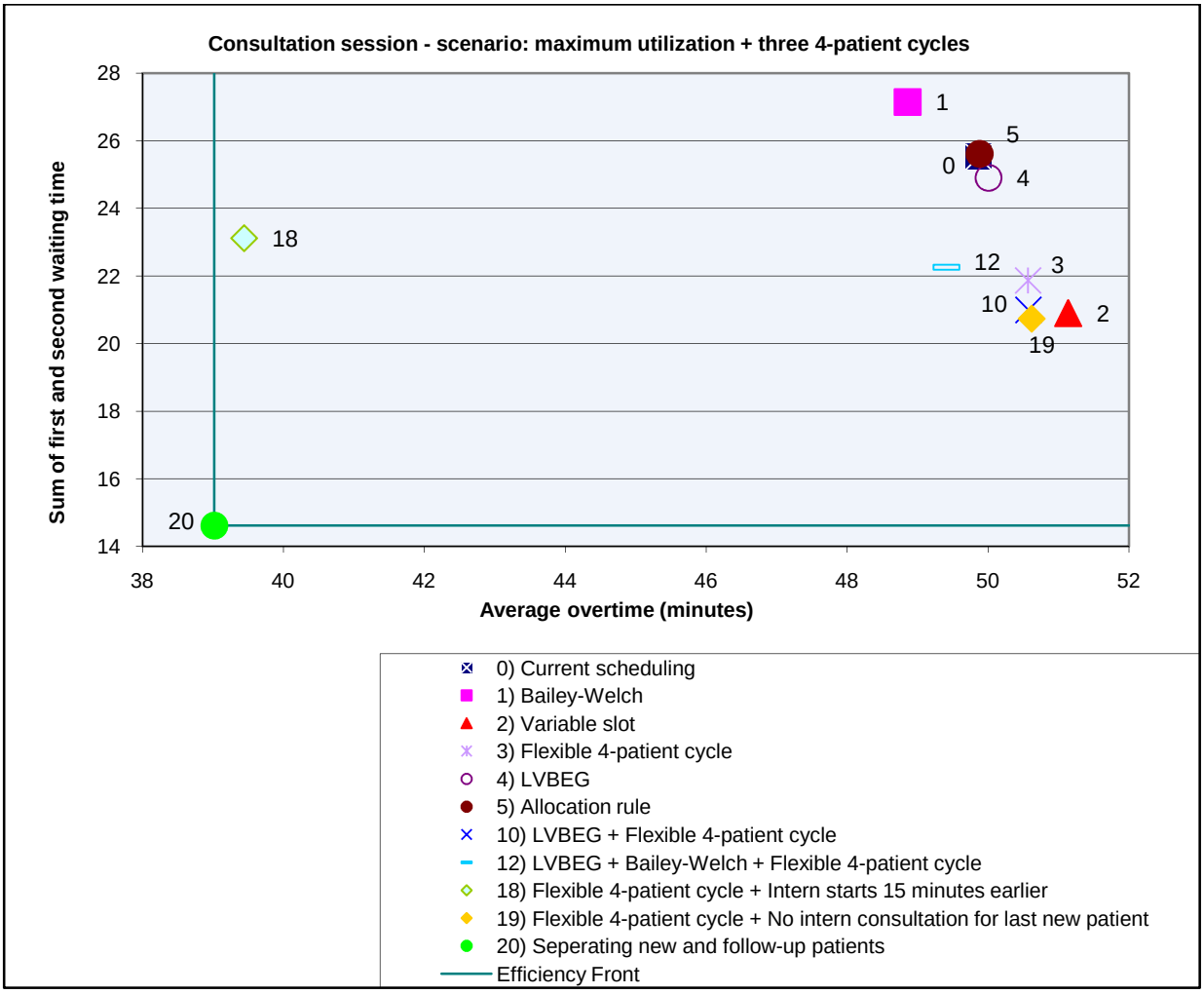



*Figure G4.1 – Pediatrician overtime and the sum of the first and second waiting time in case of maximum utilization and three new patients per consultation session.*

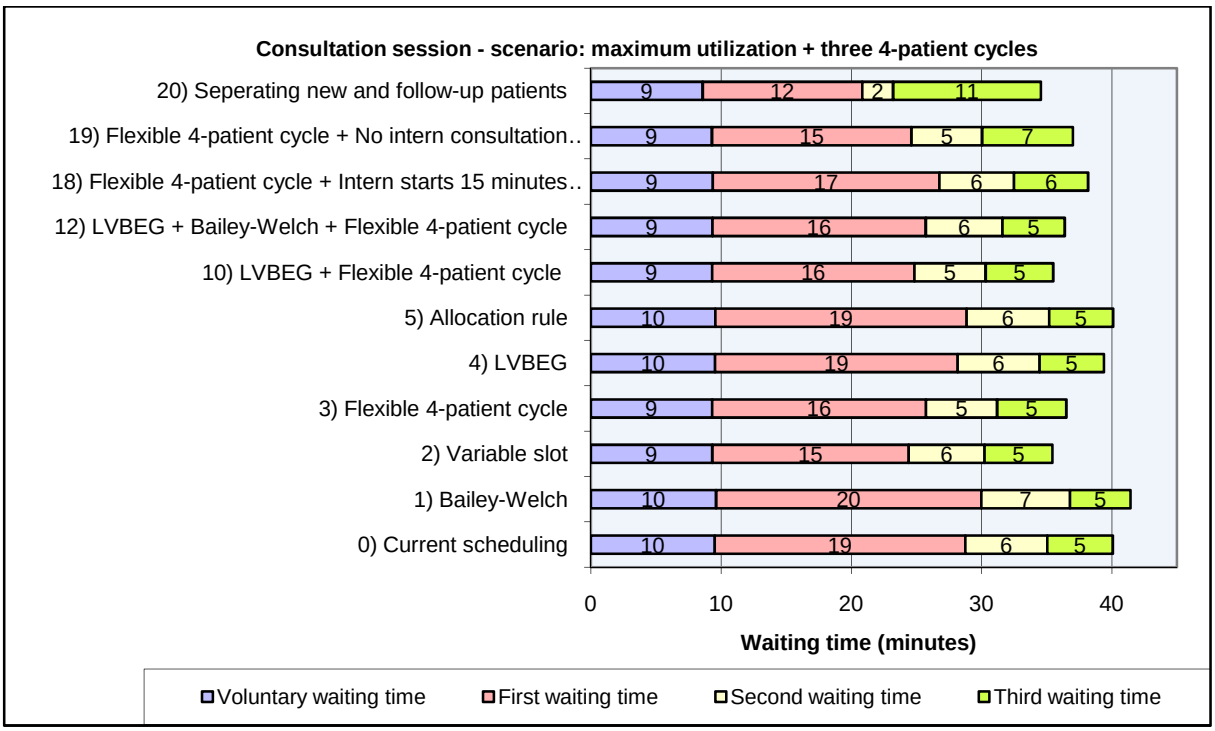



*Figure G4.2 – Overview of the different waiting times caused by various interventions.*

| Best performing interventions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Intervention* | *Service -level* | | *Waiting time (minutes)* | | | | | | *Overtime* | |
| | | | *Voluntary* | *First* | *Second* | *Third* | *Percentage reduction of voluntary, first and second waiting time* | | *Minutes* | *Percentage reduction* |
| | | | | | | | | | | |
| *Morning session – scenario: historical* | | | | | | | | | | |
| 0) Current scheduling | 66 % | | 10 | 19 | 6 | 5 | - | | 50 | - |
| 18) Flexible 4-patient cycle with intern starting 15 minutes earlier | 69 % | | 9 | 17 | 6 | 6 | 9 % | | 39 | 22 % |
| 20) Separating new and follow-up patients | 84 % | | 9 | 12 | 2 | 11 | 34 % | | 39 | 22 % |

*Table G4.1 - Overview of the current scheduling and the best performing interventions in case of an increase of the number of new patient per consultation session.*

# G5 - Conclusions and Discussion

In order to increase the number of consultations of new patients, the outpatient pediatric center of the GHZ changed the ratio of new versus follow-up patient per consultation session from 2:10 to 3:9. The center uses three instead of two 4-patient cycles to schedule these patients. This change causes a situation in which the interventions created for two new patients per consultation session do not differ on pediatrician overtime anymore. The positive effect of the flexible 4-patient cycle is diminished because in this situation a new patient is scheduled on the last slot.

We create three interventions in order to decrease the pediatrician overtime using this new ratio. (18) Flexible 4-patient cycle with the intern starting 15 minutes earlier, i.e. the three 4-patient cycles are scheduled 15 minutes earlier and the first follow-up patient is scheduled on the last appointment slot. With these 'shifts' the positive effect of the flexible 4-patient cycle on the pediatrician overtime can be regained. (19) Flexible 4-patient cycle without the last new patient retrieving a consultation by an intern. (20) Separation of new and follow-up patients. The increase of new patients creates the possibility to form consultation session especially for new and follow-up patients. Instead of three 'mixed' consultation sessions per pediatrician per week, every pediatrician has two sessions especially for follow-up patients and one especially for new patients. Since interns only assist with new patients, the consultation session with new patients only is therefore assisted by all the available interns.

We analyzed the performance of these interventions with a simulation model of a consultation session with the use of the scenario 'maximum utilization'. We found that intervention (18) and (20) outperformed the current scheduling by decreasing the pediatrician overtime with approximately 20 %. Intervention (20) also decreased the average patient waiting time with more than 30 %. Intervention (19) did not outperform the current scheduling because of the longer consultation time of new patients by pediatricians only.

Increasing the number of new patients per consultation sessions creates a new situation in which other interventions have to be applied in order to decrease the patient waiting time and pediatrician overtime. While intervention (18) uses small incremental changes to decrease the pediatrician overtime, intervention (20) demands another usage of the resources examination rooms and interns, i.e. the consultation session especially for new patients uses four examination rooms and four interns simultaneously, a situation that might not be desirable.

# G6 - Consultation of New Patients by a Pediatrician Only

In this section the procedure that is used to determine the distribution is explained. This procedure describes the duration of a consultation of new patients by a pediatrician only. The steps in calculating the distribution fit are: data selection, hypothesizing distribution, parameter estimation and determining the representativeness of the fitted distributions. The methods used to hypothesize distributions, estimate parameters and determine representativeness are based on methods describes by Averill Law and David Kelton [Law, 2000].

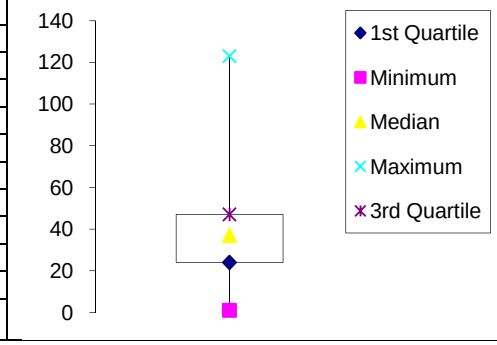
***Data Selection***

Consultations are collected using the basic selection criteria (see Appendix C3) on the data gathered from May 6th 2008 until August 31st 2009. Negative consultation durations are excluded as well as consultation of follow-up patients and consultations of new patients with an intern involved. This results in 565 consultations.

***Hypothesizing Distribution***

Based on the summary statistics, the box plot and the histogram (see Table G6.1) a normal-distribution is most likely.

| Summary statistics, box plot and histogram of durations of consultations by an intern | |
|---|---|
| Mean | 36,82 |
| Median | 37 |
| Mode | 40 |
| Standard deviation | 18,33 |
| Sample variance | 336,06 |
| Kurtosis | 1,81 |
| Skewness | 0,77 |
| Range | 122 |
| Minimum | 1 |
| Maximum | 123 |
| Count | 565 |
| | |



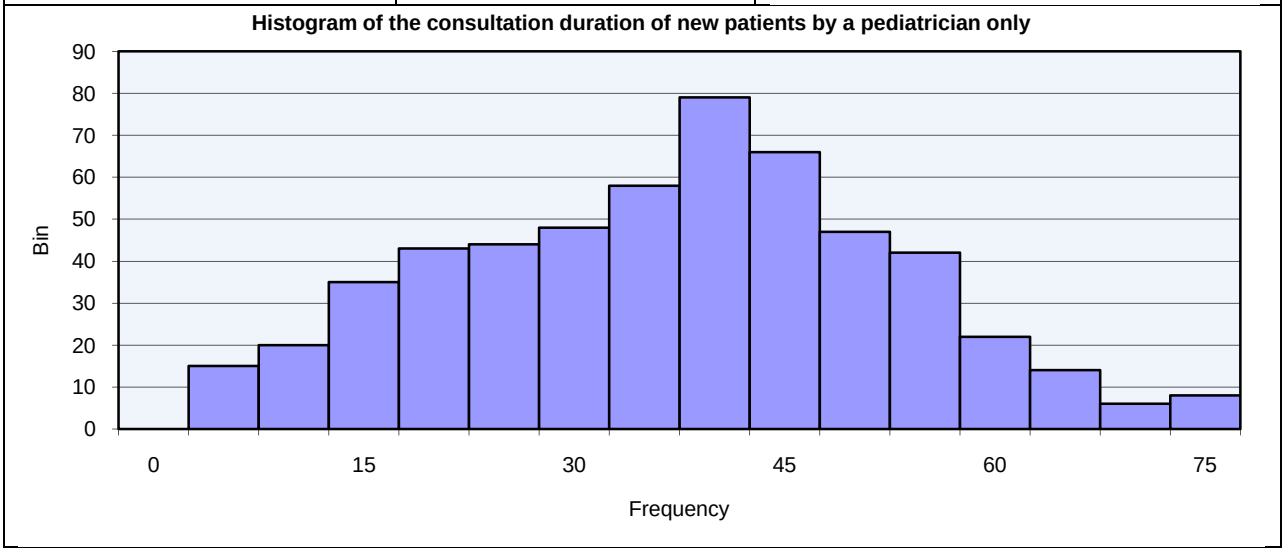




*Table G6.1 - Summary statistics, box plot and histogram of consultation duration of new patients by pediatricians only (based on data gathered from May 6th 2008 until August 31st 2009)*

***Parameter Estimation***

The parameters of a normal distribution are the mean and the standard deviation (see Table G6.2).

| Defining parameters for normal(α,β) | |
|---|---|
| $\alpha = Mean$ | $\beta = Standard\ deviation$ |

*Table G6.2 - Used formulas to determine the parameters for a normal-distribution*

***Determining the representativeness of the fitted distributions***

The found normal distribution is found out to correctly represent the consultation durations of new patients by pediatricians only. This is confirmed by a histogram over plot, a Q-Q Plot (see Figure G6.1 and G6.2) and a chi-square test (chi-square = 18,06, 18 d.f., p=0,39).

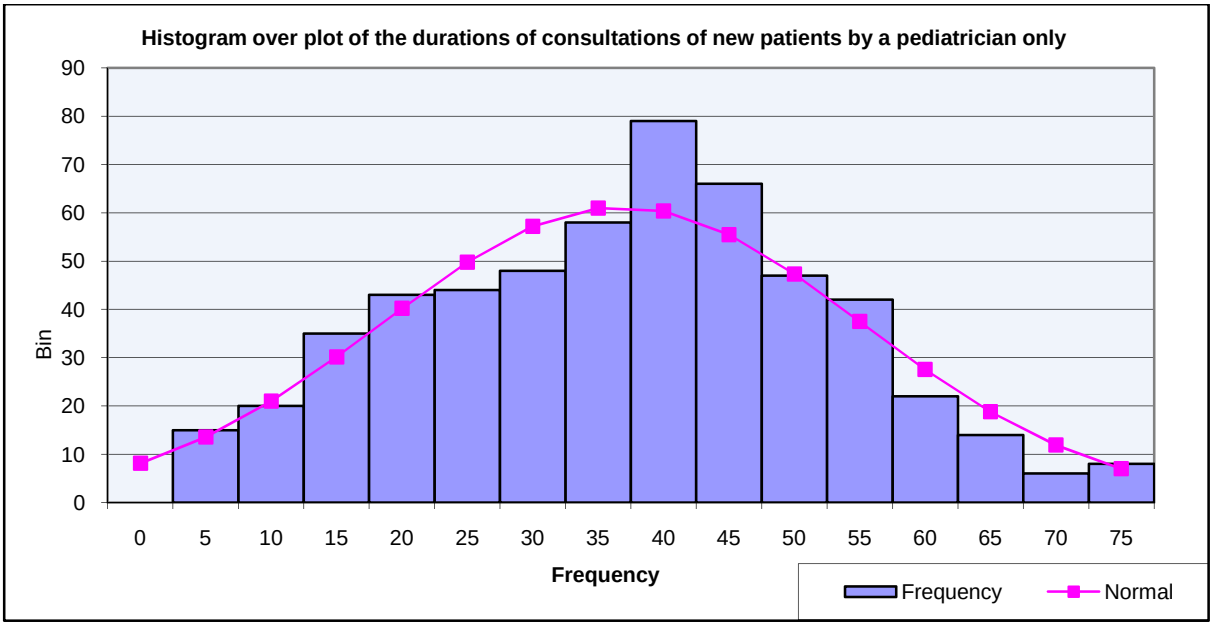



*Figure G6.1 - Histogram over plot of durations of consultations of new patients by a pediatrician only (based on data gathered from May 6th 2008 until August 31st 2009)*

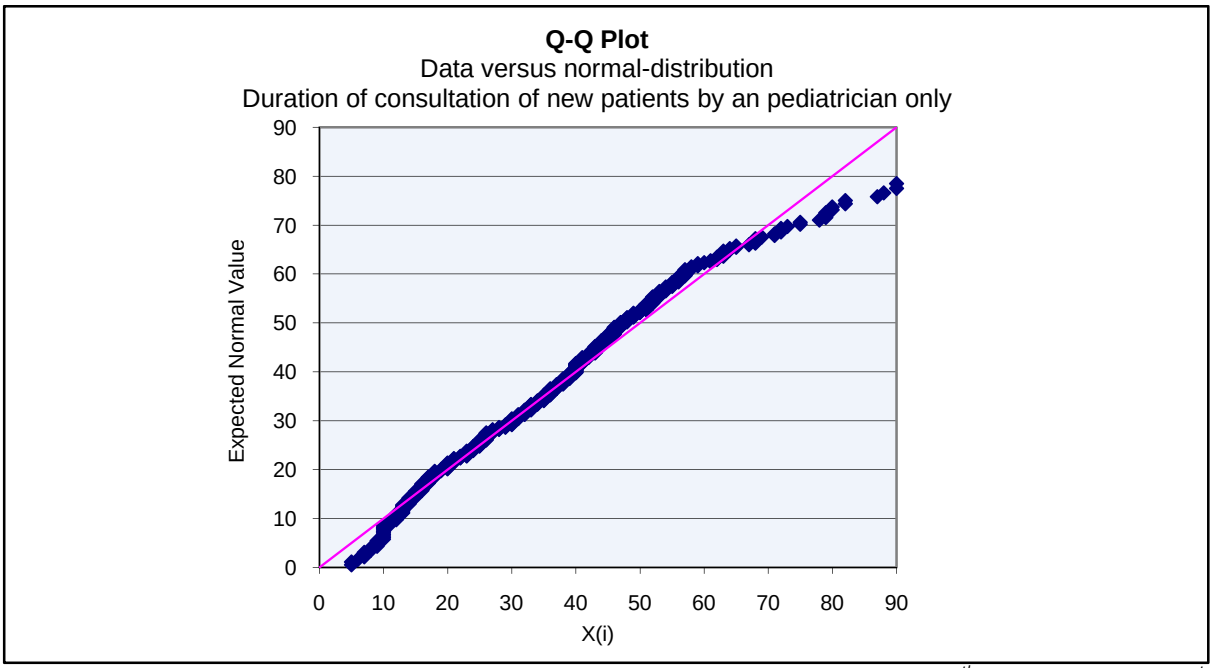



*Figure G6.2 - Q-Q plot of normal-distribution versus data. (based on data gathered from May 6th 2008 until August 31st 2009)*

***Conclusion***

The duration of the consultations of new patients by a pediatrician only can be described by a normal(37,18)-distribution.