Exploration of the front end processes of an Imaging Department

Campbelltown Hospital

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Executive Summary

Introduction
Many Emergency Departments (ED) of public hospitals in New South Wales have overcrowding issues that result in long waiting times. Campbelltown hospital, situated in the southwest Sydney-area, has the same problems. The Centre for Industry and Innovation Studies (CInIS) from the University of Western Sydney was invited to research and help solve this problem. Interviews with important stakeholders sourced these problems to the Imaging Department of the hospital.

Problem description
The Imaging Department (ID) has to deal with several inputs: patients wait at the inpatient wards and the ED, and patients come from outside the hospital for a service from the ID. These different inputs for the ID workflow are not synchronized and there exist differences and vagueness in priority. After analyzing the process for the CT room and Sonography, exploratory research was needed into the front end process of the imaging department. This front end process starts on the moment an ED staff-member enters a 'request for imaging' in the system and ends on the moment the patient enters the room.

Approach
The goal of this report is to get an overview and understanding of the processes in and around the Imaging Department and identify areas for improvement. Qualitative (Observations and semi-structured interviews) and quantitative research (data analysis) has been undertaken to answer our research questions and attain the research goal. The problem analysis is divided into process, decision making and performance.

Results
We described and mapped the front end process. Two sub-processes have been identified: the scheduling process and the patient transport process by the wards persons. While analyzing decision making in the Imaging Department, we found that the different events are self controlled by its actors. There is no central person who has an overview, which leads to unclear decision making and possible negative effects on the waiting time. On tactical level it is not clear if clinical or logistical/managerial issues have priority. The third part of the problem analysis is about performance. In the first section general characteristics of patients, procedures and days have been described. The analysis on waiting time showed long waiting times, which are explored using the type of patients, the type of examinations and the time of request. The main causes of delay are the administrative delay and 'waiting on transport time'.

Conclusions
The analysis of the process showed that the process is not standardized. Different patients, procedures and times on the day could result in different actions. The different staff members in the ID have to work with this variability, but there is no overview. In the ID everybody makes their own decision based on the information available. There is no clarity on which patients have priority. From the data analysis we conclude that almost 60% of the patients come from the ED, during weekends less scans are performed and five examination types are responsible for more than 75% of the total examinations (N=1448). Analysis of the waiting times shows that request made on the end of the day result in longer waiting time, special procedures have much longer waiting times and transport delay results in the waiting time for ED patients.

Recommendations

Our recommendations are further research into the relationship between capacity and demand with the goal to analyze if a 'walk-in system' for CT could work to lower the waiting times, other interventions are suggested where further research using simulation should explore the effects. To improve decision making ICT should be used, and a central person should be appointed to control the workflow.

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Abbreviations and definitions

General:

NSW	New South Wales
ID	Imaging Department at Campbelltown Hospital
ED	Emergency Department
WP	Wards person (= ward orderly, wards men)
RFI	Request for Imaging
CT	Computed Tomography scan / service
US	Ultrasound scan / service
PowerChart	The booking system of the imaging department

Patients:

EM	from Emergency Department
IN	from the hospital wards (in – patient / admitted patient)
OUT	from outside referral
MRN	Medical Record Number
Transport	How the patient is transported into/out the department (bed, wheelchair or walking)

Times:

Date/time of initial request	Time when the requested scan is entered into the PowerChart system by a medical specialist / certified nurse.
Waiting Time	The time between the initial request and the arrival of the patient in the CT room
Transport delay	Time between the initial request and patient in department
Admin delay	Time between time of request by a medical specialist request and available to booking
In/out department time	Time when patient arrives in/departs from the ID
Date/time request form available to receptionist for booking	Time when receptionist has picked up the request form and processed into the system
Appointment time	Time when a patient is booked
Patient in CT room (time)	Time when patient enters the CT room
Finished CT time	Time when patient leaves the CT room
Start actual CT scan (time)	Time when the actual CT scan starts (after preparations)
Stop actual CT scan (time)	Time when scan is finished
Post processing CT images	Time when the scan image is finished. The finishing of the report follows later

Preface

This project is the graduation project of my bachelor degree in Industrial Engineering & Management of the University of Twente. For 12 weeks I have been part of the research centre CInIS (Centre for Industry and Innovation Studies) of the University of Western Sydney. During this time I have been a research assistant in the Australian Research Counsil (ARC) Linkage project, which focused on the Imaging Department of Campbelltown hospital.

I have stated the following goals:

- To experience working abroad
- To experience working in and around a hospital
- To experience working in a research environment.
- To assist CInIS in their research on Campbelltown hospital

My period in Australia has been one of the best experiences I have ever had. The centre really involved me with their ups and downs. During my work in Campbelltown and on Wednesdays in Parramatta, I was a part of the team. I would like to thank Terry for triggering me to take the next step while doing my analyses.

After work, my friends and also colleges showed me more of the Aussie life. I would like to thank Kathy, Geoffrey, Ryan and Cassandra for making me feel at home at the other side of the world. I have met your families and have seen your houses. Also the weekends to the Hunter Valley and the Blue Mountains I will never forget. After my working period in the centre, my girlfriend came over to discover the east coast of this big island. This was the perfect end of my 'Aussie adventure'.

A special word goes out for Anneke. Besides being my official contact she felt responsible for my Aussie experience. I really enjoyed her company, the time in Adelaide and the Sunday evenings when I was invited for family diner. Sadly, during the writing of this report her husband and my friend, John Fitzgerald passed away. Special thoughts go out for Anneke, Christopher and Kim.

Finally, I would like to thank Erwin, Terry and Kate for the suggestions during the finishing of this report.

Jelle Kooij

Enschede, October 2009

Chapter 1: Introduction

Many Emergency Departments of public hospitals in New South Wales have overcrowding issues that result in long access times (BoozAllenHamilton, 2007). The Campbelltown hospital, situated in the southwest Sydney-area, has the same problems. The Centre for Industry and Innovation Studies (CInIS) from the University of Western Sydney was invited to do research on this problem. After interviews with important stakeholders, these problems have been attributed to the Imaging Department of the hospital.

This chapter is the introduction to this report. In the first section we describe the research environment, from the Australian healthcare system to Campbelltown hospital. In section 1.2 we will give a more detailed overview of the problem situation and in the third and final part of this chapter the research goals and questions are given.

1.1 Description of research environment

A comprehensive understanding of higher level policies and developments is needed to understand the operational and tactical processes in the problem area. In this first section the research environment will be narrowed down from general information about the Australian health care system to a description of Campbelltown hospital and its relevant departments.

1.1.1 Australian health care system

Australia is the largest island in the world and is since 1901 an independent nation. The population of Australia is around 21 million and is concentrated in the big cities. It is one of the world's most urbanized countries, with 88.2% of the population living in urban areas. Most of the population is concentrated along the eastern seaboard and the south-eastern corner of the continent. Australia's population is ageing, with the number of persons aged 65 years or more expected to double by 2051 (WHO, 2009).

The country has a federal system of government, with origins in the British system of government and law. Australia is separated in 6 States and two Territories, each of which have their own responsibilities (Hall, 1999). The Constitution established a Commonwealth (federal) Government, giving its Parliament powers in specified fields. After 1946 the Constitution was amended to enable the Commonwealth to provide health benefits and services, without altering the powers of the States in this regard. Consequently the federal and state levels of government have overlapping responsibilities in this field. The Commonwealth currently has a leadership role in policy making and particularly in national issues like public health, research and national information management. The States and Territories are primarily responsible for the delivery and management of public health services and for maintaining direct relationships with most health care providers, including the regulation of health professionals. There exists a mix of public and private sector providers that deliver health services. (WHO, 2009)

The main focus of the Australian health care system is to provide universal access to needed health care, regardless the ability to pay (Hall, 1999). There are several government programs which underpin this key aspect. Medicare, which is funded out of general tax revenue, pays for hospital and medical services. Medicare covers all Australians, pays the entire cost of treatment in a public hospital, and reimburses patients for visits to doctors (WHO, 2009).

Public hospitals exist to ensure universal access. These hospitals are funded by the states and are, next to the general practitioners, the gateway to treatment though their Emergency Departments. Most acute care beds and emergency outpatient clinics are in public hospitals. Large urban public hospitals provide most of the more complex types of hospital care such as intensive care, major surgery, organ transplants, renal dialysis and specialist outpatient clinics (WHO, 2009). Few private hospitals have emergency departments, so, in an emergency, most Australians rely on the public hospital system.

1.1.2 SSWAHS and the Campbelltown hospital

The Campbelltown Hospital is a major metropolitan hospital with 389 beds and is situated in the southwest of Sydney. (SSWAHS, 2009) The hospital is part of the Sydney South West Area Health Service (SSWAHS) and that area is one of the fastest growing parts of the State of New South Wales. In addition, the SSWAHS area is the most ethnically diversified area of the country, has a large number of recent migrants, significantly higher levels of unemployment and a high proportion of families dependent on welfare. The area has nine of the ten lowest socio-economic communities within metropolitan Sydney (SSWAHS, 2008).

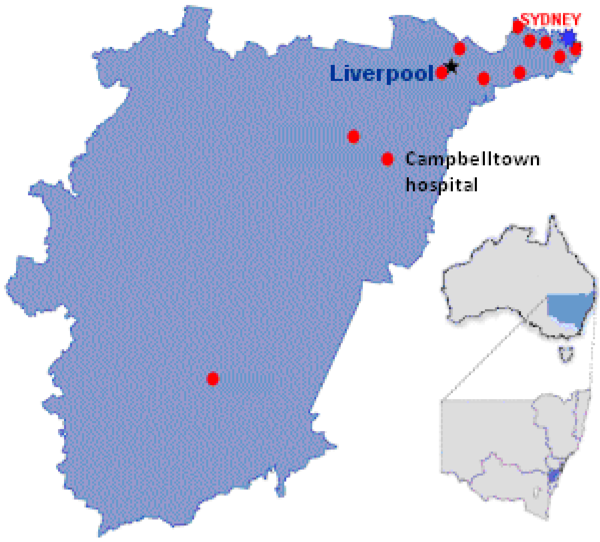


Figure 1: SSWAHS area
(source: http://www.sswahs.nsw.gov.au/)

Serving a densely populated community, the SSWAHS emergency departments collectively have experienced significant increases in demand. From 2006-07 to 2007-08, the SSWAHS witnessed (SSWAHS, 2008); (SSWAHS, 2009):

- An increase of ED presentations from 310,822 in 2006-07 to 327,945 in 2007-08
- An increase of ED admissions of 10 percent over the last two years
- An increase of ED ambulance presentations of 22 percent over the last two years

Despite improved performance within the area health service, such improvement was not always demonstrated within the Campbelltown Hospital ED. For instance, from 2005-06 to 2006-07, the SSWSAH Emergency Admission Performance (EAP) improved from 67 to 76 percent. However, figures from Campbelltown Hospital reveal a decline from 66 to 61 percent – the lowest of all the hospitals within the area (Fitzgerald, Cornelissen, Camcho-Duarte, Dadich, Samaranayke, & Vancikova, 2009).

The EAP is the percentage of patients referred to an inpatient ward within 8 hours. In addition to this, an improvement project at Campbelltown hospital inside the ED showed that only 5% of all emergency patients 'did not wait at all' in the period from July 07 to June 2008 (SSWAHS, 2009). The improvement project is a patient experience-based project (Experience Based Co-Design), which started at the beginning of 2009. Annex A gives information about the services of the hospital and statistics about key performance indicators.

Emergency Department

The Emergency Department of the Campbelltown hospital is large compared with other public hospitals in the area. Attendances at the Campbelltown Hospital Emergency Department have been relatively stable over the last 12 months. Numbers lie between 3.500 to 4.300 attendances per month (SSWAHS, 2009). The Emergency Department operates as a diagnostic unit; which means that after stabilization of the patient (if needed), the patient can only be admitted after a diagnosis is made. This means services provided by the ID to the ED are important for the patient flow in and out of the ED. If patients wait too long inside the ED, new patients cannot come in. In Australia, this is called access block (Fitzgerald, Cornelissen, Camcho-Duarte, Dadich, Samaranayke, & Vancikova, 2009).

Process redesign projects have been trying to improve performance in Emergency Departments. One of the performance targets is the 3-2-1 time target (NSW Health, 2006). This means that:

- A maximum of 3 hours is allocated for the ED to examine a presenting patient, run diagnostic tests, commence initial treatment and determine whether the patient is a likely admission
- 2 hours are available for specialty medical teams to consult with a view to admission and there is
- 1 hour for inpatient wards to be ready to take over the care of the admitted patient and move the patient.

Imaging Department

The Imaging Department (ID) acts as a service department to other departments in the hospital. The Imaging department supports the hospital organization with diagnostic resources. The ID offers three services:

- X-ray
- CT
- US

The most important physical asset of the ID is high value equipment in the department. It consists of 3 X-ray scanners, 3 US devices and one CT scanner. There is no MRI scanner in the hospital. Annex B gives more information about the personnel, treatment rooms and equipment in the ID. The medical specialists in this department are the radiologists who are clinically responsible for the outcomes and the services delivered. Radiographers operate the scanners, nurses support the clinical processes in the ID, wards persons transport the patients and receptionists have administrative tasks. There are also two Imaging Department managers. This used to be the job of one person, but since May 2009 the workload has been divided over 2 people.

YEAR	NO. OF EXAMS	NO. OF PATIENTS	EM EXAMS	EM % EXAMS	EM PATIENTS
2005/2006	38912	32940	18387	47	14645
2006/2007	42596	36827	21918	52	18091
2007/2008	46211	39196	25967	56	21839
2008 Jul to Dec	24392	20677	15269	63	12923

Table 1: Rising demand for ID services
(source: Co-design Medical Imaging Data)

Table 1 shows data about the rising demand for services of the Imaging Department. The difference in the number of examinations between 05/06 and 07/08 is more than 15%. We also see that the percentage of examinations for the Emergency Department is still rising. In other words, the ED is becoming more dependent on the ID. This dependency is caused by redesigning the EM patient protocols. In the previous situation patients were diagnosed after admission, but now diagnosis needs to be before admittance (NSW Health, 2006). The services delivered separated by type of scan are shown in table 2. Under X-ray mobile X-rays are also included. These are used for example in the operating theatres. A range of low volume procedures are combined under ‘Other’. Examples are fluoroscopy and interventional procedures.

YEAR	Xray	CT	US	Other
2005/2006	28961	4472	4023	1456
2006/2007	30641	5942	4263	1750
2007/2008	33591	6528	4352	1740
2008 Jul to Dec	17705	3515	2275	897

Table 2: Services provided
(source: Co-design Medical Imaging Data)

The normal working hours of the ID are on Monday to Friday from 9:00 to 17:00. During afterhours some of the staff members are available for emergency patients. On Wednesday morning special biopsy procedures are scheduled that take more time and require a medical specialist from the Liverpool hospital.

1.2 Problem Description

After describing the research environment we will now describe the problem situation. The ED time targets are not being met and stakeholders experience diagnostic services as a barrier to patient flow. The ID has to deal with several input streams: patients wait at the inpatient wards and the ED, and patients come from outside the hospital for a service from the ID. These different inputs for the ID workflow are not synchronised and unpredictability and vagueness in priority exist.

Previous research (Fitzgerald, Cornelissen, Camcho-Duarte, Dadich, Samaranayke, & Vancikova, 2009) has given insight into the processes from the moment the patient enters the room where his/her scan will be done, but the process before entering the room is not clear at all. So from the moment an ED staff-member enters a ‘request for imaging’ in the system to the moment the patient enters the treatment room will be the scope of this project: the front end process of the imaging department. In figure 1 this system is graphically displayed.

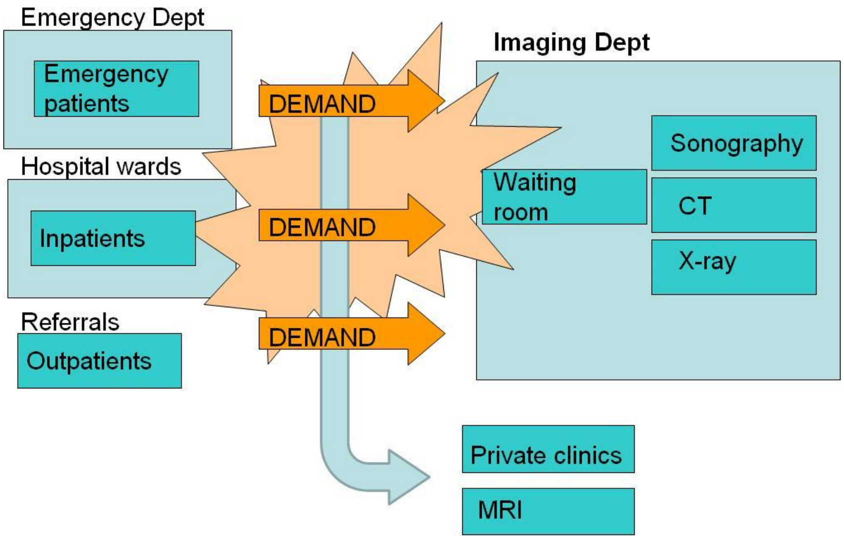


Figure 2: Front end process of the ID

An important variable is 'demand'. To be able to make future capacity and staff plans and describe the performance of the ID, more insight is needed into current demand, the expected demand growth and the outflow of patients that go to other clinics and hospitals for their scans when Campbelltown hospital ID is overloaded.

1.3 Research goals & questions

The goal of the entire research project is to decrease the waiting times in the ED of Campbelltown hospital, in other words: solve the difference between the desired and current situation. However, before this problem can be solved, detailed knowledge about the processes, goals, variables and their inter-dependent relationships is needed. This research is explorative and analyses the current situation.

The goals of this research are to get an overview and understanding of the processes in and around the Imaging Department and identify areas for improvement. While analyzing the front end processes, we will make a distinction between processes, operations and performance. This raises the following sub questions:

1. What happens after a Request for Imaging and how does this event relate to others?

   This process description will be given in section 2.1 and combines interviews and observations.

2. How are the different events managed and by whom?

   In section 2.2 the organization, staff and decision making inside the ID will be described.

3. What are the statistical characteristics of the patients, procedures and days?

4. Which processes have the major influence on the waiting time?

   To deal with questions 3 and 4, in Section 2.3, different sources of data, interviews and observations have been used. Also sources of waiting time will be given using different types of delay.

After the processes, operations and performance have been analyzed, we should have greater insight into important variables and their relations. In chapter 3 recommended interventions and suggestions for implementations are given. In chapter 3 we will answer the following question:

5. What are possible solutions to cope with the growing demand?

In chapter 4 of this report answers will be given to the questions stated above and recommendations for further research proposed. Because of the explorative nature of this research, the directions for future research will be important.

In this report we will primarily focus on the process related to CT scans and not on the other services provided by the ID. The focus on CT is because current research by a colleague is aiming on increasing CT utilization and questions came up about the front end process (De Bruin, 2009). Subjects as CT utilization and capacity will not be analyzed in this report. During the first interviews other problems were identified, that will not be the subject of this report. Examples are the communication problems with other departments and staff levels.

1.4 Methodology

To be able to give insight into the complex organization that is Campbelltown hospital, General Systems Theory has been used. Several decades ago, Ludwig von Bertanlanffy gave biology the concept of the "open" system; 'one whose viability depends on the constant interchange of resources with its environment' (Von Bertalanffy, 1972). Since then, many researchers have been trying to use this theory for describing organizations. One of the most important concepts of the General Systems theory is that a system by definition is composed of interrelated parts or elements. Every system has at least two elements, which are interconnected. (Kast & Rosenzweig, 1972). In this research the hospital organization is the entire system and the focus lies on the subsystem 'imaging department'. Campbelltown hospital is an open system with geographical boundaries.

Part of the complexity of the hospital organization is caused by the existence of different groups of actors, which have different and conflicting objectives, perceptions and attitudes. This produces a need for a combination of quantitative and qualitative methods to handle this project. The combination of methodologies in the study of the same phenomenon is called triangulation (Denzin, 1978). This is a metaphor from basic principles of geometry, which combines multiple viewpoints for greater accuracy. In other words, a combination of interviews, hospital data, data collection, observations, literature and previous reports from CInIS will be used to capture the current situation and validate findings.

The use of different human sources is also expected to contribute to the acceptance of future interventions to improve the current situation. And finally, to be able to capture what is actually going on instead of what should be happening, different groups of workers in the ID should give input and reflection to the project.

Data

CT data collection had already been commenced before the start of this project. The data has been collected by the radiographers and was filled in on paper sheets, which were stored in folders. Information from these datasheets was combined with that from ward orderly books and CT logbooks. The ward orderly book is filled in by the wards persons at the desk in the ID and the CT logs are filled in by the radiographers.

After we obtained 4 weeks of data the first explorative analyses were done. When we had 9 weeks of data we saw that characteristics were not changing significantly. At that point in time we decided to be sure and add another 4 weeks of data. The differences between 9 and 6 weeks were also minimal.

During the data analyses, we encountered some difficulties with missing data. In addition to the missing data there were some errors in the data, mainly sourced to errors caused by the conversion from paper to computer. Some entries were corrected in order to include the cases into the analyses.

In addition to primary data sources described we also used data from the Co-design project. This data was about the hospital's yearly performance and staffing since 2005.

Interviews
In order to get a better understanding of the processes, we conducted semi-structured interviews. Five interviews occurred and were recorded using a laptop computer. The participants were: 2 radiographers, 1 receptionist, the chief radiologist and the emergency department manager.

Observations
To be able to capture unwritten actions of workers in and around the ID, we observed the wards persons. Combining a previous day of observations with our 2 days, we managed to capture actions, behavior and corresponding times. The limitations of observations are that their behavior was influenced by our presence, but there are no other means to really capture and understand what they are doing and how they perform their work.

1.5 Limitations of research

Every research has some limitations. As described in the methodology section, there is some data missing. Converting the data from paper took a lot of time by my colleagues and some columns were not completely filled. In addition, there were varying levels of conscientiousness in the ID staff members responsible for the actual data collection, and different people and clocks were used.

Furthermore, a large part of the analysis of this report with the correct data has been done in the Netherlands. There was no other option to do this earlier because of the availability of digital data. A disadvantage is that special cases and/or question could not be handled. An example is feedback on what happened on days that showed outliers in the number of scans done and waiting time.

Chapter 2: Problem analysis

In chapter 1 the research environment and problem area have been described. In this chapter we will analyze the problem. The entire 'Imaging Department' system can be described as an 'input-transformation-output' model. In a dynamic model situated within its environment, the system receives various inputs, transforms these inputs in some way, and exports outputs (Kast & Rosenzweig, 1972).

This chapter is divided in three sections: in section 2.1 the different processes in and around the ID will be described. In section 2.2 the subject will be decision making and in the third section we will analyze performance. While analyzing the system we will open the 'black box' and improve understanding of underlying process or subsystems.

2.1 Processes

In this section we will start at the moment the medical specialist requests a service from the ID. While modeling the entire process we identify sub processes, which will be explained later in this section.

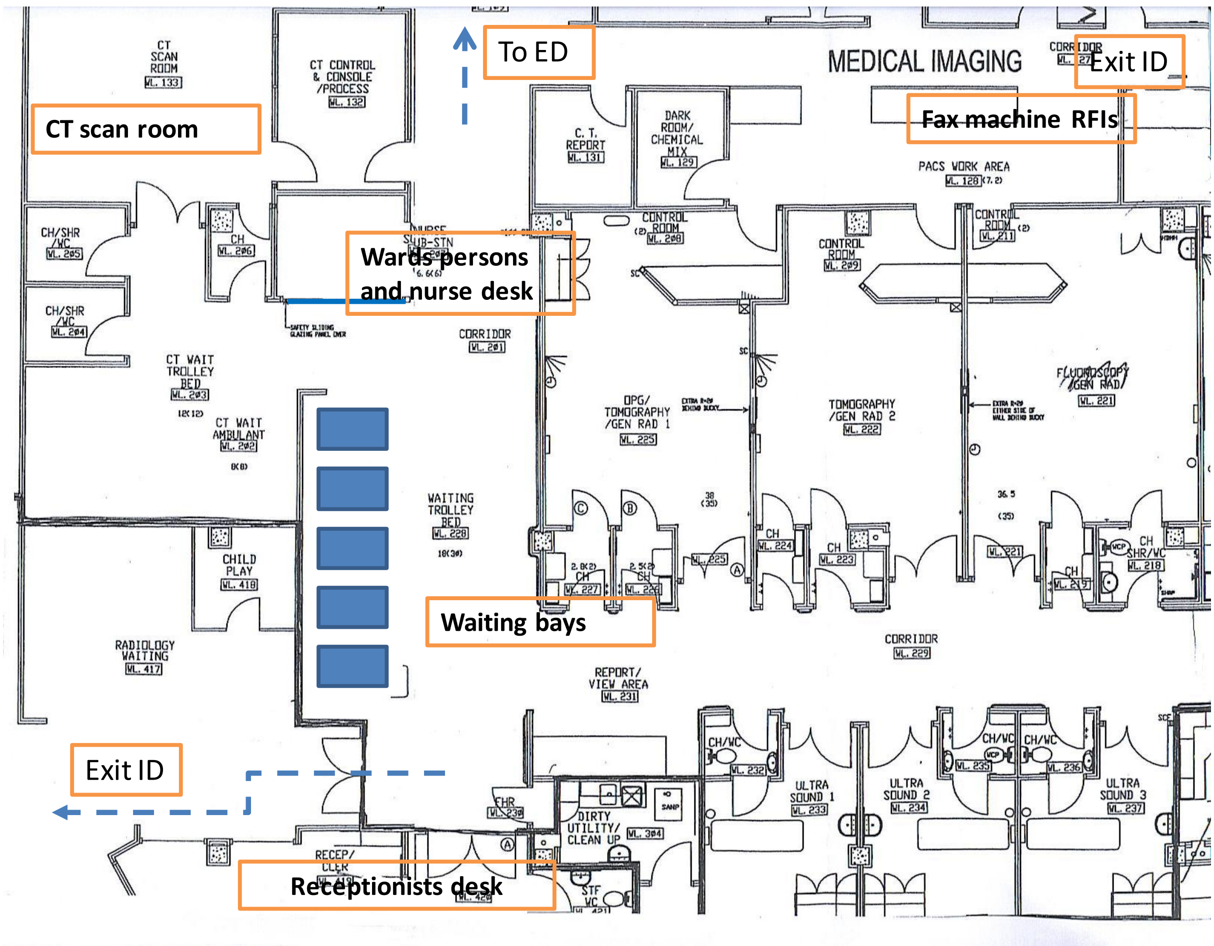


Figure 3: ID floor plan

The ID of the Campbelltown hospital used its resources to deliver requested services for the hospital. The process starts with the patient and his/hers medical specialist, which results in a request for imaging (RFI). The RFI comes from outside the Imaging Department via the intranet application called PowerChart. This results in a piece of paper in the fax machine which is located in a small corridor near the X-ray workstations (figure 3). The faxes have to be picked up by the receptionist and inserted into the ID booking system. After that the radiologist receives the request, assesses the priority and the need for the request. It depends on the priority of the request at what position in the queue the patient will be placed.

However, in certain trauma cases, the paperwork is done later and the patient immediately goes to the preparation phase for ID services if preparation is needed. Otherwise the patients will go to the CT room when it is available. Normal (non-emergency, so IN and OUT) patients are scheduled by the receptionists and receive an appointment time.

The request forms are combined to result in a schedule. This schedule however is not fixed. Because of the uncertainty of ED patients the schedule on any day can change because of clinical prioritization. Using the most current schedule available, the wards persons have to pick up the patient just before their appointment time. The wards person collects the patient and delivers him/her to the waiting room inside the ID.

When the scanner is free the radiographer and the nurses are responsible for getting the patient in the CT room and after some preparations, for example moving the patient from his bed onto the scanner bed, the CT scan can start. Another preparation can be that the patient needs contrast for the specific scan that needs to be done. Contrast can be administered using an IV or by drinking a fluid that contains the contrast.

When the scan is finished the nurses and radiographer put the patient back inside the waiting room and the wards persons are responsible for taking the patient back to his/her ward or the ED. In figure 4 on the next page the entire process is displayed. The blue boxes present patient transport and scheduling and are more complicated processes, which will be described in the following part of this section.

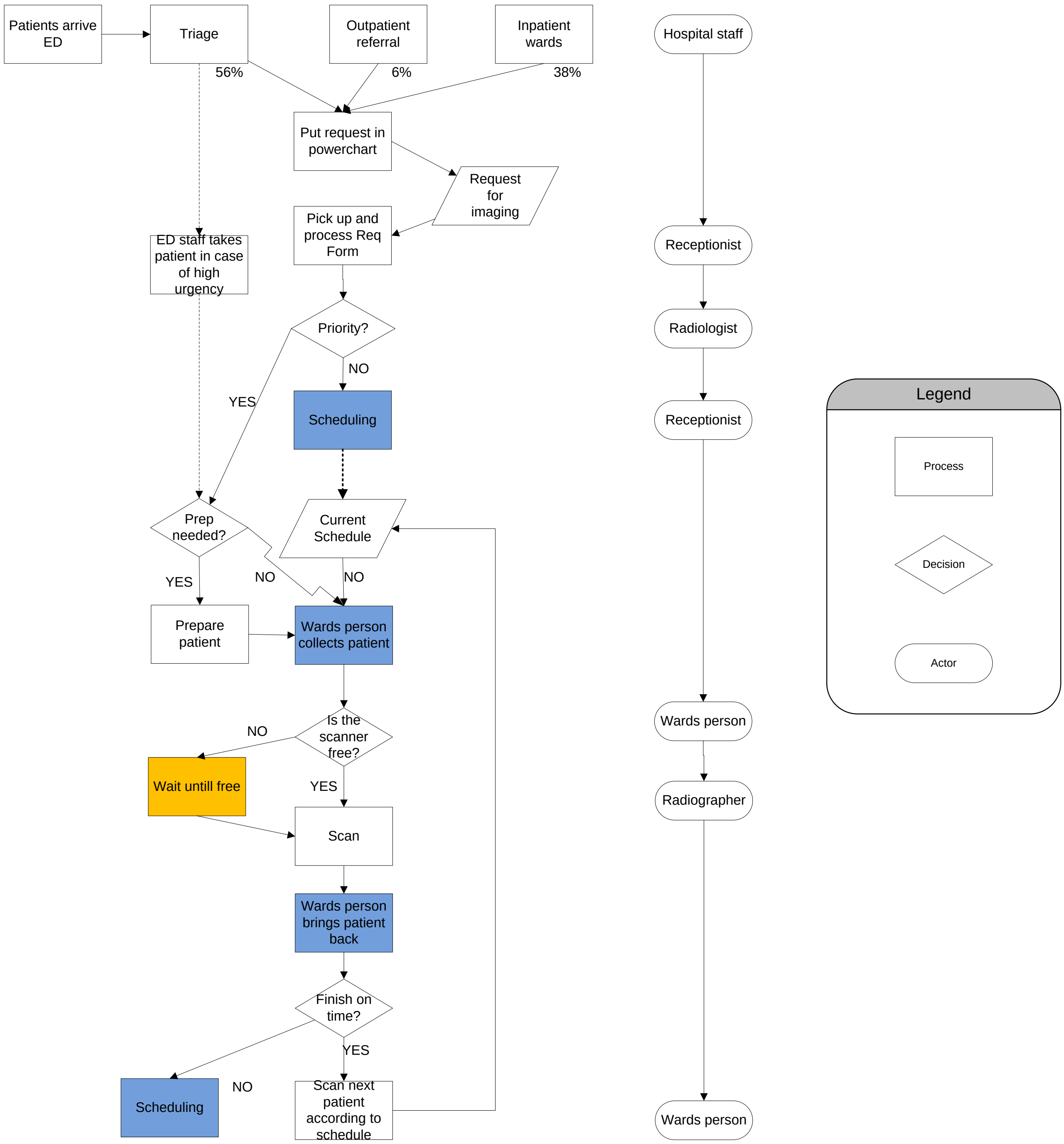


Figure 4: Events in front end process

As shown in figure 3 the scheduling process loops several times; this is because the ID does not operate as a one-way, simple process. Because of prioritization and the arrivals of new (emergency) patients the schedule constantly changes. During the entire process events can cause changes in the initial schedule. The order of the patients keeps on changing until the patient is in the CT room. The grey processes in figure 5 below influence the initial schedule. The initial schedule is the result of the scheduling process from the days before.

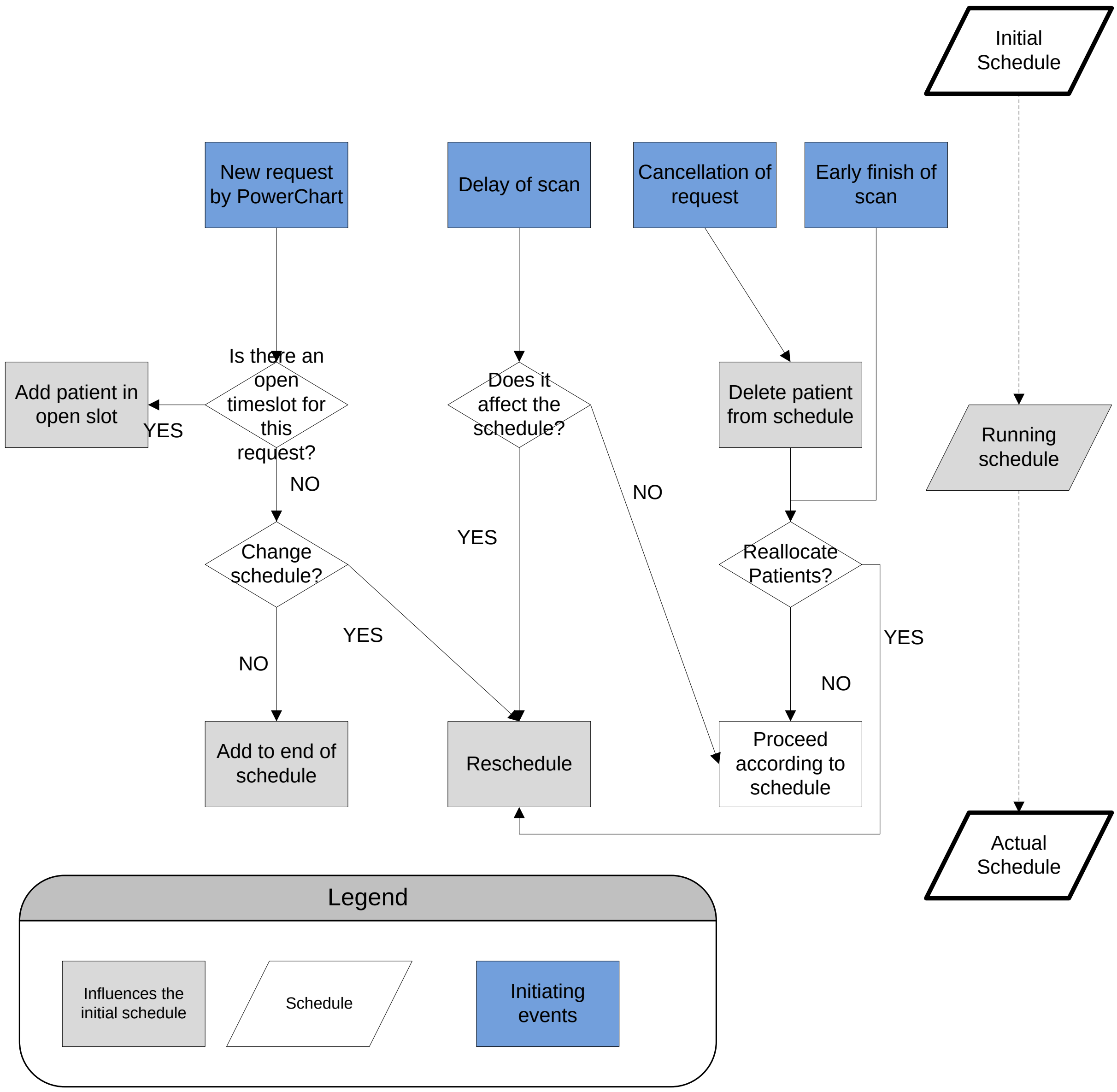


Figure 5: Scheduling process

As shown in the figure, there are 4 events which can initiate the scheduling process:

- A new request by PowerChart,
- A cancellation of a request because of patient reasons (not ready, unable to be transported),
- The delay of a scan
- An early finish of a scan.

These events cause the need for decision making by receptionists and/or radiographers. In case of requests & cancellations, the receptionists have to take action, in case of delay or earliness, radiographers can take action. This action however usually affects more people. In section 2.2 we will explain these impacts in detail.

The next subsystem is the wards persons process (Annex C). The Imaging department of Campbelltown hospital employs 5 people performing the function of a wards person (also called ward orderly). Their main responsibility is making sure that the patients are in the Imaging Department before they have an appointment, in other words, the transportation of patients. The WP does not need medical education and can be male or female. In the table below we can see that the number of WP has been growing since 2006, but there is still a part time vacancy (0,4 FTE).

Campbelltown ID				
Staff	FTE	FTE	FTE	Vacancies
	2006/2007	2007/2008	2008/2009	2008/2009
Wards person	3	4,4	5,4	0,4

Table 3:ID wards persons staff data
(Source: Co-Design Medical Imaging data)

Wards persons have to be in the department 7 days a week; within normal working hours which are 9:00 to 17:00. In addition to those hours, 1 WP is in the ID from 8:00 and 1 (other) WP will be there until 20:00. Only during the night other staff members of the hospital are involved with transporting patients, however this is not their primary task and therefore may result in delays.

The first WP starts at 08:00 to do the preparations for the day. These preparations include:

- Collecting the patient transport slips from the reception of the ID; these slips are A5 paper sheets which contain patient information, their appointment time and type of scan requested.
- Separate the slips
- Check oxygen
- Collect new oxygen if necessary.

At 8:30 and 9:00 the other WP come in and at 9:00 the first appointments are scheduled. The slips have been ordered by time and separated into different categories:

- Urgent: have priority on that day
- US
- CT
- General: is the same as X-ray
- Procedures: these are planned to occur only on Wednesdays

Once the first patients are collected from the wards and the first scans have been done; the WP have to make sure patients are being returned to their wards and the next scheduled patients are on time in the Imaging Department. Patients can be transported on a bed or in a wheelchair. Some patients just walk in (if they are capable of doing that). During the observations however, we did not observe ‘walk in patients’. Before the WP leaves the ID, sometimes a phone call is made to check whether or not the patient is ready to be transported. The administrative staff of the ID (receptionists) are expected to have sent a appointment confirmation to the patient's ward. Once the WP arrives at the ward, the WP picks up the patient's notes and collects the patient. When the patient is ready, a nurse has given permission to take the patient and the patient is prepared for transport, the WP takes the patient back to the ID. In some cases, the nurse needs to accompany the transport. The WP places the patient in a waiting bay when they arrive in the ID (there are 5 waiting bays available plus 2 extra for CT) and writes down the 'Patient in Dept time'.

The next step is determining if a patient needs to be returned to his/her ward. If so, the WP takes one or more new slips representing patients that are close to the ward that the patient needs to be returned to. If not, the WP takes the most urgent slip. In Annex 3 the flowchart of the WP process is displayed.

The process described is what usually happens. When WPs arrive at the wards they usually do not know exactly what the status of the patient is. For example the patient may have just gone for a walk, be in the toilet/shower, have an infection (e.g. MRSA) or have family around him/her because it is visitor's time. Depending on the patient's situation, the WP has to prepare the patient for transport and/or find equipment that is necessary during the transport. Delays occur due to variation in the process. In the section 2.3 the timing of events regarding patient transport will be analysed. In figure 5 on the next page the WP process is graphically displayed.

This section has described different processes of patient movement in the ID system. In this analysis we identified two complex subsystems, the scheduling process and the WP process. In the first process (scheduling, displayed in figure 5), four events are identified that cause the actors to make decisions. The nature of a hospital, with human beings as a product, demands for timely and correct decisions. These decisions will be analyzed in section 2.2. The WP process shows that the WP need to make decisions about which patient they select for transport. This could cause changes in the original schedule. Due to unplanned events, like waiting for the patient in the ward, delay can occur. In section 2.3 we will analyze this so called transport delay.

2.2 Decision making

In the previous section the process has been described and two sub processes have been identified. In the figures decision moments (diamond) have been identified, which have critical influences on patient flow. These decisions are all operational decisions, which are made with limited information and on an ad-hoc basis. During these decision moments all staff groups within the Imaging Department may be involved. In this section we will analyze the decision moments, the results of these decisions and the different objectives held by staff members in the ID.

The first decisions occur outside the ID. Medical specialists use their knowledge to determine diagnostic resources are needed. This may result in an ID service request (RFI). The next decision, the assessment by the radiologist of whether or not the scan is needed, is also a clinical decision. After this moment however, decisions will be made based on primarily logistical issues.

The first operational decision that influences patient flow is when the receptionist places the patient in the schedule. This placement results in an appointment time. This scheduling decision is based on the priority of the patient, the availability of a service time slot in the current schedule and experience of the receptionist herself. The priority is set by the radiologist, but the receptionist has the responsibility of scheduling and communicating the changes. Note that receptionists do not have logistical education. Even more unclear the factors influencing decisions made for patients with a medium priority.

The second possible change in the patient’s queue position occurs by the wards persons. When the schedule is made, the wards persons are responsible for getting the patient in the department on time. As described in the previous section, the WPs have to get the patient in *and* out. So to maximize their number of patient transports they often pick a new patient from the ward where the previous patient was collected from. This sounds efficient, but using this method, the order of patients will change continuously.

The third possible change in patient order can occur when the radiographer and the nurse get the patient from the waiting room to the CT room. Because of the possible changes in the initial schedule, they do not exactly know which patient is available. When there is more than one patient waiting for a CT scan, the radiographer has to pick one. Due to this decision, the radiographer also influences the schedule when a scan is delayed or finished early. In the case of delay, rescheduling could occur based on priority. When a scan is finished early, the radiographer can inform a WP to pick up an extra (in)patient, who was originally scheduled for later in the day.

The above described factors influence the order of patients and thereby influence waiting times of individual patients. Figure 6 illustrates the effect of the uncontrolled and uncoordinated decisions:

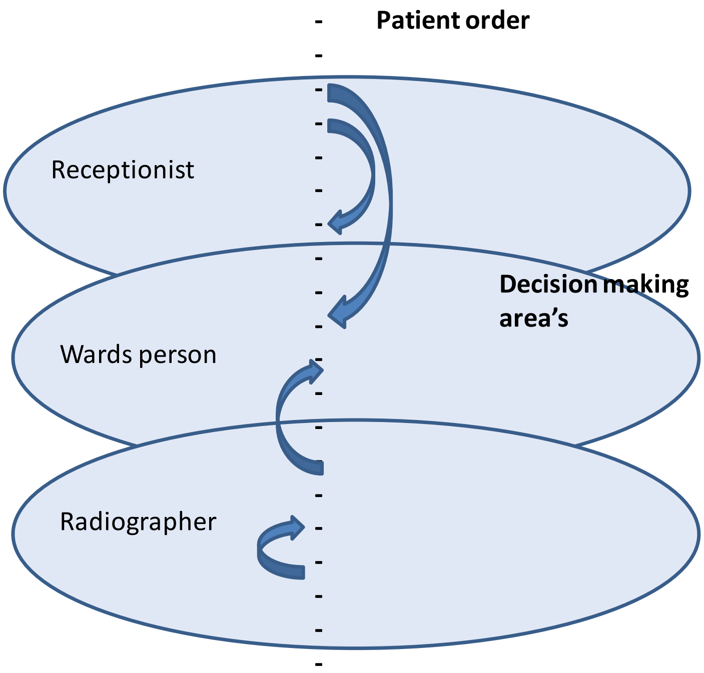


Figure 6: Effect operational decision making

From interviews with the staff members displayed in figure 6 and the chief radiologist, we captured the decision making described above. Everybody in this process is the professional in his/her area and they all say they know how to do their job. But what they do not know is what their colleagues know. There is a lack of coordination and information.

On the higher (tactical) level we identified the underlying cause of the decision making problems. This cause is the conflict between clinical and managerial priorities. The three types of patients relate to different priorities:

- Inpatients: Staff from the wards inside the hospital say their patients have priority because they want to minimize the length of stay and the related costs for the hospital.
- Outpatients: This group of patients has been referred by their GP. In the Australian system this means that their insurance has to pay for their treatment. In other words, outpatients yield revenue and also provide training opportunities for junior radiographers.
- Emergency patients: The emergency patients usually have clinical priority. If these patients do not have priority, the delay causes access block.

In this section decision making problems have been discussed. The lack of formal process control and coordination of information, which should be timely and complete, causes continuous changes in the order of patients. The effects on the overall waiting time are hard to determine. On tactical level the conflict between clinical and managerial priority has a negative effect on how to set priorities.

2.3 Performance

In the previous sections processes and decision making have been analyzed. In systems thinking, inputs will be transformed by the system (processes and decision making) and lead to output. The characteristics and volume of the output can be seen as the performance of the system. We will first give information about the patients and the different procedures in section 2.3.1. Then, in section 2.3.2 we will analyze the waiting times and finally the causes of delay (2.3.3).

2.3.1 General characteristics

The output of the system is the delivered services: images of the scans. These scans are undertaken on three types of patients. In table 4 below the case mix of the patients is given. We can see that the majority of the scans are for the Emergency Department. This means that more than 55% of the patients that undergo a scan are unplanned and usually are urgent.

Data collection 17/3/09 - 15/6/09

PatientType			
	Frequency	Fraction	Cumulative
EM	817	56%	56,42
IN	548	38%	94,27
OUT	83	6%	100,00
Total	1448	100	

Table 4: Case mix patients
(Source: CT data until 15-6-2009, N=1448)

Patients can arrive in the Imaging department by foot, wheelchair or in a bed. The wheelchairs and beds need to be collected by the wards persons. From 637 cases in the collected data, we can see that less than 5% arrived by foot. This implies that the WP process is a critical process for the patient flow in and out of the Imaging Department.

Another output variable is the type of scan. There are 50 different kinds of CT examinations and also combinations of scans occur. Table 5 gives the case mix of the examinations:

Data collection 17/3/09 - 15/6/09				
CT exam				
		Frequency	Percent	Cumulative
XB		592	40,88%	40,88%
XAPC		254	17,54%	58,43%
XSPA		123	8,49%	66,92%
XAP		83	5,73%	72,65%
XNPC		49	3,38%	76,04%
XCAC		40	2,76%	78,80%
XBC		35	2,42%	81,22%
XEX		27	1,86%	83,08%
XCA		24	1,66%	84,74%
XFNA		19	1,31%	86,05%
Other:			13,95%	100,00%

Table 5: Case mix CT examinations
(Source: CT data until 15-6-2009, N=1448)

There are 90 different entries in the list of CT examinations. The examinations or combinations which have occurred less than 16 times (less than 15% of the total) have been combined in 'other' (table 5). The CT examinations which end with a 'C' are examinations were contrast is used. As described in section 2.1, contrast can be administered using IV or by drinking a fluid. The latter, which is called oral contrast, results in an unavoidable (or necessary) waiting time. This is because the fluid has to be processed in the specific organs of the patient. In subsection 2.3.2 of this chapter we analyze the influence of taking oral contrast fluids on the patient waiting time.

As described in section 1.1 the normal ID working hours are from Monday to Friday from 9:00 to 17:00. During weekends scans can be done for ED and inpatients, but there are no planned (out) patients. In figure 7 we can see the 'average number of scans done' by days of the week.

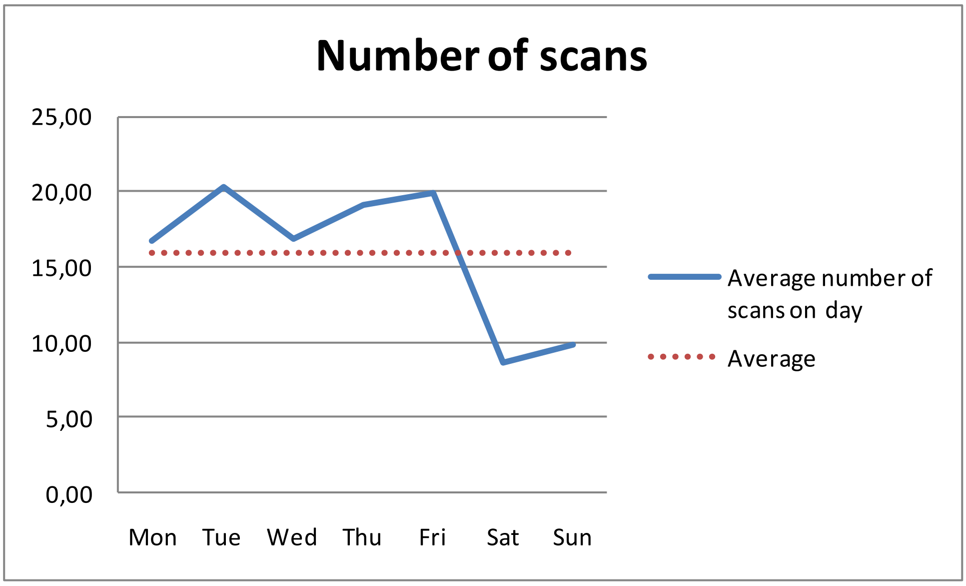


Figure 7: Number of scans
(Source: CT data until 15-6-2009, N=1448)

From figure 7 we can see that there is a difference between the weekend and normal working days. We can also see that the number of scans on Mondays and Wednesdays is lower than the other days of the week. This does not proof that the utilization of the CT room on those days is lower; for example on Wednesdays usually complicated biopsy procedures are scheduled. These usually take more time than standard brain scans (XB).

From the data we can also conclude that almost 84% of the scans are done during normal working days. However, the scans done in afterhours on Friday should be counted as weekend scans (weekend starts on Friday after 17:00). Using SPSS for data analysis, we created table 6 and the box plots in figure 7 to get an idea of the behavior of ID demand.

Number of scans						
Period	Days	Mean	Stand dev	Min	Max	Skewness
Week	65	18,6	6,363	2	31	-0,140
Weekend	26	9,3	5,539	0	24	0,413
Total	91	15,91	7,424	0	31	-0,046

Table 6: Behavior of demand
(Source: CT data until 15-6-2009, N=1448)

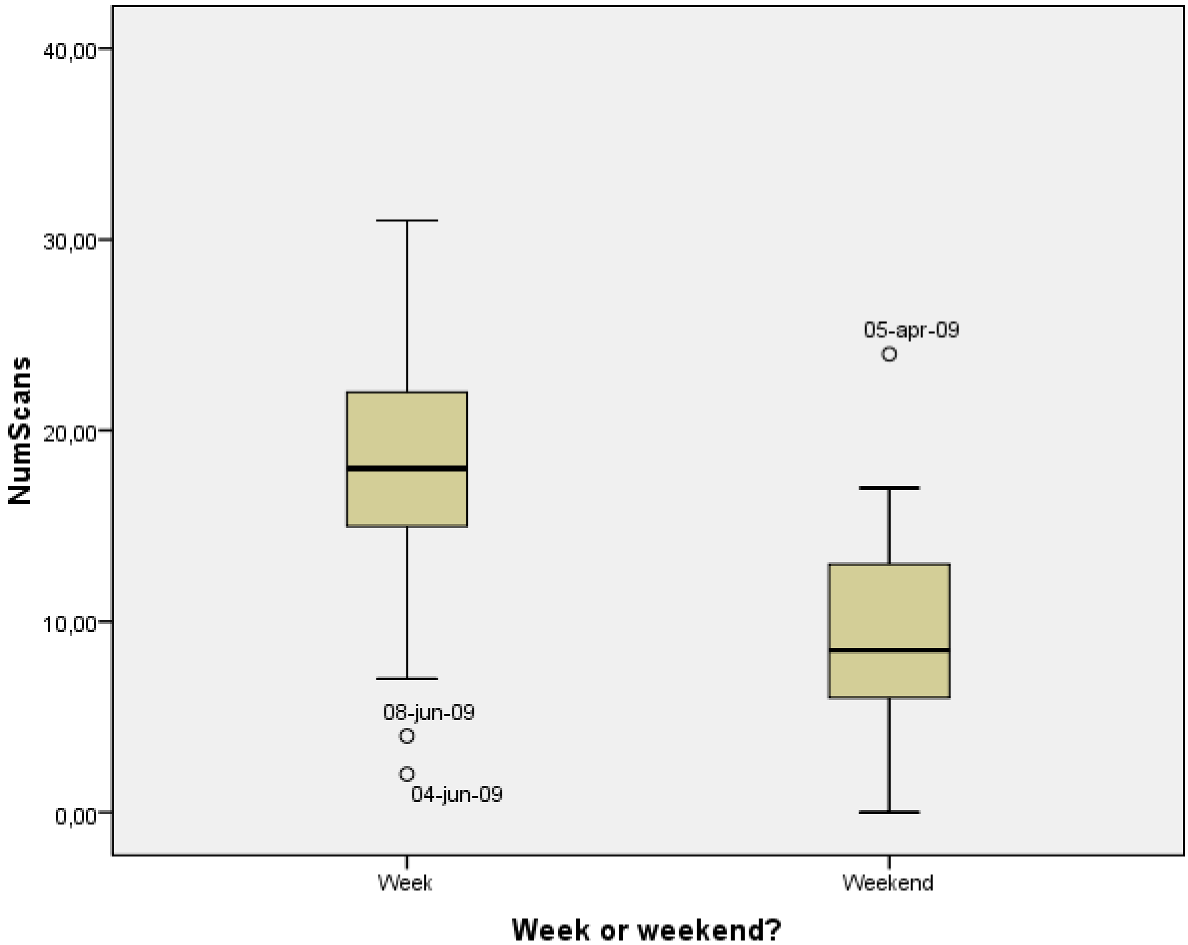


Figure 8: Box plot - behavior of demand
(Source: CT data until 15-6-2009, N=1448)

We can see from figure 7 that there are 3 days (June 4 and 8, April 5 2009) that show too high or low demand (based on the statistical rule: an observation is an outlier when the observation is more than 1,5 times the inter quartile range). Low demand can be a result of a lack of staff due to sickness. There are 2 weekend days where there have been no scans at all. This can be explained by the existence of equipment maintenance days.

In this section of the report general characteristics of patients, CT examinations and the days of the week have been analyzed. Patient information shows us that the ED is the main source of requests for images. The analysis of the CT examinations showed that there are a lot of (combinations) of CT examinations possible, but 10 kinds are responsible for 85% of all scans. The overview of the days of the week gives insight on how many scan were done on the different days of the week. In section 2.3.2 we will further analyze the patient waiting times.

2.3.2 Waiting time

Waiting times are the result of limited resources and have a negative effect on the quality of care, employee satisfaction and patient satisfaction. As set by the NSW Department of Health, the waiting time is defined as:

"The time between the initial request and the moment the patient arrives in the CT room. "

From the 1448 entries in the entire dataset only 910 entries are complete. After calculating the waiting time with the gathered data, we found that negative waiting times exist. The negative waiting times, or earliness, of patients are the result of administrative delay. When urgent patients arrive in the ED, the staff members of both departments handle the paper work later. Of the 910 entries, 18 cases show negative waiting times. These will not be used in calculations, so N becomes 892. In table 7 waiting time characteristics are shown.

	Descriptive statistics						
	N	Min	Max	Mean	Std Dev	Skewness	Kurtosis
Waiting time	892	0:00 hr	314:05 hr	15:20 hr	30:27 hr	4,266	26,563

Table 7: Waiting time data
(Source: CT data until 15-6-2009)

From table 7 we conclude that there are 556 cases incomplete from the total of 1448 cases. This is higher than preferred, but we need 4 column entries in the data sheet before we can calculate the waiting time. Outpatients have a very high percentage of missing values. Going back to the initial data set, mostly the entries missing are the day and time of request.

	Descriptive statistics										
	Freq		%		Mean	Median	Stan dev	Max	Min	Skewness	Kurtosis
Waiting times	Valid	Missing*	Valid	Missing*							
EM	502	315	34,67%	21,75%	3:05	1:18	9:08	124:05	0:00	9,53	108,39
IN	383	165	26,45%	11,40%	28:57	21:02	33:33	213:49	0:14	2,26	6,18
OUT	7	76	0,48%	5,25%	150:11	106:30	116:15	314:05	17:50	0,764	-1,053
Total	1448		100,00%								

*Where the combination of time of req and waiting time is missing

Table 8: Waiting times per patient type
(Source: CT data until 15-6-2009)

Table 8 gives insight in the distribution per patient type (EM, IN, OUT). We can derive that the Emergency patients have the shortest range and average waiting time (3:05hrs). However, the median value, which is less affected by outliers, is 1:18hrs. Outpatients have a very wide range, which could be influenced by the limited number of cases available. The mean waiting time of outpatients is 150:11hrs (6 days, 6 hours and 11 minutes). Another aspect of the data is the high number of outliers. Using SPSS, we identified the outliers with their CT examinations. A preliminary explanation could be that the outliers are the more complicated procedures; for example the procedures that need contrast or specific knowledge or skills from medical specialists.

To analyze if a relationship exists between the type of examinations and the waiting time, we grouped all the examinations that occurred less than 19 times (see table 5) and then analyzed the ten most frequently occurring procedures. The CT exam XFNA (fine needle aspiration) has by far the longest waiting time (mean: 159:03hrs, median: 141:54hrs). The shortest XFNA waiting time is more than 23 hours. The reason for these long waiting times is that this procedure needs a special medical specialist, only available in Campbelltown hospital on Wednesday morning. While comparing the XFNA we see that no EM patients have had this procedure. This means that these examinations did not have high priority. The exam with the highest frequency, the normal brain scan without contrast (XB), shows a median of 1:23hrs. In figure 10 the graph showing the waiting times per CT exam is displayed.

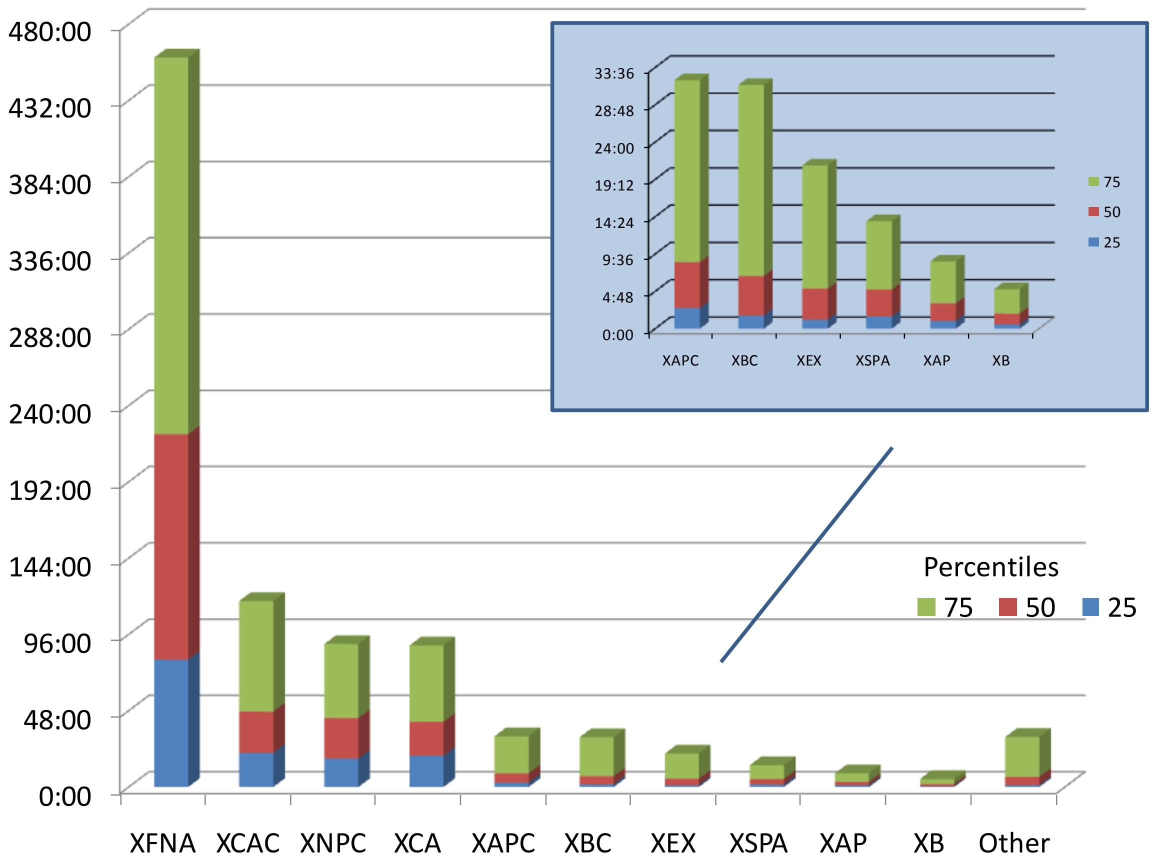


Figure 9: Waiting times - most occurring examinations
(Source: CT data until 15-6-2009, N=892)

Examining the differences between the examinations that need or not need oral contrast reveals that the mean waiting time without oral contrast (13:00hrs) is much lower than the waiting times for examinations that need oral contrast (22:22hrs). This is an expected result. Annex D contains other descriptive statistics about contrast examinations.

Another possible influence on waiting times is the time of the day the request is made. To analyze these influences we have made 2 different time categories. The first one is a division between normal working hours and after hours. The other division is made per hour; for example the statistics of waiting times between 09:00 and 10:00. When we divide the waiting times for the requests in normal working hours and after hours, we see that requests in normal working hours result in longer waiting times. The longest waiting times in the normal working hours are all IN or OUT patients. The after hours waiting times have a median of 1:36, which is not that high. In table 9 the statistics are displayed.

Descriptive statistics											
	Freq		%		Mean	Median	Stan dev	Max	Min	Skewness	Kurtosis
Waiting times	Valid	Missing**	Valid	Missing*							
After	294	134	20,30%	9,25%	8:50	1:36	19:35	134:47	0:06	3,922	17,064
In	594	114	41,02%	7,87%	18:19	3:17	34:00	314:05	0:00	4,039	23,281
-		312		21,55%							
Total	1448		100,00%								

*Where the combination of time of req and waiting time is missing

Table 9: Waiting times per In/After hours
(Source: CT data until 15-6-2009)

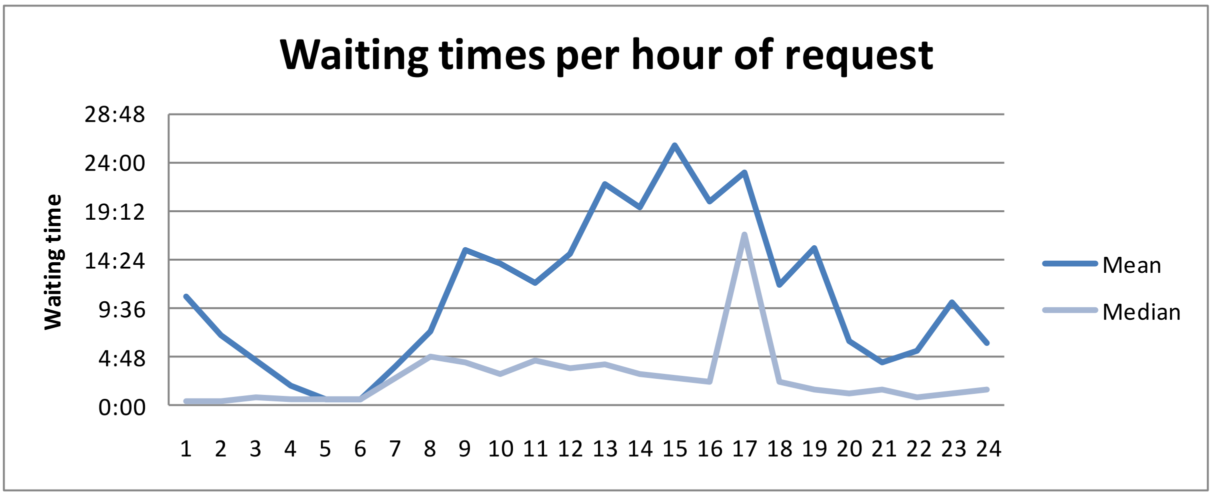


Figure 10: Waiting time per hour of request
(Source: CT data until 15-6-2009, N=892)

In figure 10 the means and medians of the hour of request are displayed. From the median line we see that before 7:00 in the morning and after 18:00, waiting times are relatively low. Another characteristic is that at the end of the standard working day the waiting times are higher. In Annex E other statistics are displayed regarding the hour of request and waiting times.

In this section waiting times have been analyzed. Combining different variables of the process gives us insight into the length and the behavior of the waiting times. This insight shows that average waiting times are more than 15 hours. When we divide all the cases in the three different patient types, average waiting times for emergency patients are shorter (mean: 3:05, median: 1:18). We have also seen that one examination (XFNA) has much longer waiting times than other examinations.

2.3.3 Causes of delay

In section 2.3.2 the definition of the waiting time was given. The total waiting time however can be divided into smaller parts. As showed in figure 12, the total waiting time contains the time stamp points: 'Time scan requested', 'In department time' and 'In CT room'. The time between 'In dept time' and 'In CT room' is the time the patient is in the waiting room of the department (usually in a bed). The time period between 'Time scan requested' and 'In department time' can be further divided in the following categories: Admin delay, Scheduled waiting time and Transport delay.

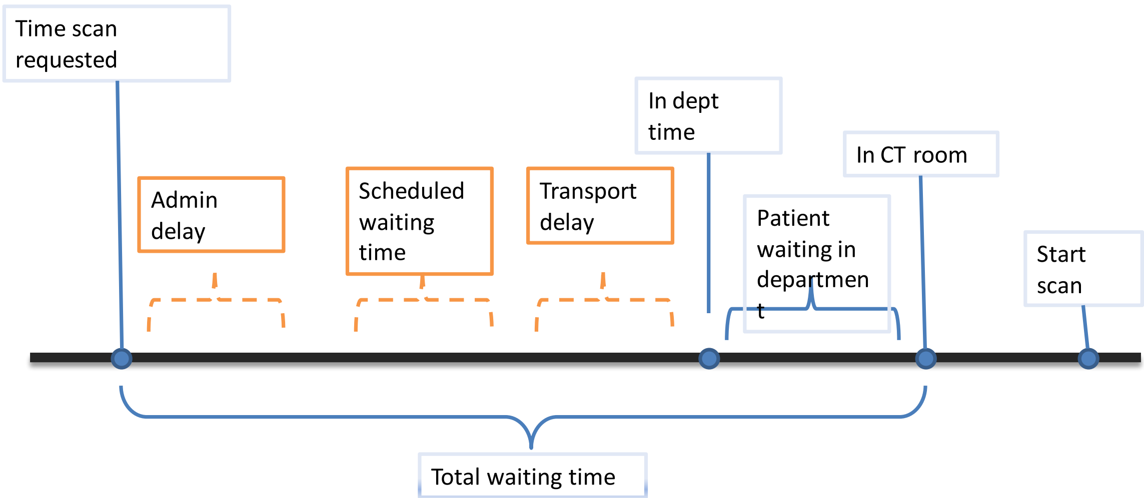


Figure 11: Total waiting time explored

Administrative (admin) delay is the time which is wasted between the time of initial request and the time the request is available to the ID and entered into the ID booking system. The next period is the time the patient has to wait before his/hers appointment. This time is the result of scheduling policy, the priority of the request and the CT workload at that moment. When the appointment time of the patient comes close; wards persons have to get the patient and transport him/her to the ID. The time the patient is late because of waiting for transport is called the transport delay.

The next step is to identify the extent of these delays. Admin delay is hard to measure, because of the possibility of getting the patient into the CT room before handling the paper work. When we analyze the data we sometimes see a higher admin delay than the actual waiting time. The transport delay can be calculated comparing the appointment times and the 'In department time'. In the case of emergency patients, the appointment time is 'asap' or 'now'. This means analysis per ED case to capture what percentage the admin and transport delay is of the total waiting time is not possible with this data set. In addition, the differences in time between the appointment time and the 'in department time' are positive and negative; revealing earliness and lateness. Tables 10 and 11 contain the statistics of the transport and admin delay.

	Transport Delay				
Lateness					
	Mean	Median	Stan dev	Kurtosis	Skewness
	0:20	0:10	0:32	32,21626	4,58909
Earlieness					
	Mean	Median	Stan dev	Kurtosis	Skewness
	1:33	0:20	3:33	16,98614	-3,9948

Table 10: Transport delay
(Source: CT data until 15-6-2009, N=195, M=139)

Admin Delay (hh:mm)				
Mean	Median	Stan dev	Kurtosis	Skewness
3:09	0:28	7:30	26,92197	4,430591

Min			Max		
1	2	3	1	2	3
0:00	0:00	0:00	66:04	48:43	44:06

Table 11: Admin delay
(Source: CT data until 15-6-2009, N=257)

Table 11 shows statistics on admin delay. The actual number of cases (N=283) is lowered by 26 cases because these were negative delays. This proves the fact that some patients come in before handling the paper work.

Following the previous analysis and in order to get a better understanding of the transport times we have performed observation and further data analysis. In the data analysis we separated the actual times from the cases that show 'now' and 'ASAP'. Here we made the assumption that the cases with 'now' and 'ASAP' are EM patients. Comparing the appointment times with the 'in department times' (N=325) shows 44% of the patient are late. Annex F contains graphical presentations of the earliness and lateness. The average is less than 7 minutes *early*. This means that the wards persons are usually on time with patients that are planned. The patients with priority need a scan as soon as possible. So their waiting for transport time is the time between the request and the 'in department time' (N= 95). Calculating the transport delay we find that the average waiting for transport time is 1:24 hours (median = 0:57 hrs). Compared with the transport delay for planned patients (0:06 early) this is much longer. This longer waiting time can be caused by non-availability of the CT room. When we compare the statistics from the EM patients (table 8) with the 'waiting on transport time' we see that the medians only differ by 21 minutes. In Annex F a graphical presentation of the 'waiting on transport time' from the ED is given.

During the observations, we have viewed 13 patient transportations and 4 wards persons. These transportations all happened in 4 hours and there were 6 cancelations. These were caused by for example: the patient is already dismissed from the hospital or the patient has gone to another hospital. During observations we noted every action of the WPs and categorized their actions in 4 categories: travelling time, waiting at the wards, work time at the wards and work time in the ID. We have not used waiting time in the ID because the grey area of waiting and working is difficult to divide.

Total	h:mm	%
Waiting time at wards	1:23	35%
Work time in ID	1:19	33%
Work time at wards	0:46	19%
Travelling time	0:32	13%
Total time	4:00	100%

Table 12: Wards persons data
(Source: WP Observations)

From table 10 we can see that only 33% of their time is transport time. To maximize the throughput of the ID, the number of transported patients should also be as high as possible so there are always patients waiting. Our calculations show that the average transporting time per patient is 0:06 (h:mm). However, in several transports there was no patient involved (travelling time ≠ transporting time). While walking with the WPs, they were constantly complaining about the elevators; to get to several wards they need to take 2 elevators. The transport to the ID takes the only 2 minutes because it is located next to the ED. The waiting time at the wards is the only idle time identified. 13% of the time the WPs are available, they are waiting for the patient to get ready to be transported. The total number of trips from or to the ID is 21, which results in an average time per run of 3:46 (m:ss). In these 21 trips, only 2 trips to the ED are undertaken and no outpatients have been collected.

In this section we have analyzed the causes of delay. Based on the data we can conclude that for planned patients, the admin and transport delays do not have much influence on the total waiting time. Our calculation showed however, that the EM patients waiting time is mainly caused by the 'waiting on transport time'.

The problem analysis forms the basis for this report. In section 2.1 the process has been described. Interviews and observations showed us that there exists variation in the process. In addition to that, two sub processes have been identified. Section 2.2 described the decision making problems. Different decisions are taken by different staff members. There is no overview and decisions are made on information available. In section 2.3 the performance of the department is analyzed using the data and observations. The mean waiting time is more than 15 hours. After that, we differentiated on patient type, type of CT examination, in or after hours and the hour of request. In section 2.3.3 causes of delay have been analyzed.

Chapter 3: Recommended interventions

In this chapter we will use our findings from the previous chapters to propose interventions and directions for further research. The interventions are partly the result of group discussions from progress meetings of the Campbelltown hospital project team. The goal in this report is to explore the front end processes and identify problems, which means that interventions are not the primary goal. The structure of this chapter follows that of chapter 2; the interventions will be divided into process and decision making. Improvements in both sectors aim to improve performance.

3.1 Process interventions

Data analysis showed that there is day to day variation in demand. The variance in the ID process can be divided into arrival and flow time variability, which both have a negative effect on utilization. (Baker, Phibbs, Guarino, Supina, & Reynolds, 2004) (Elkhuizen, Sambeek, Hans, Krabbendam, & Bakker, 2007). As well as the utilization, demand variation can also have a negative impact on the working conditions for the staff and the clinical outcomes (Villa, Barbieri, & Lega, 2009). To deal with this variation, different kinds of buffers can be used. Hopp and Spearman stated the following rule (Hopp & Spearman, 2001):

Buffering Law: *Systems with variability must be buffered by some combination of:*

1. Inventory

2. Capacity

3. Time.

This means that if you do not do something to reduce variability, you will pay in terms of high Work In Progress (WIP, many patients in the process), under-utilized capacity and/or reduced customer service (long lead times and long waiting times). In the case of a CT scan, inventory as a buffer cannot be used. You cannot store CT scans; every patient needs his/her time for one unique scan. The second option is the use of capacity. At this moment there is one CT scanner and to buy another one is a large investment and a big step in increasing the capacity. Further research needs to be done to compare the utilization of the CT scanner to determine when and if a new investment is needed. In other words; the only useable option is to use time to buffer the variability. At this moment this results in high waiting times. From observations and data analysis we can conclude that the planning and scheduling is an unclear process, that results in long waiting times for patients. A possible option to reduce delay is to create a walk-in system. This means that patients go into the waiting room without having an appointment. More information can be found in the MSc graduation thesis of J. Kranenburg (Kranenburg, 2009). The current planning & scheduling processes will be canceled with an expected positive effect on the utilization of expensive equipment. A very important factor of a walk-in system is that the capacity should be enough to meet the demand. As stated before, data analysis should be done to predict scanning times to determine if capacity is sufficient to meet demand.

Another possible intervention is to change to working times and the number of staff available on the different parts of the day, for example the 'end of the day requests' result in high waiting times. If normal working hours were until 19:00 instead of 17:00, the day capacity is increased by 25%.

Further research should gain insight in optimizing working rosters. Interviews pointed out that staff occupation is minimal; even if one staff member is sick, there are immediate problems.

This research started with the aim to decrease ED waiting times. From our data analysis we saw that the transport times have a big influence on the total waiting time of ED patients. Possible options to decrease this transport time are to increase the number of wards persons and/or assign one WP to only transport ED patients. Additional training for the ED wards person could take away the restriction that in some cases the transport needs to be accompanied by a nurse.

Admin delay can be minimized by digitalizing the PowerChart system. In the current situation receptionists have to walk to the other side of the department to pick up the request forms. This happens 'at random', because the receptionists do not know when new requests come in. When using a system for bookings, the medical specialists may even have the option to book patients themselves. This could have the benefit that they know in advance how long the waiting time is. This new options would change the role and function of the radiologist. The function of the radiologist would become more clerical when they would still make the priority decisions and they will probably experience a loss in autonomy.

From the data analysis we also saw that CT procedures requiring a medical specialist (the fine needle aspiration XFNA and fine needle biopsy XFNL) have a longer waiting time. Possible interventions are to set up another time in the week (next to the Wednesday morning) to do this kind of procedures, train own medical specialists to do these kinds of procedure or make arrangements with other hospitals that these procedures can occurs in another hospital. This decision should be made at a strategic level and could result in only basic CT examinations being undertaken at Campbelltown hospital. The interview with the chief radiologist from the ID pointed out that the goals of Campbelltown hospital are to provide broad and specialized care, however the budget suffices for basic care only. Another argument from the interview is that he also wanted a MRI scanner. As an example he gave that on the previous day 9 of the 26 scans done would have been better performed by MRI, if available. Further research could consider the investment in a MRI scanner and the effects on the demand for CT scans.

The possible interventions mentioned all have in common that they aim to maximize the utilization of expensive technology. Future research could use proven methods, like lean thinking, to reduce waste in the process (time, money) and make sure the supporting processes are optimal coordinated.

3.2 Decision making interventions

The current process is on paper straightforward, but in practice there are some grey areas. The conflict in decision making described in section 2.2 should be solved and communicated to all stakeholders. When all the staff members know which patients have priority, department goals can be satisfied.

The two sub-processes described in section 2.1 (scheduling and transporting) provide insufficient information to stakeholders. The result can be that decisions made, by for example a wards person based on his/her available information, will be ineffective and inefficient because of other decisions by a radiographer or receptionist. We think that if operational decisions could be more controlled by one central person in the department, then the entire process will become more effective. In current staff roles however, there is no central function. The new function should be something similar to a traffic controller. In addition to this new function, the information should be more complete and timely. A way to do this is to implement an information system (Villa, Barbieri, & Lega, 2009). The precise functions and methods of this information system should be subjects for further research. A starting point for this system is the information system used in the Emergency Department. This system links the patient's information, with their location and the requested services from other departments (laboratory and Imaging Department).

This chapter has given some suggestions for recommended interventions. Most interventions should be further explored through computer simulation. Others can be a real-life experiment in the hospital.

Chapter 4: Conclusions & Recommendations

In this chapter we will give answers to our research questions and provide recommendations for improvement. These recommendations will not focus on changing the current situation, but on starting formal research to improve and come to a desired situation. The goals of this report were to get an overview and understanding of the processes in and around the Imaging Department and identify areas for improvement. Qualitative and quantitative research has been done to answer our research questions and attain the research goal.

4.1 Conclusions

RQ1: What happens after a Request for Imaging and how do these events relate to each other?

The first research question concerned the entire front end process of the ID. We used interviews and observations to describe the process and make the process flowchart in figure 3. Two sub-processes have been defined: the scheduling process and the transport process by the wards persons. The different stakeholders have all participated in validating the described process and we reached the conclusion that the entire process is not optimal.

RQ2: How are the different events managed and by whom?

The second question was about decision making in the ID. The different events are self controlled by ID staff actors. There is no central person who has an overview, which leads to unclear decision making and possible negative effects on waiting time. On a tactical level, it is not clear if clinical or logistical/managerial issues have priority.

RQ3: What are the characteristics of the patients, procedures and days?

After analyzing the process and decision making we analyzed the performance of the system. General characteristics of the patients, procedures and days have been described in section 2.3. We found that almost 60% of the patients scanned are EM patients. The busiest days in the ID are Tuesday and Friday and in weekends significantly less scans are done. The most performed CT examination is a brain scan without contrast (40,88% of all examinations).

RQ4: Which processes have major influence on the waiting time?

After the general characteristics, extensive data analysis has been done to analyze the waiting times. At first, we found that mean waiting time is more than 15 hours, but after dividing all the cases in categories, more detailed information was found. Outpatients have the longest waiting times (mean and median) and the EM patients have a median of 1:18 (h:mm). The mean waiting times are greatly influenced by special cases and procedures. The XFNA procedure only occurs on Wednesdays, because of the medical specialty needed. We can also conclude that requests made at the end of the day result in longer waiting times. In section 2.3.3 we identified causes of delay and found that for EM patients, the 'waiting for transport' times are long compared to the total waiting time.

RQ5: What are possible solutions to cope with the growing demand?

Chapter 3 gave recommended interventions to cope with the growing demand. Process and decision making interventions are suggested as directions for further research. Most of the recommended interventions should be used during simulation to analyze the expected effects.

4.2 Recommendations

This last section of this report summarizes our recommendations and directions for further research.

The extensive data analysis from chapter 2 gave us (some) insight into the factors that require further research. The recommended process intervention that was described as a walk-in system for CT (or all diagnostic services provided by the ID) could improve the situation. Current research in the AMC by the University of Twente can be compared with the situation in the Campbelltown hospital. Also other recommended interventions such as the increase of ID working hours and changing the situation of the WPs, could possibly improve the situation. These interventions should be simulated using the PlantSimulation ©(Siemens, Tecknomatix) software. This could improve the adoption by the hospital staff and gives the option to try different scenarios and compare their performance indicators.

The next recommendation concerns decision making in the ID (described in section 2.2). Discussions with higher management should be undertaken to decide on the priorities of the different patient groups. On operational level one central person should be managing the other staff members and the patient flow. Also ICT solutions can be used to improve the accuracy, availability and timeliness of information. ICT improvements are a direction for further research. At this moment it is unknown what the functions, characteristics and restrictions of an information system in the Imaging Department should be.

Further research needs to be done to compare the demand with capacity of the ID and relate these variables to the utilization of the CT scanner. This research is needed before the 'walk-in system' intervention can be analyzed. This research could also motivate analysis of the results of buying another CT scanner or a new MRI scanner.

Other directions for further research that are outside the scope of this report are the communication problems in the ID and between the ID and other departments. Interviews with staff members pointed out that staff from ID interpret the definition of 'urgent' differently than the ED staff. This definition of urgency can be further analyzed using the work of Brislin and Kim, that is focusing on different understanding and uses of time (Brislin & Kim, 2003). From observations we saw that time is lost when the wards persons wait for the patient in the ward, and when the staff in the wards were not informed to prepare the patient earlier.

Annex A: Campbelltown hospital information

Hospital name:	**Campbelltown Hospital**
Total bed Days	98,133
Average length of stay (acute)	4.3
Daily average of inpatients	269
Occupancy rate	94.1%
Acute bed days	107,509
Non-admitted patient services	299,358
ED attendances	44,275
Source: Selected activity chart by facility; provided by NSW HEALTH	

The Campbelltown hospital operates together with the Camden hospital and the Queen Victoria Memorial home, which is an aged care facility. The Campbelltown and Camden hospitals offer:

Aged Care and Rehabilitation	Allied Health	Ambulatory Care
Cancer Therapy	Cardiology	Day Surgery Unit
Emergency Care	Intensive Care	Maternity Services
Medicine	Medical Transit Unit	Outpatient Clinic
Pediatrics	Pediatric Ambulatory Care	Palliative Care
Pharmacy	Radiology	Respiratory
Special Care Nursery	Stroke	Surgery (2 wards)
Clinical Library		
Mental Health Service		
Macarthur Ambulatory Care Service		
Macarthur Clinical School		

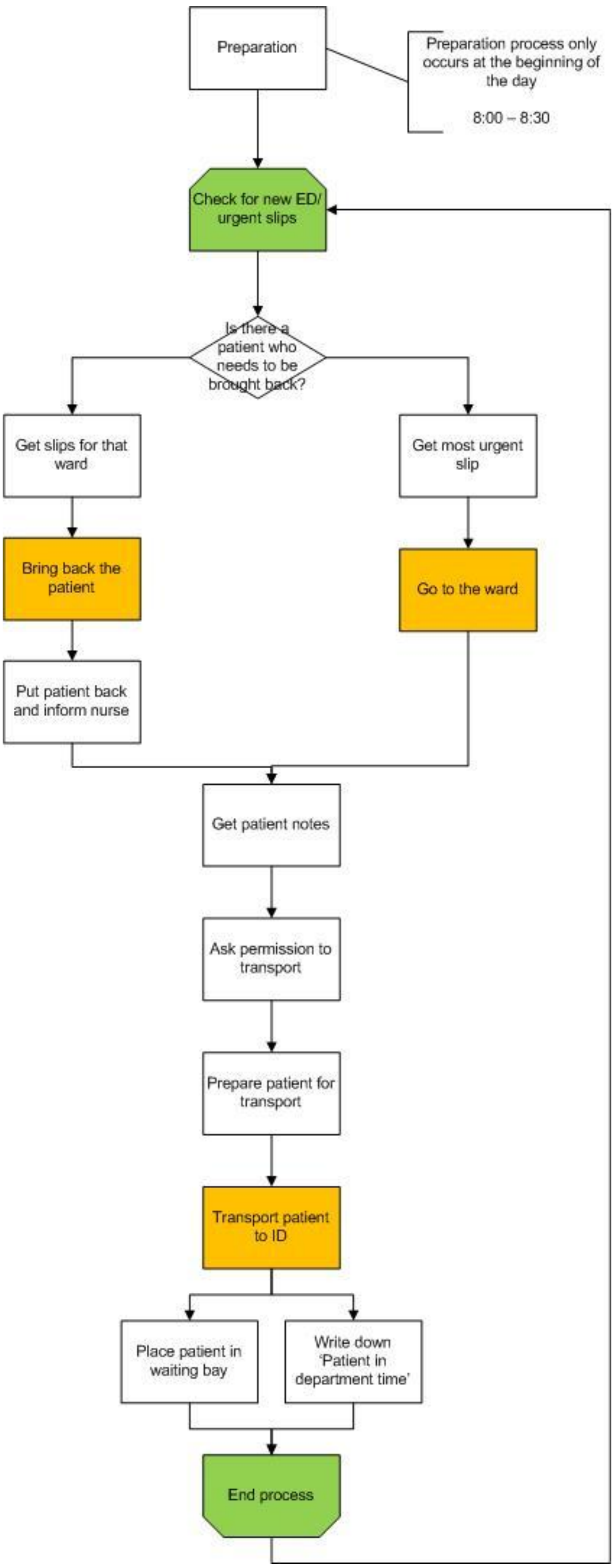
http://www.sswahs.nsw.gov.au/CCQ (viewed on 25-5-2009)

Annex B: Imaging Department resources

CAMPBELLTOWN/CAMDEN					
STAFF	**FTE**	**FTE**	**FTE**	**VACANCIES**	**SICK LEAVE**
	2006/2007	**2007/2008**	**2008/2009**	**2008/2009**	**2008**
RADIOLOGIST	3,1	3,1	3,7	**1**	64
REGISTRAR	1	1	1	**0**	
NURSE	2,2	4	4	**1,4**	128
RADIOGRAPHERS	19,8	21,8	21,8	**2 plus 1 wc**	1489
WARDSPERSON	3	4,4	5,4	**0,4**	425
ADMIN	4,9	4,9	4,9	**0**	
TOTAL	**34**	**39,29**	**40,2**		**2106 hrs**
	Note: admin staff under another cost centre from 2007				
	NUMBERS				
WAITING ROOM		13 seats			
BED WAITNG	5 Bays	5 seats			
CT BED WAITING	2 Bays				
GENERAL ROOMS	3				
FLUOROSCOPY ROOM	1				
CT	1				
US ROOM	3				
MOBILE UNIT	2				
IMAGE INTENSIFIER UNIT	2				

Source: Co-Design medical imaging data. Received from ID manager.

Annex C: Wards persons process



Annex D: Statistics on waiting time vs oral contrast

Descriptives

	Exams that used oral contrast			Statistic	Std. Error
WaitingTime	0	Mean		13:00: uur	01:10: uur
		95% Confidence Interval for Mean	Lower Bound	10:41: uur	
			Upper Bound	15:19: uur	
		5% Trimmed Mean		07:45: uur	
		Median		02:07: uur	
		Variance		1,200E10	
		Std. Deviation		06:25: uur	
		Minimum		00:00: uur	
		Maximum		02:05: uur	
		Range		02:05: uur	
		Interquartile Range		07:45: uur	
		Skewness		4,889	,094
		Kurtosis		33,314	,189
	1	Mean		22:22: uur	01:58: uur
		95% Confidence Interval for Mean	Lower Bound	18:28: uur	
			Upper Bound	02:16: uur	
		5% Trimmed Mean		18:20: uur	
		Median		12:01: uur	
		Variance		1,131E10	
		Std. Deviation		05:32: uur	
		Minimum		00:19: uur	
		Maximum		21:49: uur	
		Range		21:30: uur	
		Interquartile Range		23:11: uur	
		Skewness		2,764	,163
		Kurtosis		10,735	,324

Extreme Values

	Exams that used oral ...			Case Number	PatientType	Value
WaitingTime	0	Highest	1	466	OUT	314:05:00.00
			2	465	OUT	307:30:00.00
			3	612	IN	188:30:00.00
			4	364	IN	166:31:00.00
			5	1396	IN	165:34:00.00
		Lowest	1	631	EM	0:00:00.000
			2	991	EM	0:06:00.000
			3	186	EM	0:06:00.000
			4	1113	EM	0:07:00.000
			5	735	EM	0:07:00.000[a]
	1	Highest	1	844	IN	213:49:00.00
			2	227	IN	162:23:00.00
			3	569	IN	140:20:00.00
			4	1291	IN	106:40:00.00
			5	283	IN	97:41:00.000
		Lowest	1	1319	EM	0:19:00.000
			2	813	EM	0:24:00.000
			3	223	EM	0:28:00.000
			4	866	IN	0:47:00.000
			5	456	EM	0:50:00.000

a. Only a partial list of cases with the value 0:07 are shown in the table of lower extremes.

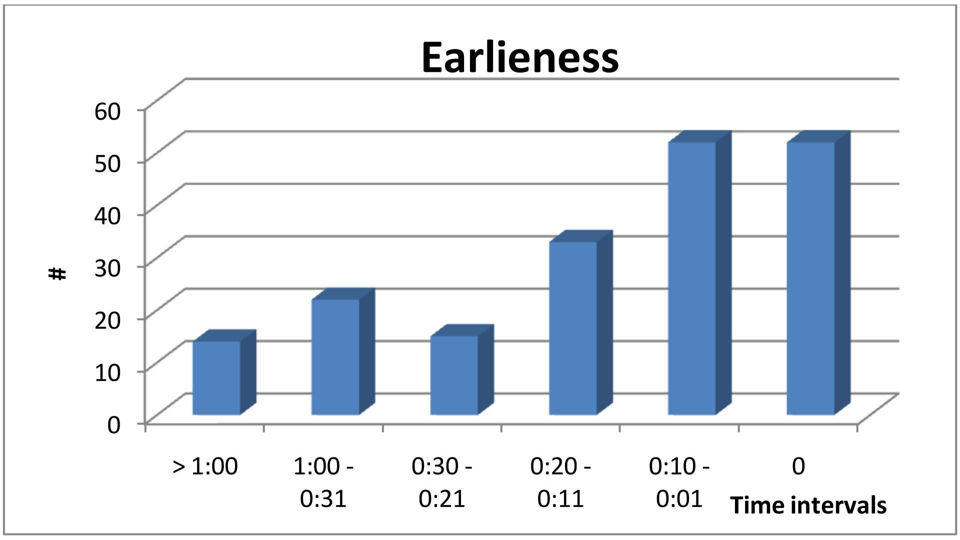
Annex E: Statistics on waiting time vs hour of request

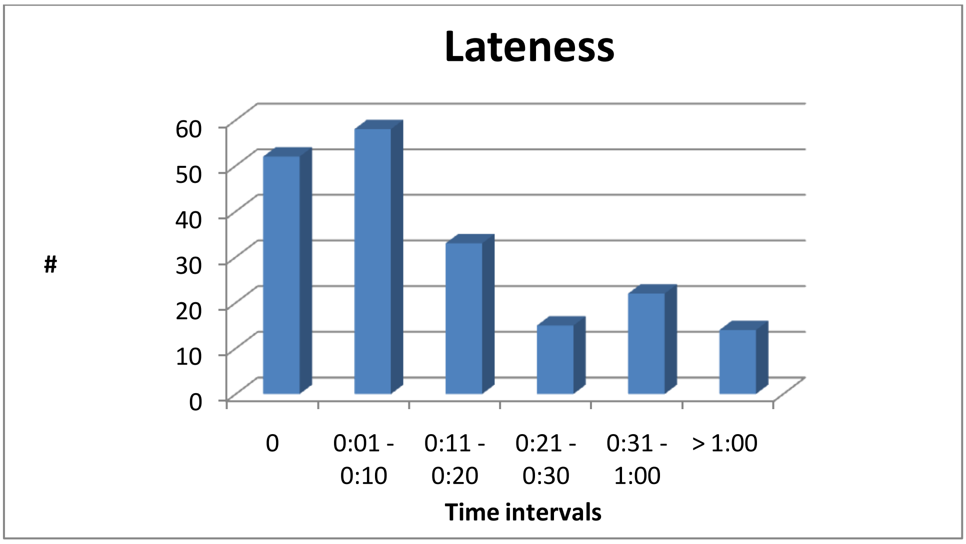
	Freq		%		Mean	Median	Stan dev	Max	Min	Skewness	Kurtosis
Categories	Valid	Missing**	Valid	Missing**							
0 - 1hr	15	7	1,04%	0,48%	10:44	0:28	27:29	106:40	0:08	3,46	12,53
1 - 2hr	10	1	0,69%	0,07%	6:58	0:27	17:45	56:57	0:13	3,04	9,35
2 - 3h	18	3	1,24%	0,21%	4:29	0:46	7:37	31:15	0:12	2,81	9,26
3 - 4h	6	3	0,41%	0,21%	1:54	0:38	3:00	8:00	0:19	2,36	5,65
4 - 5h	2	1	0,14%	0,07%	0:39	0:39	0:03	0:42	0:37	-	-
5 - 6h	4	2	0,28%	0,14%	0:40	0:38	0:31	1:16	0:10	0,21	-4,07
6 - 7h	16	3	1,10%	0,21%	3:53	2:39	5:58	25:37	0:16	3,6	13,73
7 - 8h	35	6	2,42%	0,41%	7:16	4:49	13:02	76:11	0:11	4,71	24,36
8 - 9h	42	6	2,90%	0,41%	15:15	4:15	27:56	124:05	0:06	2,82	7,9
9 - 10h	65	11	4,49%	0,76%	13:59	3:01	40:45	314:05	0:24	6,57	47,62
10 - 11h	66	9	4,56%	0,62%	12:02	4:29	14:46	75:17	0:11	1,83	4,28
11- 12h	73	11	5,04%	0,76%	15:00	3:37	26:26	147:04	0:08	2,77	8,97
12 - 13h	65	13	4,49%	0,90%	21:53	3:58	35:44	165:34	0:14	2,56	6,6
13 - 14h	66	10	4,56%	0,69%	19:33	3:06	33:06	166:31	0:19	2,56	7,39
14 - 15h	78	16	5,39%	1,10%	25:41	2:46	44:48	213:49	0:00	2,4	5,88
15 - 16h	60	17	4,14%	1,17%	20:11	2:15	44:19	307:30	0:16	4,98	30,4
16 - 17h	65	10	4,49%	0,69%	22:55	16:52	31:40	142:02	0:06	2,15	5,12
17 - 18h	56	17	3,87%	1,17%	11:58	2:16	15:53	66:53	0:07	1,82	3,58
18 - 19h	40	19	2,76%	1,31%	15:35	1:39	28:58	134:47	0:07	2,78	8,08
19 - 20h	31	22	2,14%	1,52%	6:19	1:08	16:57	85:16	0:07	3,93	16,66
20 - 21h	21	19	1,45%	1,31%	4:15	1:31	6:12	17:04	0:07	1,55	0,67
21 - 22h	17	19	1,17%	1,31%	5:24	0:46	9:32	35:59	0:20	2,44	6,3
22 - 23h	21	12	1,45%	0,83%	10:12	1:16	20:43	88:04	0:08	3,06	10,27
23 - 24h	16	11	1,10%	0,76%	6:12	1:31	9:17	34:15	0:11	2,11	4,91
no req data*		312		21,55%							
	888	560	61,33%	38,67%							
Total	1448		100,00%								
Mean					10:57	2:43	20:06	101:02	0:12	2,89	10,67

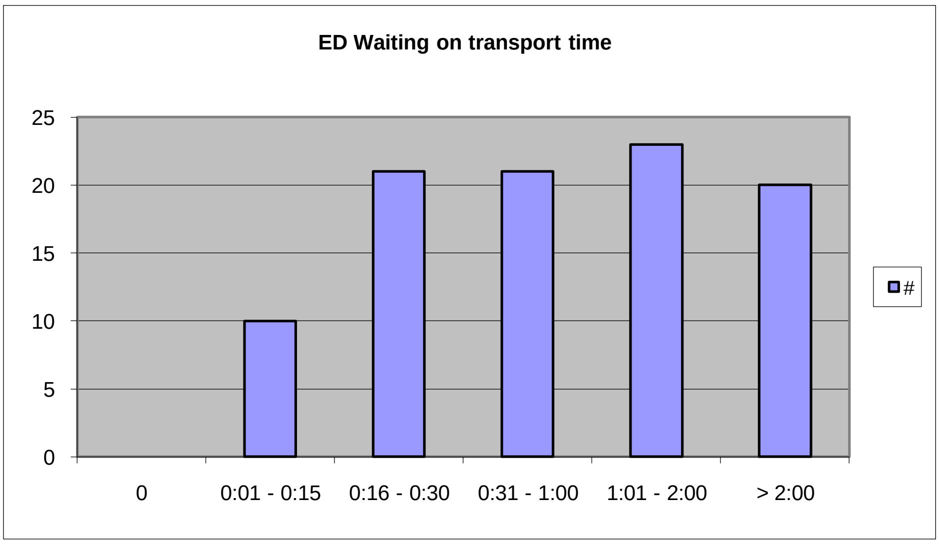
*Cases were time of request is unknown

**Where the combination of time of req and waiting time is missing

Annex F: Transport times







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