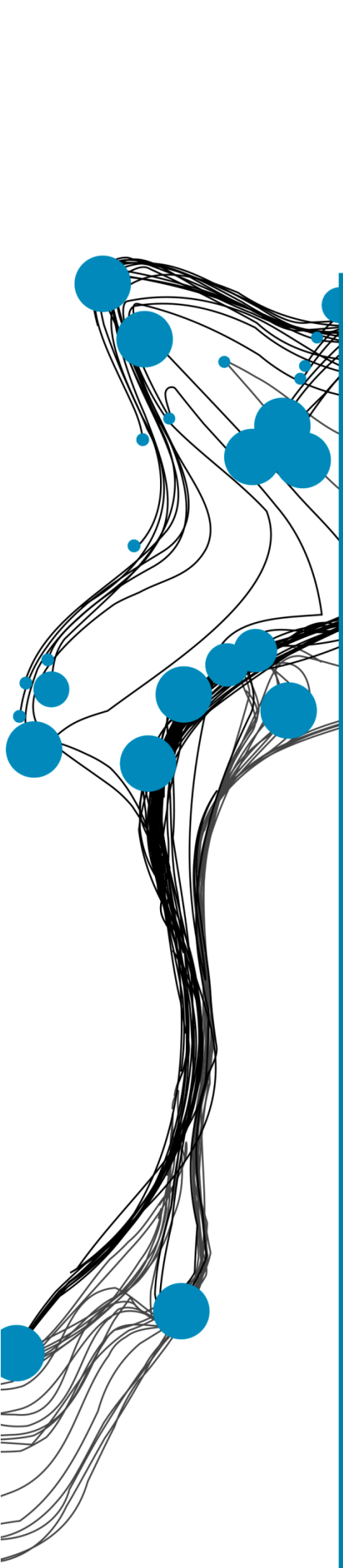

MASTER THESIS

Optimising the Emergency Department performance of the Dr. Horacio E. Oduber Hospital

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HEALTH SCIENCES

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Dr. Horacio E. Oduber HOSPITAL

UNIVERSITY OF TWENTE.

Management Summary

Motivation and research objective

In 2014, the Dr. Horacio E. Oduber Hospital (HOH) in Aruba started a project called 'Hunto Miho', which means 'better together'. With this project, HOH has aimed to move towards becoming one of the best hospitals in the region. The Emergency Department (ED) of HOH is attended by more than 34,000 patients per year, and over 73% of the ED arrivals visit on the basis on self-referral. Self-referrals often do not have a health problem that requires ED care. In Aruba, during working hours on working days, patients with an acute health problem can visit the General Practitioner (GP) or the ED. During the evening, night, weekend or holidays, patients with an acute health problem can visit the General Practitioner's Station (GPS) or the ED. A better statistical understanding is required by HOH of the ED performance measurements and how to optimise the ED performance.

The following research objective was composed:

> ***Providing insight into the current performance of the ED in the Dr. Horacio E. Obduber Hospital, resulting in recommendations on how to optimise the ED performance.***

Research methods

This research is conducted according to the Algemeen Bedrijfskundige Probleemaanpak (ABP) (Heerkens & Winden, 2012). Firstly, a context analysis is performed to identify bottlenecks by gaining insight into the current ED and GPS processes and their planning and control. Secondly, the current ED performance is measured based on eight selected Key performance indicators (KPIs) selected by stakeholders. These KPIs are measured by a data-analysis in Excel. Lastly, the most suitable interventions to optimise the ED performance are identified and the effect of these interventions is described according to Excel calculations and a review of the literature.

Results

Bottlenecks

The bottlenecks are divided into four categories: patient, GPS, planning and steering on performance.

Patient

- Over 73% of ED arrivals are self-referrals who often do not need ED care.
- Patients can visit the ED an unlimited number of times without paying deductibles.
- Patients perceive long ED waiting times.
- The Manchester triage system (MTS) is not fully able to recognise whether the patient needs ED care or is could be cared for by another healthcare provider.

GPS

- The GPS sometimes closes before closing time.
- Huisartsenvereniging Aruba (HAVA) does not want more patients to visit the GPS or to have longer opening hours.
- There is insufficient collaboration between the GPS and ED.
- It is complex to share the results of diagnostic tests between the GPS and ED**.**

Planning

- Staff members of the ED sometimes perceive a great working load.
- ED planning does not fully anticipate variation in demand.

Steering on performance

- The current ED performance is partly unknown.
- The KPIs were not defined.
- There are no acceptable goals defined for the KPIs.

Current Emergency Department performance

The ED performance has not yet been measured by HOH. The current ED performance was based on the selected and measured KPIs. *Table 1* provides insight in the current ED performance.

Table 1: selected KPIs and their current performance

KPI:	Current performance:
Throughput time	71.2%
Waiting time 1	43.0%
Waiting time 2	43.4%
Waiting time 3	48 minutes (39.3% under 30 minutes)

Room utilisation	40.4%
Nurse- and doctor utilisation	Nurse: 1.6; Doctor: 2.9.
ED arrivals who can be treated by GP(S) care	21.1%
ED arrivals being seen by an ED physician	72.8%

Relations between Key Performance Indicators

The selected KPIs are influencing each other. The KPI 'throughput time' shows that 71.2% of the ED arrivals have their throughput time within the norm. The average throughput time was 2 hours and 58 minutes with a standard deviation of 1 hour and 28 minutes between January 2018 and April 2019. Waiting times 1, 2 and 3 are KPIs that determine throughput time. In 43.0% and 43.4% the norms of respectively waiting time 1 and waiting time 2 is met. Waiting time 3 shows an average of 48 minutes with a standard deviation of 42 minutes. Of the ED arrivals, 39.3% have a waiting time 3 that is lower than 30 minutes. This means that the throughput time scores worsen because more than half of the ED arrivals do not meet the norms of waiting times 1 and 2 and an increase of throughput time occurs. Additionally, if a patient needs to be admitted to a ward, on average, 48 minutes increase in throughput time per patient who needs to be admitted to a ward.

The room, nurse- and doctor utilisation are perceived KPIs to explain the scores on the throughput time, waiting time 1, 2 and 3. The average room utilisation is 40.4% and varies according to the type of room. However, from January 2018 until April 2019, all rooms are occupied for 2 hours. Only in 0.02% of the time all ED rooms are occupied by patients. The nurse and doctor utilisation varies per hour and is on average: 1.6 (range: 0.9 – 2.4) for nurses and 2.9 (range 1.5 – 4.8) for doctors. Based the room utilisation, there is no reason for the throughput time, waiting times 1, 2 and 3 to score as these KPIs currently score. There seems to be no capacity problem in terms of space. It is almost never the case that all rooms are occupied by patients. There is no literature available concerning a norm for nurse- and doctor utilisation but, considering the scarcity of ED staff, throughput time, waiting times 1, 2 and 3 are probably scoring worse because of the staff shortages.

A high share (21.1%) of the ED arrivals are patients who could be treated by GP(S) care. These patients should visit their GP or the GP(S) in order to reduce the ED workload. If not referred to the GP(S), these patients are assumed to be the patients who have the highest

throughput time and wait longest because of the low urgency of their need to be treated. This results in a lower ED performance although these patients are not, effectively, ED patients.

A result of low scores within the norms of throughput time and waiting times is that patients leave before being seen by an ED physician. Currently, 27.2% of the arrivals leave before being seen by a physician. This percentage might be reduced by optimising the throughput time and waiting times 1 and 2.

Most suitable interventions to optimise the ED performance

The possible interventions to optimise the ED performance are selected according to stakeholders' opinions. After confirming and adjusting the bottlenecks and KPIs, the stakeholders brainstorm possible and suitable interventions to optimise the current ED performance based on the results of the bottlenecks and KPIs. This leads to three possible interventions. The effects of these interventions on the KPIs and bottlenecks are calculated based on data adjustments and literature. The following possible interventions and their effects are described.

1. Extend opening hours of the GPS: the GPS opens from 16:00 to 00:00 instead of 18:00 to 22:00. This would result in the decrease of six ED bed admissions per week. The total workload during these the additional hours decreases by 6.4%. If all GP(S) patients would visit GP(S), this would result in 21.1% less ED arrivals, a decrease of approximately 1 hour and 40 minutes (20.8%) in triage time per day and a decrease of approximately 12 hours (6.5%) in total throughput time per day.
2. Appropriate use of the fast-track rooms results in higher patient satisfaction, a decrease in throughput time with 30%, a waiting time decrease of over 35% and a decrease in patients who leave without being seen ranging from 0 – 65%. However, also resulting in an increase in the number of ED visits, at: 4.4%. However, the feasibility with the current employee capacity should be considered.
3. More personnel and different shifts. Two options best distributed the workload.

- the optimisation of the current situation where the nurse- and doctor capacity does not increase. This situation results in a more even workload distribution of the nurses. However, the doctors are unable to shift because of HOH's regulations.

- the ideal situation is evidence by the quantitative performance analysis' where the nurse and doctor capacity increase according to the necessary nurse and doctor capacity levels stated by HOHs management. This situation results in the most even workload for both nurses and doctors.

Implementation

To implement these interventions, the suggestion is to use a step-by-step plan that contains the following steps:

1. Create a roadmap together with the stakeholders
2. Involve ED and GPS employees
3. Start with the selected changes
4. Evaluate the changes

Further research

Further research should focus on:

- The effectiveness of interventions: the interventions' effectiveness should be further researched.
- Patients and high waiting times: further research should focus on decreasing the waiting times and the patients' perception regarding waiting times.
- ED arrivals who need GP(S) care: ED arrivals who need GP(S) care is a KPI that needs to be measured again to be more certain of the percentage. Further research should focus on how to influence ED arrivals who need GP(S) care to visit the right healthcare provider.
- Retain employees and attract new employees: Research should be performed on how HOH can attract more new employees and ensure that these new employees continue working at the ED of HOH.

Managementsamenvatting (Dutch)

Aanleiding en doel van het onderzoek

In 2014 is het Dr. Horacio E. Oduber Hospital (HOH) in Aruba een project gestart genaamd 'Hunto Miho', wat 'samen beter' betekent. Met dit project wil HOH bijdragen aan de ambitie om een van de beste ziekenhuizen in de regio te zijn. De spoedeisende hulp (SEH) van HOH wordt bezocht door meer dan 34.000 patiënten per jaar, van wie meer dan 73 procent zelfverwijzer is. Zelfverwijzers hebben vaak geen gezondheidsprobleem waarvoor SEH-zorg nodig is. Op Aruba, tijdens kantoortijden op werkdagen, kunnen patiënten met een acuut gezondheidsprobleem de huisarts (HA) of de SEH van HOH bezoeken. `s Avonds, `s nachts, in het weekend of tijdens vakantiedagen kunnen patiënten met een acuut gezondheidsprobleem terecht bij de huisartsenpost (HAP) of de SEH van HOH. HOH heeft meer cijfermatig begrip nodig wat betreft de meting van de SEH-prestatie en hoe deze SEH-prestatie te optimaliseren.

De volgende doelstelling is geformuleerd voor dit onderzoek:

> ***Inzicht verkrijgen in de huidige prestatie van de SEH in het Dr. Horacio E. Oduber Hospital, resulterend in suggesties voor het optimaliseren van de SEH-prestatie.***

Onderzoeksmethoden

Dit onderzoek is uitgevoerd volgens de Algemeen Bedrijfskundige Probleemaanpak (ABP) (Heerkens & Winden, 2012). Allereerst is een contextanalyse uitgevoerd om inzicht te krijgen in de huidige SEH- en HAP-processen en de planning en besturing, om vervolgens knelpunten van de SEH te identificeren. Ten tweede is op basis van acht, door de stakeholders geselecteerde, Key performance indicators (KPI's) de SEH-prestatie gemeten. Deze KPIs zijn gemeten tijdens de gegevensanalyse in Excel. Ten slotte zijn de meest geschikte interventies voor het optimaliseren van de SEH-prestatie geselecteerd en het effect van deze interventies is bepaald door Excel-berekeningen en op basis van literatuur.

Resultaten

Knelpunten

De knelpunten zijn verdeeld in vier categorieën: Patiënt, HAP, Planning en Prestatiesturing.

Patiënt

- Meer dan 73 procent van de SEH bezoekers zijn zelfverwijzers, die vaak geen SEH-zorg nodig hebben.
- Patiënten kunnen de SEH een onbeperkt aantal keren bezoeken zonder daarvoor eigen risico te betalen.
- Patiënten ervaren lange wachttijden op de SEH.
- Het Manchester Triage System (MTS) kan niet volledig onderscheiden of de patiënt SEH-zorg nodig heeft of ook behandeld kan worden door een andere zorgverlener.

Huisartsenpost (HAP)

- De HAP sluit soms voor sluitingstijd.
- Huisartsenvereniging Aruba (HAVA) wil niet meer patiënten behandelen op de HAP en wil geen langere openingstijden van de HAP.
- Er is onvoldoende samenwerking tussen de HAP en SEH.
- Het is complex om de resultaten van diagnostische onderzoeken te delen tussen de HAP en SEH.

Planning

- SEH-medewerkers ervaren een hoge werkdruk.
- De SEH-planning anticipeert niet volledig op de variatie in de zorgvraag.

Prestatiesturing

- De huidige SEH-prestatie is onbekend.
- Er waren geen KPI's gedefinieerd om de prestatie de meten.
- Voor de KPI's zijn geen acceptable doelen geformuleerd.

Huidige prestatie Spoedeisende hulp

Tabel 1 geeft inzicht in de huidige SEH prestaties op basis van de geselecteerde KPIs.

Tabel 1: geselecteerde KPIs en de bijbehorende huidige prestatie.

KPI:	Huidige prestatie:
Doorlooptijd	71,2%
Wachttijd 1	43,0%
Wachttijd 2	43,4%

Wachttijd 3	48 minuten (39.3% onder de 30 minuten)
Kamerbenutting	40,4%
Verpleegkundige- (VPK) en artsbenutting	VPK 1,6; Arts: 2,9.
SEH-bezoekers, die kunnen worden behandeld door de HAP	21,1%
SEH-bezoekers, die worden gezien door een (SEH-) arts	72,8%

Verbanden tussen de Key performance indicators

De geselecteerde KPI's beïnvloeden elkaar. De KPI 'Doorlooptijd' laat zien dat de doorlooptijd van 71,2 procent van de SEH-bezoekers binnen de norm valt. De gemiddelde doorlooptijd was 2 uur en 58 minuten met een standaardafwijking van 1 uur en 28 minuten voor de periode: januari 2018 tot en met april 2019. Wachttijd 1, 2 en 3 zijn KPI's die de doorlooptijd bepalen. In 43,0 en 43,4 procent van de SEH-bezoeken wordt voldaan aan de norm voor respectievelijk wachttijd 1 en wachttijd 2. Wachttijd 3 heeft een gemiddelde van 48 minuten met een standaardafwijking van 42 minuten. Van de patiënten die moeten worden opgenomen op een verpleegafdeling heeft 39,3 procent een wachttijd 3 die korter is dan 30 minuten. Dit betekent dat de doorlooptijd hoger is, omdat meer dan de helft van de aankomsten niet voldoet aan de normen van wachttijd 1 en 2. Ook is er een toename in doorlooptijd van gemiddeld 48 minuten per patiënt, wanneer een patiënt opgenomen moet worden op een verpleegafdeling (wachttijd 3).

De kamerbenutting en VPK- en arts-benutting zijn geselecteerde KPI's om de scores van doorlooptijd en wachttijd 1, 2 en 3 te kunnen verklaren. De gemiddelde kamerbenutting is 40,4 procent en varieert per type kamer. Echter, vanaf januari 2018 tot en met april 2019 zijn alle 13 kamers slechts 2 uur bezet geweest. Dit betekent dat 13 kamers bezet zijn in 0,02 procent van de totale tijd. De VPK- en arts-benutting varieert sterk per uur van de dag en is gemiddeld 1,6 (bereik: 0,9 – 2,4) voor verpleegkundigen en 2,9 (bereik: 1,5 – 4,8) voor (SEH-) artsen. Op basis van de kamerbenutting is er geen reden voor de lage scores van de KPIs doorlooptijd en wachttijd 1, 2 en 3; er lijkt geen ruimte capaciteitsprobleem te bestaan. De reden hiervoor is dat de 13 kamers bijna nooit tegelijk bezet zijn. Over een norm voor VPK- en artsenbenutting is geen literatuur beschikbaar, maar als wordt meegenomen dat er een

tekort aan SEH-personeel bestaat in HOH, dan is het aannemelijk dat de doorlooptijd en wachttijd 1, 2 en 3 slechter scoren vanwege het tekort aan personeel.

Van de SEH-bezoekers is 21,1 procent patiënt die door de HA kan worden behandeld. Deze patiënten zouden hun HA of de HAP moeten bezoeken zodat de SEH ontlast wordt. Als deze categorie patiënten niet wordt doorverwezen naar de eigen HA of HAP ondervindt deze vaak de hoogste doorlooptijd en wachttijden vanwege de lage urgentie. Dit leidt dan tot een lagere SEH-prestatie terwijl deze patiënten geen SEH-zorg nodig hebben.

Een gevolg van een hoge doorlooptijd en wachttijden is dat patiënten vertrekken voordat ze door een (SEH-) arts worden gezien. Momenteel vertrekt 27,2 procent voordat zij door een (SEH-) arts gezien waren. Dit percentage zou kunnen worden verlaagd door de doorlooptijd en wachttijd 1 en 2 te optimaliseren.

Meest geschikte interventies om de spoedeisende hulp prestatie te optimaliseren

De mogelijke interventies om de SEH-prestaties te optimaliseren werden geselecteerd op basis van een stakeholderanalyse. Na het bevestigen en bijstellen van de knelpunten en KPI's brainstormden de stakeholders over mogelijke en geschikte interventies om de huidige SEH-prestatie te optimaliseren op basis van de resultaten van de knelpunten en KPI's. Dit leidde tot drie interventies. De effecten van deze interventies op de KPI's en knelpunten werden bepaald op basis van gegevensanalyse en literatuur. De volgende interventies en hun effecten zijn beschreven.

1. Het verlengen van de openingstijden van de HAP: de HAP is open van 16.00 tot 00.00 uur in plaats van, van 18.00 tot 22.00 uur. Dit leidt tot een afname van zes SEH-opnames per week. De totale werkdruk neemt tijdens deze extra uren af met 6,4 procent. Als alle HAP-patiënten de eigen HA of HAP zouden bezoeken, zou dit resulteren in 21,1 procent minder SEH-bezoeken, een afname van ongeveer 1 uur en 40 minuten (20,8%) in triagetijd per dag en een afname van 12 uur (6,5%) in totale doorlooptijd per dag.
2. Fast-track kamers gebruiken voor fast-track geschikte patiënten: Verwacht wordt dat dit resulteert in een hogere patiënttevredenheid, een afname van de doorlooptijd met 30%, een afname van de wachttijd met 35% en een afname van het aantal patiënten, die niet worden gezien door een (SEH) arts, die varieert van 0 tot 65%. Echter, deze interventie resulteerde ook in een toename van het aantal SEH-

bezoeken met 4,4%. Wel moet rekening worden gehouden met de haalbaarheid van deze interventie op basis van de huidige formatie en planning van diensten.

3. Meer personeel en verschillende diensten. Twee interventies verdeelden de werkdruk het best over het aanwezige personeel.

- De optimalisatie van de huidige situatie waarbij de VPK- en artsencapaciteit niet zijn toegenomen. Deze situatie resulteerde in een beter verdeelde werkdruk voor de verpleegkundigen. De diensten van de (SEH-) artsen bleken echter niet te kunnen worden gewisseld vanwege minimale bezettingsregels op de SEH van HOH.
- De situatie gebaseerd op de kwantitatieve prestatieanalyse waarbij de VPK- en artsencapaciteit zijn toegenomen volgens de gewenste capaciteit die werd aangegeven door het management van HOH. Dit resulteerde in de meest gelijkmatige werkdruk voor zowel SEH-verpleegkundigen als (SEH-) artsen.

Implementatie

Om deze interventies in de praktijk te kunnen brengen, wordt aanbevolen om tijdens de implementatie een stappenplan te gebruiken, dat uit de volgende stappen bestaat:

1. Maak samen met de stakeholders een roadmap.
2. Betrek SEH- en HAP-werknemers.
3. Begin met de geselecteerde interventie(s).
4. Evalueer de veranderingen.

Vervolgonderzoek

Vervolgonderzoek zou gericht moeten zijn op:

- Effectiviteit van de interventies: deze moet verder worden onderzocht.
- Patiënten en hoge wachttijden: vervolgonderzoek zou gericht moeten zijn op het verminderen van de wachttijden en de beleving van wachttijden door patiënten.
- SEH-bezoekers die kunnen worden behandeld door de HAP: deze KPI zou opnieuw moeten worden gemeten om zekerder te zijn over het uiteindelijke percentage SEH-bezoekers die ook behandeld kunnen worden door de HAP. Vervolgonderzoek moet gericht zijn op hoe SEH-bezoekers, die kunnen worden behandeld door de HAP, ook daadwerkelijk de juiste zorgverlener bezoeken en hoe deze keuze wordt beïnvloed.

- Behoud van werknemers en aantrekken van nieuwe werknemers: onderzoek moet gedaan worden naar hoe HOH meer nieuwe werknemers kan aantrekken en hoe HOH ervoor kan zorgen dat deze nieuwe medewerkers blijven werken op de SEH.

Preface

I began my master's thesis research in February 2019 and five months later, this is the outcome of my master's work in Health Sciences: Optimisation of Healthcare Processes. This master assignment was conducted at HOH. For two years, I studied at the University of Twente in Enschede. Before studying at the University of Twente, I graduated from 'HBO-Nursery' at Saxion Hogescholen in Enschede.

I want to thank all the people who were involved in my master's thesis. Sincere thanks to the HOH for the opportunity to conduct my research in Aruba. I also thank Stefan Lucas, Jennifer Odor, Mayra Tromp and Ineke Hartmans. Because of their contribution, I was able to gain insight into activities behind the scenes of HOH. Previously, the hospital was a place where I provided care to patients during internships. These previous experiences of providing care in a hospital helped me during my master's research. However, a different approach was needed to complete this thesis. I had a lot of fun in Aruba and met amazing people during my time there.

I also want to thank my examination committee: Erwin Hans and Karin Groothuis-Oudshoorn for their support and supervision. The feedback and meetings were always pleasant and constructive. Lastly, I thank Stephan Bras for his role and feedback.

Dennis de Kleijn

Enschede, July 2019

Contents

List of Abbreviations

ABP	Algemene Bedrijfskundige Probleemaanpak
AZV	Algemene Ziektekosten Verzekering
ED	Emergency Department
EMR	Electronical Medical Record
GP	General Practitioner
GPS	General Practitioner's Station
HAVA	Huisartsenvereniging Aruba (General Practitioner Association Aruba)
HOH	Dr. Horacio E. Oduber Hospital
ImSan	Instituto Medical San Nicolas
KPI	Key performance indicator

1 Introduction

The first chapter introduces the research conducted at the Dr. Horacio E. Oduber Hospital (HOH) in Aruba to derive recommendations for optimising the Emergency Department (ED) performance. The research context of HOH is presented in Section 1.1. Section 1.2 describes the problem. The research objective and research questions are set out in Section 1.3. Section 1.4 describes the scope of this research.

1.1 Research context: HOH

This section provides insight into the research context: HOH (Section 1.1.1), the Emergency Department of HOH (Section 1.1.2), the General Practitioner's Station (Section 1.1.3) and Hunto Miho and the mission and vision of HOH (Section 1.1.4).

Figure 1.1: The Dr. Horacio E. Oduber Hospital (HOH, 2019).

1.1.1 Dr. Horacio E. Oduber Hospital

HOH, as illustrated in *Figure 1.1,* officially opened in 1977. It is the only hospital in Aruba. Aruba is an island in the Caribbean Sea and part of the ABC-islands. It is also part of the kingdom of the Netherlands, where Papiamento and Dutch are the official languages. Aruba has 116,000 residents (Central Intelligence Agency (CIA), 2019). The hospital has a capacity of 172 regular nursing beds and offers all major medical specialisms, such as General Surgery, Neurology and Paediatrics. The hospital admits more than 10,000 patients per year. It has more than 900 employees and more than 70 medical specialists (Dr. Horacio E. Oduber Hospital (HOH), 2019).

There are 29 different specialisms within the hospital: General Surgery, Neurosurgery, Anaesthesiology, Neurology, Cardiology, Oncology, Dermatology, Surgical Oncology, Gynaecology, Ophthalmology, Intensive Care, Orthopaedics, Internal Medicine, Pathology, Paediatrics, Pain Management, Clinical Chemistry, Plastic Surgery, Clinical Pharmacy, Psychiatry, Ear Nose and Throat (ENT), Radiology, Pulmonology, Rehabilitation, Nephrology, Urology, Gastroenterology, Bacteriology and Emergency physicians (Andringa, 2018).

1.1.2 Emergency Department of Dr. Horacio E. Oduber Hospital

The ED of HOH is a specialised department that provides unplanned and urgent medical care to patients with acute conditions or injuries. Patients, who are visiting the ED of the HOH, are both Aruban patients and patients from abroad, who are mainly tourists visiting Aruba. Every year more than 34,000 patients visit the ED of HOH, which is open 24 hours per day, seven days per week.

1.1.3 General Practitioner's Station in Aruba

The GPS in Aruba is an independent organisation. This organisation provides care to patients with acute conditions or injuries, which are mostly of lesser urgency. The GPS can treat most of the patients that visit the GPS but occasionally the patients need to be referred to other healthcare providers. Patients who visit the GPS, are Aruban patients and patients from abroad (mainly tourists visiting Aruba). The goal for the GPS is to obtain 14,000 patient visits per year, resulting in relief for the ED during busy times to help patients more quickly and at the right place. The GPS is open during evenings, weekends and holidays. The opening hours are provided in Appendix A: Context analysis, *Tables A.2 – A.4*.

1.1.4 Hunto Miho, mission and vision of Dr. Horacio E. Oduber Hospital

Dr. Horacio E. Oduber Hospital is striving to be one of the best hospitals in the region (HOH, w.d.). In 2014, a multi-annual improvement programme called: '*Hunto Miho'* started. The goal is to provide reliable healthcare with healthy business management. Healthcare logistics is stated to be one of the most important pillars of this programme. These healthcare logistics are approached analytically. This is a different approach to the hospital. In this improvement programme, analytical support contributes to decision making and is always the starting point for the initiation of improvement projects of healthcare logistics.

The mission and vision of HOH are described in their multi-annual policy plan. The hospital aims: *'To be a part of the best hospitals within the region, where regional and selected supraregional care to the patient is offered*' (HOH, w.d.). With three explanation points:

- **Best:** to provide effective (professional), safe and efficient integrated care.
- **Hospital:** Classified as a regional hospital with selected supraregional functions.
- **Region:** the Caribbean area, including Venezuela and Colombia.

The vision regarding the provision of services to their patients is stated as follows: *'We, the HOH, provide reliable care to our patients. In contribution with our partners, we provide care in a patient-centred and professional way within a healthy business environment'*. This vision results in six core pillars provided in *Figure 1.2* and explained in *Table 1.1* (HOH, w.d.).

Figure 1.2: Six core pillars of HOH.

Table 1.1: Six core pillars including long term goals.

Core pillar	**Long term goal crucial to the service provided by the hospital**
Reliable care	The provided care needs to be safe and reliable. Patients and all involved must be able to rely on the hospital: the absence of unnecessary risks and keep promises. A quality and safety system ensures improvements.
Patient-centred	The patient, family and other partners are treated respectfully. The service provided by all employees of HOH is patient-centred. The hospital aims to improve patient experiences, such as communication, planning, waiting times. They aim to measure these patient experiences regularly.
Professional	Employees have a professional attitude to their patients and colleagues. Individual responsibility is respected, but employees can also address their own responsibility. Time is spent on professional development, knowledge, attitude and skills, based on evidence-based standards.
Together	The hospital acts proactively within the care chain in Aruba and takes steps for further improvement of the health of the Aruban residents by collaborating with their partners.
Healthy business environment	Rising care-related costs demand additional awareness to use limited resources and budgets smartly. The internal and external accountability, using a planning and control cycle, takes place regarding efficient and effective business management.
We, the HOH	Employees and their collaboration with other employees are the keys to the successful functioning of the hospital. As an organisation, the hospital should be an attractive employer and stimulate an open culture.

1.2 Problem description

Currently, over 34,000 patients visit the ED of the HOH every year, corresponding to approximately 95 patient visits every day. Over 73% of patients visiting the ED are self-referred patients. HOH expects that a large proportion of these self-referrals should visit their General Practitioner (GP) or the GPS because their health-related problems can be solved by a GP or the GPS. During working hours, on working days, in Aruba, patients with an acute health problem can visit the GP or the ED. During the evening, weekend or holidays patients with an acute health problem can visit GPS or the ED. However, there continue to be many patients visiting the ED with a care need that can be solved by a GP during the opening hours of the GP(S). The hospital has stated that this problem has a negative influence on the ED's performance, such as waiting times and throughput time (HOH, 2018a).

The hospital tried to solve the problem of the patients that need GP care visiting the ED. The GPS was physically placed near the ED (at a 50-meter distance), and extending the opening hours of the GPS is under consideration. It was expected that it would:

- be easier to guide patients to the correct healthcare provider
- lower barriers for patients to visit the GPS instead of the ED

However, the result of the shift of the GPS closer to the ED was that the ED waiting times and throughput time were not decreasing compared to the old situation where the GPS was further away from the ED. The patients that had to wait longer to receive care are patients with a care need with low urgency; mostly these patients can be treated at the GP(S). The General Practitioners Association in Aruba (HAVA) is against longer opening hours for the GPS because the number of patient arrivals was already perceived to be too high.

The effects of placing the GPS close to the ED have not yet been perceived or measured. The hospital needs more numerical understanding considering the performance measurements of the ED after changing the location of the GPS and, mostly importantly, how to optimise the ED performance. Currently, there is data available, but the data remains unused regarding the ED performance measurement. This is important in order to select solutions to the problem that are most suitable to be considered and implemented.

1.3 Research objective and research questions

The research objective of this study is:

> ***Providing insight into the current performance of the ED in the Dr. Horacio E. Obduber Hospital, resulting in recommendations on how to optimise the ED performance.***

The Algemene Bedrijfskundige Probleemaanpak (ABP) was used to determine the approach of this research (Heerkens & Winden, 2012). In order to accomplish the research objective, the following research questions need to be answered. There also follows an elaboration on how to answer these questions.

1. *What bottlenecks are perceived by the ED regarding the entire patient process at the ED of HOH and GPS and what resources are used?*

To gain insight into the patient processes at the ED of HOH and GPS, the ED and GPS patient processes are reviewed. Consequently, the current collaboration between the ED and GPS is discussed. Bottlenecks of the patient processes and current collaboration are considered. The resources are discussed with the healthcare planning and control framework, where the four different levels are contemplated: strategic, tactical, offline operational and online operational. Bottlenecks are evaluated for every level. This research question is answered in Chapter 3 and Sections 4.1 and 4.2.

2. *To what extent are Key performance indicators (KPIs) of the ED performance defined and what is the current ED performance?*

To answer the second research question, a quantitative performance analysis of the current situation is provided in Chapter 4. In order to select and define relevant key performance indicators (KPIs), stakeholders are identified to selected KPIs, which are also based on the mission and vision of HOH. After the selection of KPIs, the KPIs are defined and the bottlenecks are presented, which are relevant for the first research question. The data used in the calculation of the KPIs and the relation between KPIs are considered in order to determine the current ED performance. The second research question is answered in Section 4.3 and 4.4.

3. *What are the three most suitable interventions to optimise the ED performance according to stakeholders?*

To answer the third research question, stakeholders and the research literature were consulted in order to obtain the possible interventions to optimise the ED performance, which is discussed in Chapter 5. Three possible and suitable interventions according to stakeholders were selected. The effects of these interventions were determined by data mutations and literature. The third research question is answered in Chapter 5.

4. *How should HOH apply the best suitable interventions in practice?*

For HOH, it is important that this study also includes an implementation plan with basic steps on how to implement the three most suitable interventions according to stakeholders. Therefore, a step-by-step plan is created in order to implement these recommended interventions. The fourth research question is answered in Chapter 6.

1.4 Scope

1.4.1 Emergency Department and specialities

Several processes, in and outside the hospital, affect the ED. However, it is impossible to take all these processes into account. The scope of this research includes ED arrivals with a care need and ED processes. Patients with different and multiple diseases and conditions can visit the ED. One specific or multiple specialities may treat the ED patient.

1.4.2 General Practitioner's Station

The research focuses on patients who visit the GPS in their care process, sometimes in combination with an ED referral. This research also focuses on the GPS processes.

1.4.3 Admissions and referrals

ED patients can be admitted to other wards within the hospital. The ED care pathway is included in the study, but after the ED visit, when the patient is admitted to a ward in the hospital, going to the GP or going home, the care pathway is excluded. This is because this study is mainly focused on the ED and partly on the GPS. In this research, referral means that the patient is referred to another healthcare provider. Admission means that the patient is transferred to a ward in the hospital.

2 Theoretical framework

This chapter presents the relevant research literature, and considers the application of the outcomes of the literature reviewed in the subsequent chapters of this study. The healthcare planning and control framework is outlined in Section 2.1 and applied in Section 3.2. Stakeholder theory is discussed in Section 2.2 and applied in Section 4.1. Relevant literature on ED KPIs is provided in Section 2.3 and applied throughout Chapter 4.

2.1 Healthcare planning and control framework

This section discusses the healthcare planning and control framework of Hans, van Houdenhoven and Hulshof (2011) (*Figure 2.1*). This framework is used as a tool to gain insight into the planning and control decision making regarding the ED and the GPS.

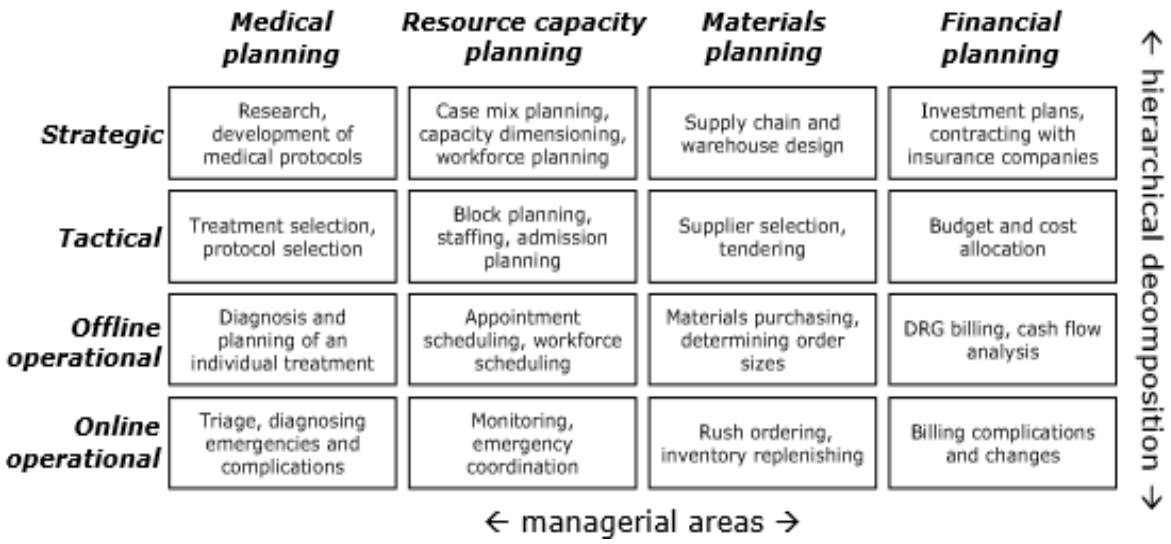

Figure 2.1: Healthcare planning and control framework (Hans et al., 2011).

The healthcare planning and control framework consists of two axes: the hierarchical decomposition and managerial areas. The vertical axis consists of four hierarchical levels:

- **Strategic decisions** are long term, structural decisions. Applied to the ED and GPS planning, a strategic decision can be to build more ED stations to increase capacity. The planning horizon of strategic decisions is usually in years.
- **Tactical decisions** are medium-long term decisions. Applied to ED and GPS planning, a tactical decision can be the allocation of the ED and GPS capacity to different months. The planning horizon of tactical decisions is usually in months.

- **Offline operational decisions** are short term decisions. Applied to ED and GPS planning, an offline operational decision is scheduling the capacity of personnel. The planning horizon of offline operational decisions is usually days or weeks.
- **Online operational decisions** are decisions that monitor and control the process. Applied to ED and GPS planning, online operational decisions are continuously made because there are only patients visiting the GPS and ED, who need different levels of urgent care. There is no planning horizon regarding this type of decision because the moment when an online operational decision needs to be made is unknown.

Furthermore, the horizontal axis of the framework consists of four managerial areas:

- **Medical planning decisions** are decisions, mostly made by clinicians, concerning medical protocols, treatments and diagnoses.
- **Resource capacity planning decisions** are decisions about planning, scheduling and monitoring the resource capacity, such as number of employees and ward beds.
- **Materials planning decisions** are decisions about storing and distributing materials.
- **Financial planning decisions** are decisions about budgets and controlling financial flows.

Within this study, a sufficient degree of context for the GPS needs to be discussed in order to solve the ongoing problem within the ED. Unfortunately, the information for the context analysis regarding the GPS is not always (publicly) available.

2.2 Stakeholder theory

The stakeholder theory (Mitchell, Agle & Wood, 1997) helps with defying and selecting the KPIs that are most appropriate for the different stakeholders. It is important to involve all people who influence or are concerned in a certain activity within the ED's and GPS's primary process. Also, the interests of every stakeholder should be considered regarding the KPIs.

Figure 2.2 provides insight into the possible stakeholders within an organisation.

Before the research, the stakeholders of the ED were identified. Group meetings were arranged with the manager of the ED, assistant manager of the ED, ED nurses, ED doctors and directly involved stakeholders. Ultimately, involving stakeholders in the process of selecting and defining KPIs results in more suitable KPIs.

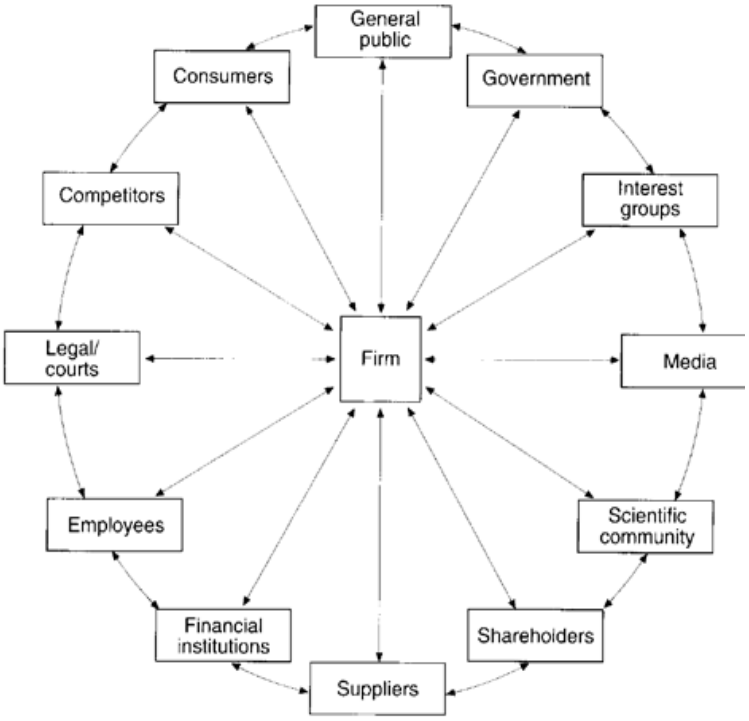

Figure 2.2: Possible stakeholders for an organisation (Mitchell et al., 1997).

2.3 Key performance indicators

In this section, Performance management (Section 2.3.1). measuring performance (Section 2.3.2) and ED's KPIs (Section 2.3.3) are discussed.

2.3.1 Performance management

Performance management enables an organisation to assess whether the organisation has met its desired performance objectives and allows the organisation to benchmark with other organisations. Waring (2000) has developed a model to measure the performance of hospitals, as seen in *Figure 2.3.*

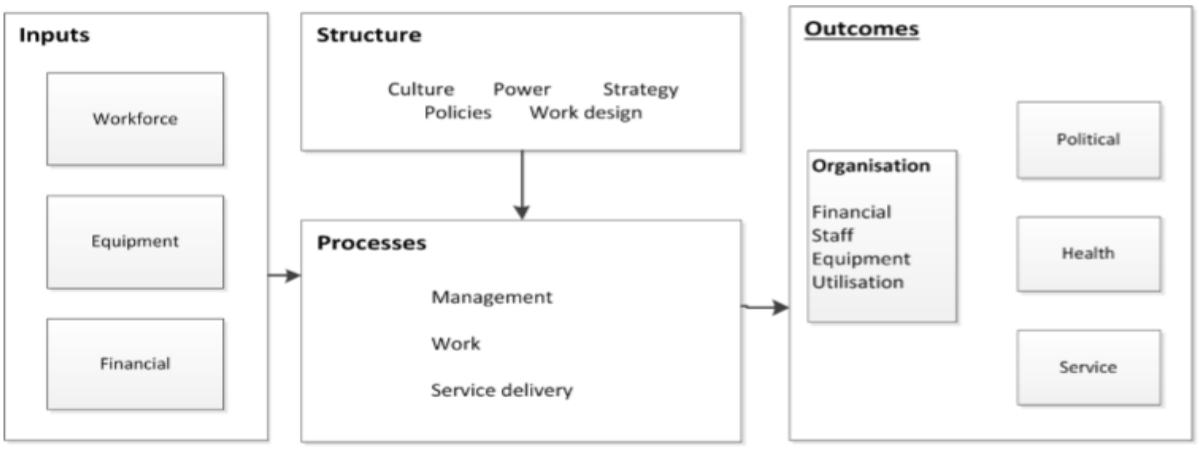

Figure 2.3: Simplified model: basic organisational performance model.

The KPIs can be divided into different subgroups: inputs, structure, processes and outcomes.

- **Inputs** are the need for human, technical and financial resources in order to run the process.
- **Structure** of a hospital contains all the factors that influence the functioning of the organisations, such as: strategy, culture and agreements.
- **Processes** are all factors that are involved in delivering healthcare such as management, work and services.
- **Outcomes** are the actual outcomes of the processes. These are grouped into organisational, service, health and political outcomes.

2.3.2 Measuring performance

The usage of KPIs enables the assessment of the performance of a process, department or an organisation. Performance can be defined as: '*The process to quantify the efficiency and effectivity of an action'* (Neely, Gregory & Platts, 1995), where a KPI is defined as: '*A quantifiable indicator that can measure the performance of a process'* (Hamers, 1996). The critical issue is to select the right KPIs for a process, department or organisation.

An important condition for KPIs is that these should be usable, measurable and relevant (Carter, 1991). According to Arah (2005), KPIs should be linked to goalsetting of policy, measure the performance of policy or create an intention to improve. A norm for the KPI should be available in order to indicate whether the KPI deviates from the target or desired result.

2.3.3 The Emergency Department's key performance indicators

As stated in the multi-annual improvement programme at HOH: '*Hunto Miho', t*he goal of this project is to improve the process within the hospital based on analytical data. It is important to identify where in the process improvement is needed. To identify where in the process improvements are needed, the ED performance within the current situation needs to be measured using ED's KPIs to gain statistical insight. Statistical insight is the base to determine which interventions should be considered to improve the ED's performance. According to the research literature and the stakeholders, there are several KPIs that can be used to measure ED performance. The following KPIs were selected and defined to be most

applicable to measure the ED performance (Abo-Hamad & Arisha, 2013; Sørup, Jacobsen & Forberg, 2013; Wilson & Ngyuen, 2004):

- Throughput time
- Waiting time 1
- Waiting time 2
- Waiting time 3
- Room utilisation
- Nurse and doctor utilisation
- ED arrivals who can be treated by GP(S) care
- Arrivals being seen by an ED physician

These KPIs represent the opinion of the most important stakeholders: HOH patients, managers, ED personnel and GPS personnel. Chapter 4 elaborates on these KPIs.

Definitions of KPIs should be unequivocal in order to compare hospitals. In this way, hospitals can learn from each other. The comparison of the KPIs within several hospitals is called benchmarking. The definition of benchmarking is: '*A continued and structured improvement process where the performances and processes of the best performing organisation is a point of reference for organisations that are performing less than the best performing organisation to set challenging goals and improve processes*' (Zairi & Leonard, 1994).

The previously mentioned KPIs are used to perform a baseline measurement. This provides insight into the current ED performance. The management is, therefore, able to make decisions regarding planning and controlling the ED complex.

3 Context analysis

This chapter describes the current situation of HOH and the GPS. Section 3.1 provides information about the ED's and GPS's processes. The planning and control of HOH is discussed in Section 3.2. Identified bottlenecks are described in Section 3.1.4 and 3.2.5

This chapter aims to partly answer the first research question stated in Section 1.3:

- *What bottlenecks are perceived by the ED regarding the entire patient process at the ED of HOH and GPS and what resources are used?*

3.1 Processes of patients visiting the ED and GPS

This paragraph describes several important aspects to illustrate the ED and GPS processes. Section 3.1.1 provides insight into the ED patient process. Section 3.1.2 provides insight into the GPS patient process. Section 3.1.3 describes the current collaboration between the ED and GPS. Section 3.1.4 contemplates the bottlenecks of the current processes of patients visiting the ED and GPS.

3.1.1 The process of patients visiting the ED

The processes of ED arrivals are illustrated in *Figure 3.1* and *Figure 3.2.* The explanation of the ED process is provided below *Figure 3.2*.

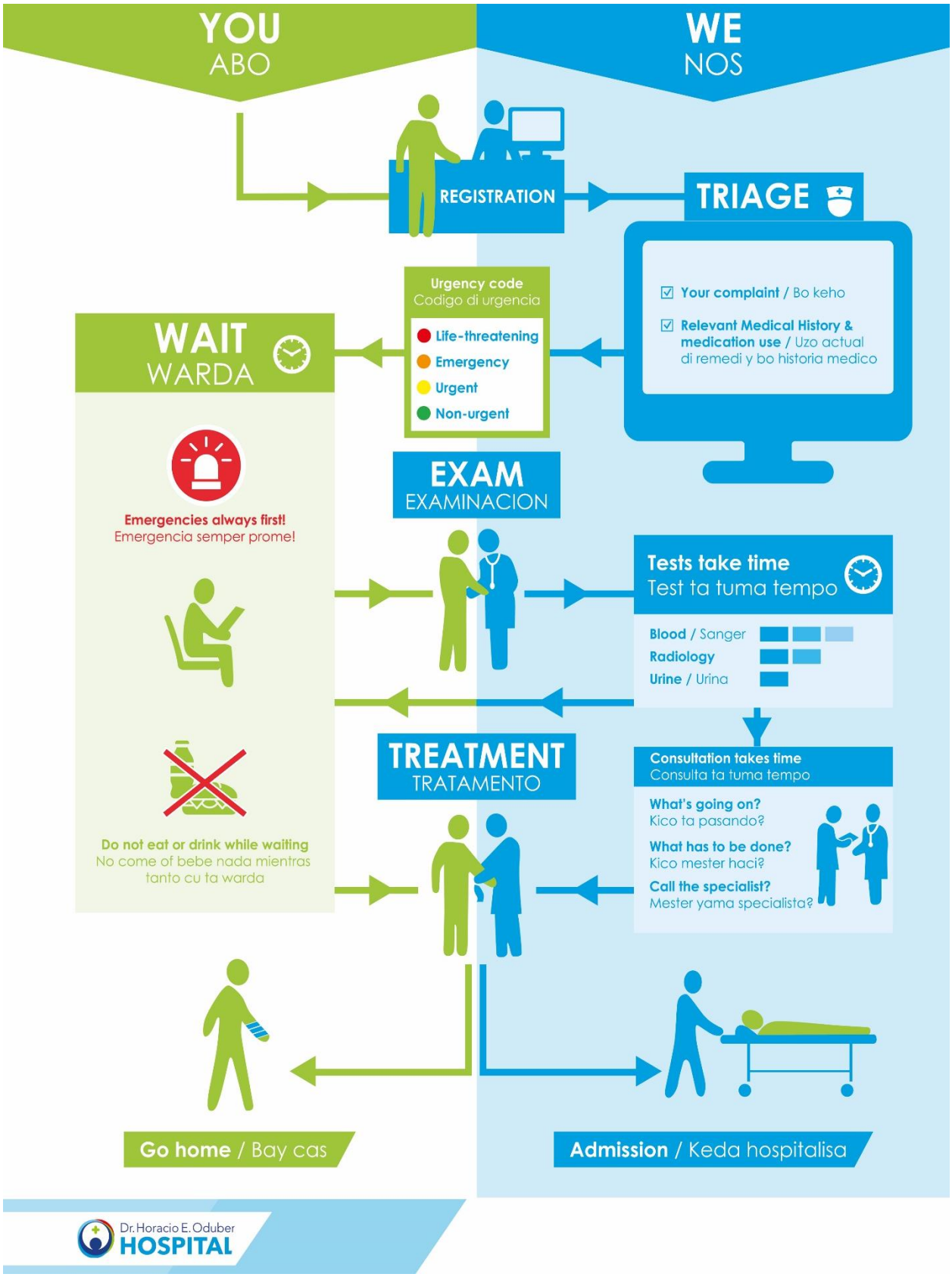

Figure 3.1: The process steps of patients arriving at HOH at the Emergency Department.

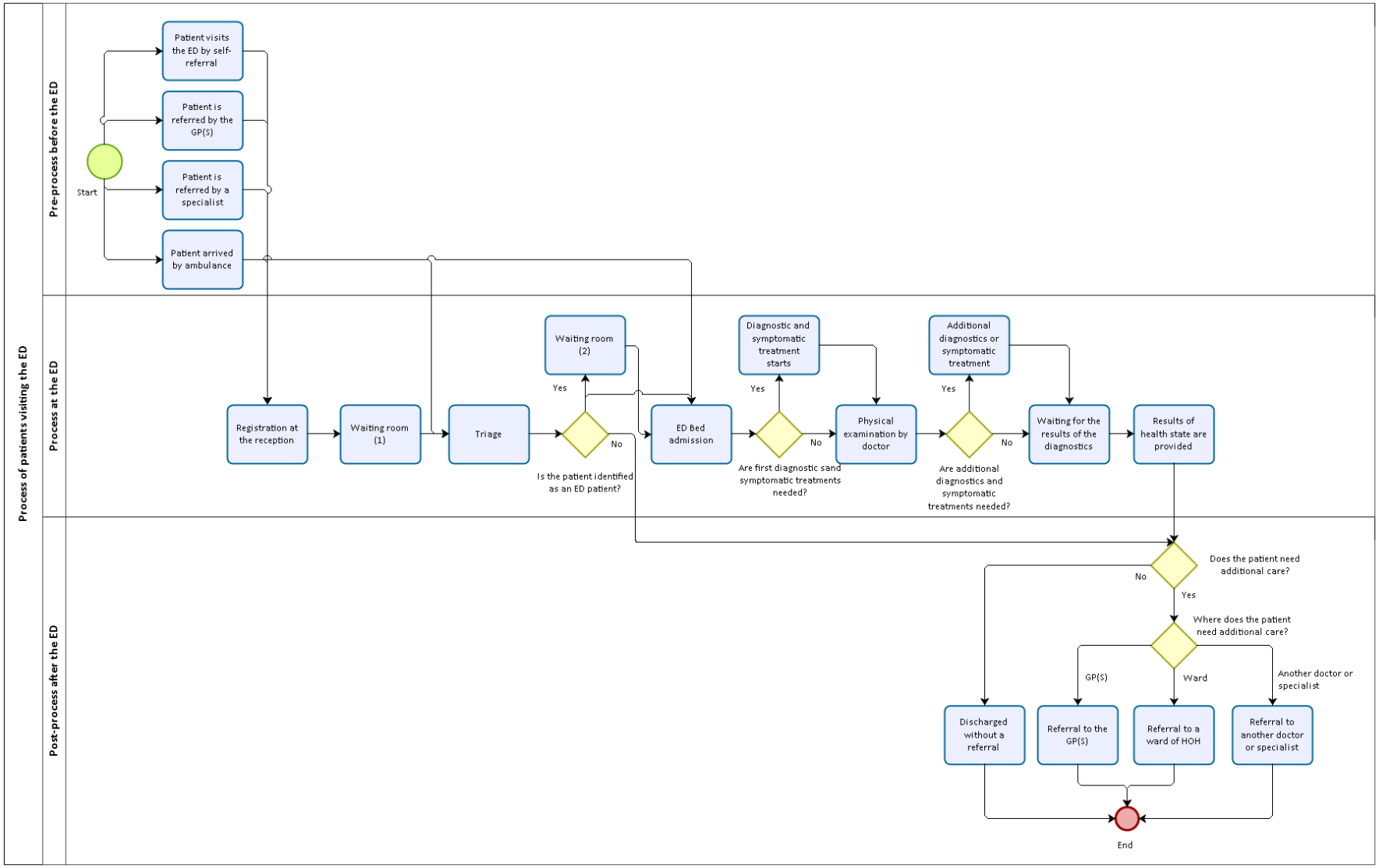

Figure 3.2: The process steps of ED arrivals.

The following process steps can be distinguished within the processes of ED arrivals. These steps are considered to be the normal ED flow:

ED arrival

This process step can be different per ED arrival. There are four modes of ED arrival:

- Self-referral: This means that the arrival visited the ED without another healthcare provider's referral. This is the biggest group of ED arrivals (73%).
- Referral by the GP(S): the GP referred the patient to the ED.
- Referral by a specialist: a specialist referred the patient to the ED.
- Ambulance: an ambulance drives the patient to the ED. The ambulance in Aruba needs to deliberate with a doctor, mostly a GP, whether the patient needs ED care. The employees of the ambulance are not qualified for this type of decision making. They are qualified to perform medical interventions.

Registration at the reception

After arriving at the ED, the patient is registered by the ED receptionist. The patient is now registered in the Electronical Medical Record (EMR).

Waiting room (1)

After being registered in the EDs' EMR, the patient has to wait in the waiting room until the triage can take place.

Triage

The patient is called by the ED nurse for triage to investigate the urgency of the patients' health-related problems. The patient is provided with an urgency colour, according to the Manchester triage system (MTS). If needed, the first diagnostic tests are already performed, for example: blood tests and urine tests.

Possible referral

The patient could be referred to another healthcare provider. The ED nurse can refer patients to a GP, the GPS or other healthcare providers. The referral is based on the opinion of the ED nurse, and sometimes the ED doctor, regarding the health problems of the patient.

Waiting room (2)

The patient waits again in the waiting room. The goal is that the waiting time of the patient is no longer than the maximum waiting time according to the urgency assigned by the MTS.

The waiting time determined in the MTS is the waiting time between the triage and determining the urgency before the patient sees an ED physician.

ED bed admission

The patient is admitted to an ED bed.

Diagnostic and symptomatic treatment

According to the result of the triage, the diagnostic and symptomatic treatment starts. A blood test has already been performed by the ED nurse.

Physical examination

The patient is physically examined by an ED doctor.

Additional diagnostics or symptomatic treatment

After the physical examination, the patient undergoes additional diagnostics or symptomatic treatment if needed.

Waiting for the results of the diagnostics

The patient waits for the results of the diagnostics and a treatment plan is made and discussed with the patient.

The results of the diagnostics

The patient receives the results of the diagnostics and their care plan.

Referral or discharge

According to the patient needs, the patient is either admitted to a ward of HOH, referred to another doctor or specialist (internal or external) or is discharged without further supervision.

3.1.2 Process of arrivals visiting the GPS

The processes of GPS arrivals are illustrated in *Figure 3.3*. The explanation of the parts within the process is provided on the next page in *Figure 3.3*.

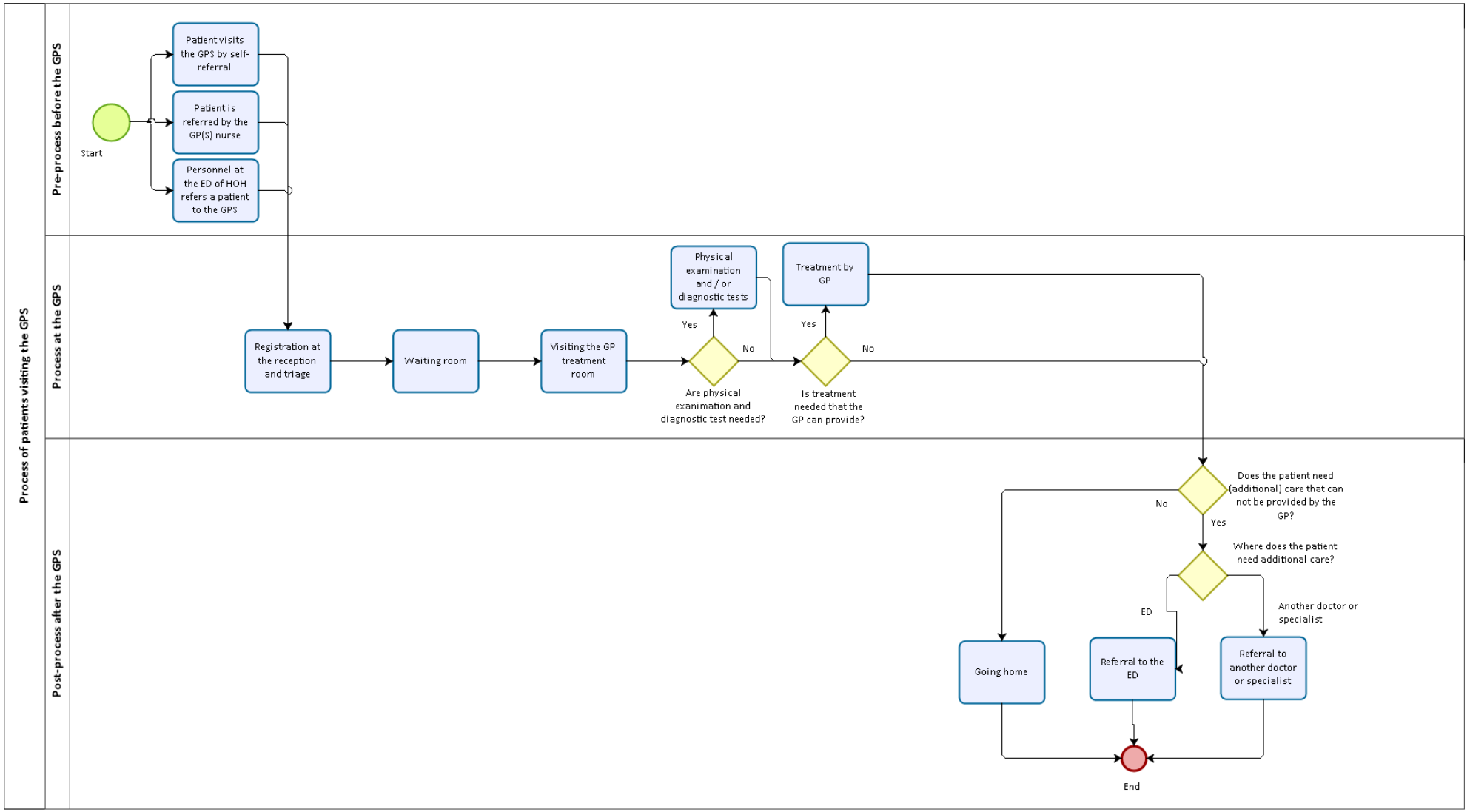

Figure 3.3: The process steps of GPS arrivals.

Arrival at the GPS

This process step can be different for every group of arrivals. Arrivals can arrive through:

- Self-referral: this means that the arrival goes straight to the GPS without any other healthcare providers suggesting the arrival to visit the GPS.
- GP-nurse: the GP-nurse advices the arrival to visit the GPS.
- ED of HOH: the ED refers the arrival to the GPS.

Registration at the reception and triage

When physically arriving at the GPS, the patient receives a ticket with a number and the patients are registered by the GPS nurse. The GPS-nurse tries to indicate the severity of the patients' health related problems based on the clinical view and experience of the GPS nurse. The GPS nurse is responsible for the order in which patients are seen by the GP.

Waiting room

The patient will take place in the waiting room and waits an uncertain amount of time before GP visit.

Visiting the General Practitioner's treatment room

The patient is called by the GP and enters the GP treatment room.

Physical examination and diagnostic tests

The patient is physically examined and diagnostics tests are conducted in order to determine the problem of the patient. However, the GP's ability to perform diagnostic tests is limited. The GP is able to perform urine and glucose tests. Other diagnostic tests should be performed in a laboratory.

Treatment

If the GP is able to perform the treatment, the patient is treated at the GPS-station.

Referral or going home

According to the patient's needs and the doctor's advice, the patient receives an ED referral, a referral to another doctor or specialist or goes home without further supervision.

3.1.3 Current collaboration between the GPS and ED

Currently, there is insufficient collaboration between the GPS and ED to provide care to ED and GPS patients at the right place. The ED nurses and doctors refer to the GPS in some

cases but mostly provide care to almost all ED arrivals. If the GPS is unable to treat the patient, the patient receives an ED referral. The GPS has limited diagnostic tests available. The GPS is unable to request other diagnostic tests, apart from the urine and glucose test. If the patient needs other diagnostic tests, the patient needs to visit the ED and the diagnostics tests are performed at the ED. If the GPS requests laboratories other than HOH's laboratory, the results of the diagnostic tests cannot be shared. This construction leads to the performance of many unnecessary diagnostic tests because of insufficient collaboration and the limited possibilities for the GPS to perform diagnostic tests.

3.1.4 Bottlenecks

During the descriptive phase of the afore mentioned processes, bottlenecks were identified:

Process of patients visiting the ED

- Self-referrals are often not patients that need ED care based on ED triage. In 2018, over 73% of ED arrivals were self-referrals. Self-referrals are often patients with low urgencies and sometimes can sometimes be treated by GP(S) care. This may contribute to the worsening of the ED performance measurements.
- The ED can determine the urgency of the patient with the MTS. However, the current urgency classifier, the MTS, is not fully able to recognise whether the patient needs ED care or is also satisfied with the care provided by another healthcare provider. This may lead to high ED waiting times and throughput time.

Process of patients visiting the GPS

- It is complex to share the results of diagnostic tests between the GPS and ED. The two organisations are not fully able to share information on diagnostic tests. This leads to additional ED waiting times and throughput time because the tests need to be performed again.
- The GPS sometimes closes before closing time, resulting in patients who do not trust the GPS as a reliable healthcare provider. This may result in more patients visiting the ED without an ED care need. This may lead to high ED waiting times and throughput time because of overcrowding of patients who do not need ED care.

Current collaboration of the GPS and ED

- There is insufficient collaboration between the GPS and ED in order to provide acute care to all patients at the right place. This leads to high ED waiting times and throughput times because of overcrowding of patients who do not need ED care.

3.2 Planning and control

This section discusses the healthcare planning and control for the current situation based on the literature provided in Section 2.1. The healthcare planning and control framework is used as a tool to gain insight into the EDs' and GPSs' planning and control decision making.

The focus of this research is mainly on the ED. However, a sufficient amount of context on the GPS is needed in order to solve the ED's ongoing problem. Unfortunately, this context on the GPS is not always publicly available. The following paragraphs describe the different levels of the healthcare planning and control framework: strategic level (Section 3.2.1), tactical level (Section 3.2.2), offline operational level (Section 3.2.3) and online operational level (Section 3.2.4). Section 3.2.5 describes the bottlenecks of the ED and GPS current processes.

3.2.1 Strategic level

This section describes the strategic level of the healthcare planning and control framework. The current complexes, triage systems, case mix profiles, production agreements, personnel and management are discussed within this level.

Current ED-complex

The ED has 13 rooms for emergency patients. These rooms vary in terms of space and usability for different types of patients. Two ED rooms are reserved for cardiac and trauma patients with high urgencies. Three ED rooms are reserved fast-track rooms, but these are also used for non-fast track patients. Eight rooms are for various types of patients.

Current GPS-complex

There is one treatment room for all patients visiting the GPS. This room has to provide care to all patients visiting the GPS during opening hours.

Triage systems: ED Triage system

The ED uses the MTS to determine the urgency of a patient's health status. Colours are assigned to patients based on their need of care. The different urgencies all have a maximum amount of waiting time between triage and bed admission. *Table 3.1* shows the classification of patients according to the MTS (HOH, 2018a).

Table 3.1: Manchester triage system (HOH, 2018a).

Name	Urgency	Maximum waiting time after triage
Immediate	**Red**	0 minutes
Very urgent	**Orange**	10 minutes
Urgent	**Yellow**	60 minutes
Standard	**Green**	120 minutes
Non-urgent	**Blue**	240 minutes

Triage systems: GPS triage system

The GPS does not use a triage system to determine the urgency of the patient's health status. The GPS uses the expertise of the GPS nurse in order to determine the urgency of the patient's health status. The GPS nurse also determines if the patient needs to see the GP that is working at that moment. When more patients arrive at the GPS, the GPS nurse determines in which order the patients need to be seen by the GP.

Case mix profile: ED

Dr. Horacio E. Oduber Hospital is the only hospital on Aruba. The hospital also treats patients coming from Instituto Medical San Nicolas (ImSan), which has an ED but can only provide limited types of care to patients. The diagnostic departments of ImSan are closed in the evening and during the night. This means that these patients should have to visit the ED of HOH in order to be diagnosed. Sometimes, patients from the other ABC-islands, Bonaire and Curacao, need urgent care in Aruba.

Data from 2018 show that 34,621 patients visited the ED of HOH. In 2018, 6,246 (18.0%) of patients were admitted to a ward in the hospital for further investigation of their health status after visiting the ED. *Figure 3.4* shows the distribution of ED arrivals' urgency in 2018 (HOH, 2018b).

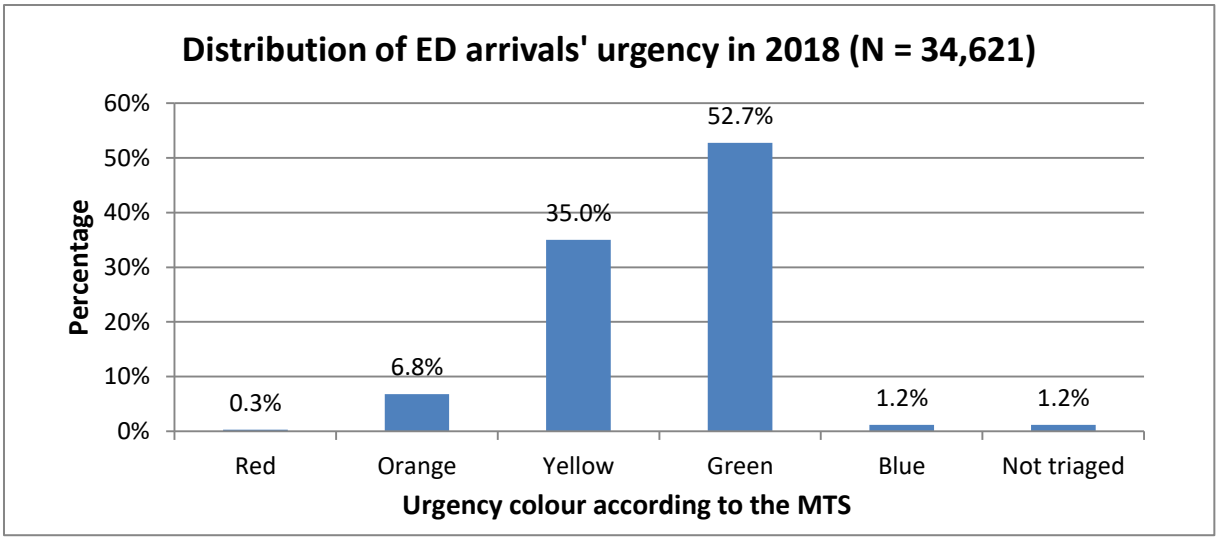

Figure 3.4: Distribution of ED arrivals' urgency in 2018 (N = 34,621) (HOH, 2018b).

Emergency Department arrivals have different health related problems. The hospital provided data on the main health-related problems. The data was gathered from 15 April, 2018 until 22 April, 2018. During this week, a total of 632 ED arrivals were registered. Most arrivals arrived with injury and poisoning (27.6%) or symptoms, signs and abnormal findings (20.9%). *Figure 3.5* shows the distribution of the arrivals' main health related problem (HOH, 2018b).

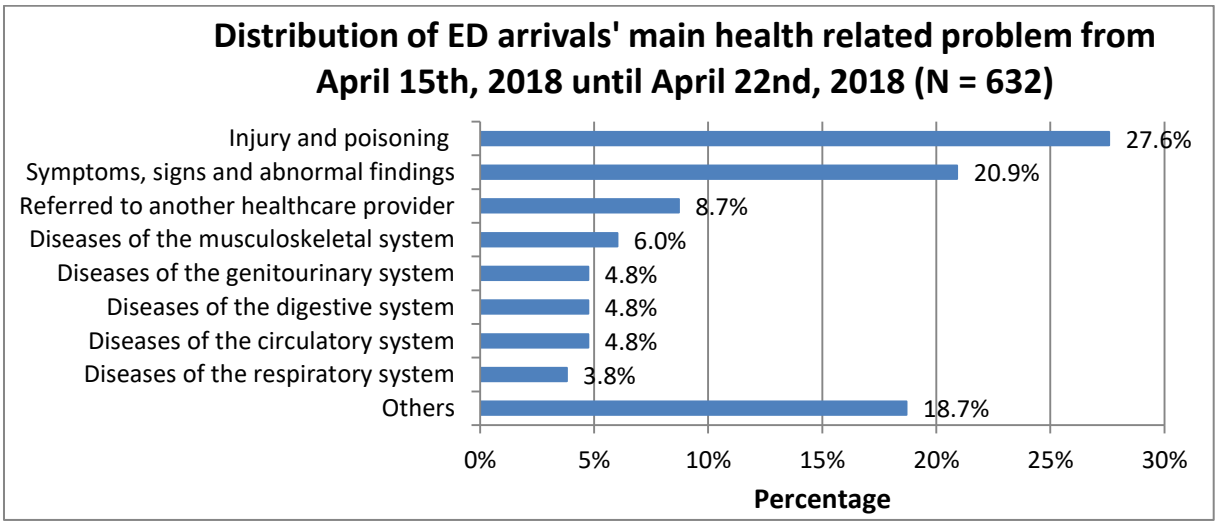

Figure 3.5: Distribution of ED arrivals' main health related problem from April 15th, 2018 until April 22nd, 2018 (N = 632)

Case mix profile: GPS

The GPS is close to the ED and provides GP care to approximately 13,000 patients each year. Between May 2018 and October 2018, 84.9% (5,488 patients) visited the GPS without visiting the ED on the same day. A total of 15.1% (977 patients) visited both on the same day.

Production agreements: ED

The ED's production agreements are determined with the Algemene Ziektekosten Verzekering (AZV). The AZV makes agreements on how many patients can be treated by the corresponding institution. Every performed treatment needs an AZV declaration. After reaching the budget for a specific treatment, the compensation for a treatment is stopped. It is complex to strictly adhere to ED production agreements, which is why AZV does not limit the number of ED arrivals. Furthermore, AZV does not include any deductibles for health care.

Production agreements: GPS

The GPS's production agreements are also determined with the AZV. The AZV states that the GPS should see at least 40 patients per shift. After 40 patients, the GPS can close even before its closing time.

Personnel: ED

A summary of the ED personnel, all employed by HOH, is provided. The profession is given and the number of employees is given between brackets:

- Receptionists (8)
- Nursing staff (21)
- Doctors (9)
- Plaster technician (2)

Personnel: GPS

A summary of the GPS personnel, all employed by the GPS, is provided. The profession is given and the number of employees is given between brackets:

- Nurses (3)
- GP (2)

Management team of the ED

The hospital has a management team that is responsible for managing the ED. The management team makes decisions on different hierarchical levels concerning the ED complex. The management team of the ED consist of the following members:

- Medical manager
- Care manager
- Assistant care manager

3.2.2 Tactical level

This section describes the tactical level of the healthcare planning and control framework. The ED workload per month, personnel staffing, shifts and cardiac and trauma patients at the ED are discussed within this level.

The ED workload per month

Figure 3.6 and additional information provided in Appendix A: Context analysis *Table A.1* show the ED workload per month and per urgency in 2018. The urgency level red has very few ED arrivals, as confirmed by Appendix A: Context analysis *Table A.1.* The urgency level that most frequently visited the ED was green (on average: 1,533 patients per month). Additionally, the number of ED arrivals varied from 2,691 (June) to 3,165 (March). In March, all urgency levels had more ED visits (HOH, 2018b). The average number of ED arrivals was approximately 2,892 patients per month with a standard deviation of 162 arrivals. This results in a 95% confidence interval of 2,800 – 2,984 arrivals. In 2018, therefore, there were significantly more ED arrivals than the average in January, February, March and November. In June, July, August and September, there were significantly fewer patient visits than average. This is based on the average number of days per month (30.4 days) corrected for the number of days per month.

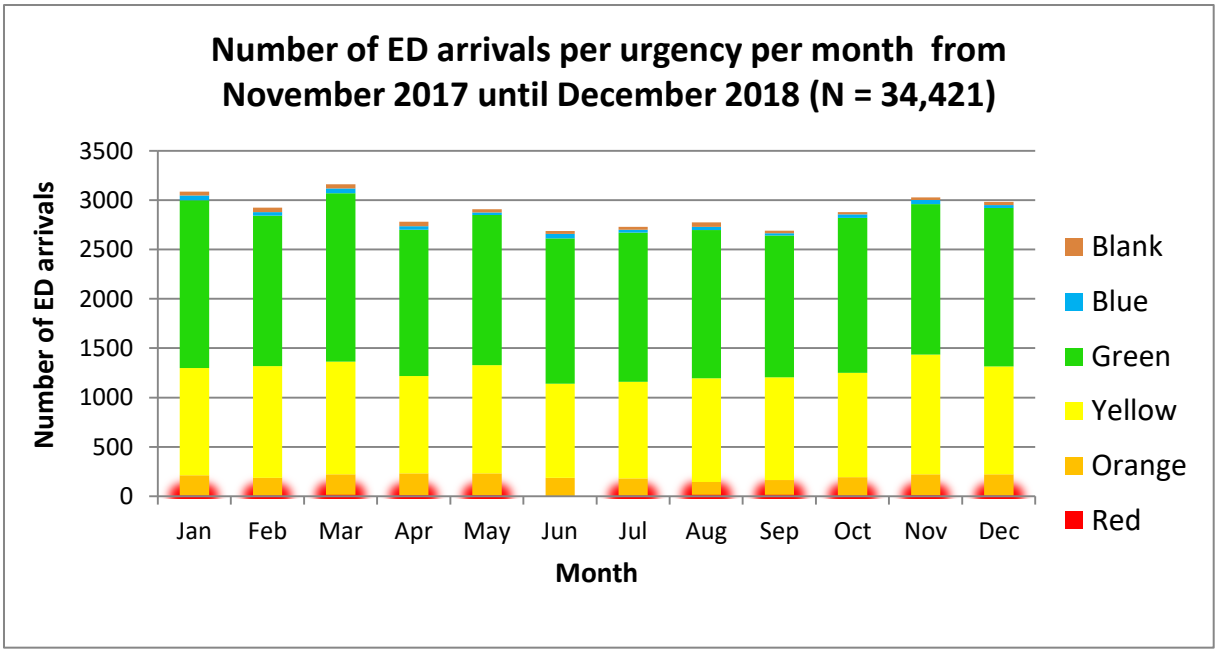

Figure 3.6: ED workload per urgency per month from November 2017 until December 2018 (N = 34,421).

Personnel staffing: ED

An ED team consists of the following employees present in different numbers per shift:

- Receptionist(s) (1-2)
- Nurses (3-5)
- Doctor(s) (1-2)

The ED doctors and nurses need to supervise multiple patients per shift. In Appendix A: Context analysis *Table A.2* and *A.3* provide further information on the shifts for ED personnel and the number of employees working per shift.

Personnel staffing: GPS

A standard GPS team consists of the following people present in the same numbers per shift:

- Nurse (1)
- GP (1)

Within the GPS, the nurse and GP working during a shift treat one patient at a time in the treatment room. The number of employees working at the GPS does not vary during the day or during shifts. Appendix A: Context analysis *Table A.4* provides insight in the shifts for GPS personnel and the number of employees working per shift.

ED shifts and GPS shifts

The ED and GPS are currently working with different shifts with different employees. An overview of the ED's working hours and shifts from Monday to Sunday for the nurses and doctors is given in Appendix A: Context analysis *Tables A.2* and *A.3.* An overview of the GPS's working hours and shifts from Monday to Sunday without holidays is given in Appendix A: Context analysis T*able A.4.* The desired ED occupation per shift is: five nurses and two doctors during the day shift, six nurses and three doctors during the evening shift and four nurses and two doctors during the night shift. However, because of shortness in staff, these numbers cannot be accomplished and the current ED occupation is: five nurses and two doctors during the day shift, five nurses and two doctors during the evening shift and three nurses and one doctor during the night shift.

Cardiac and trauma patients at the ED

There are two ED beds reserved for cardiac and trauma patients. Patients that are assigned to these beds are clinically unstable and mostly were triaged with high urgency according to the MTS. Four nurses and one doctor are present during a resuscitation, two nurses and one doctor supervise the patients until clinically stable. When the patient is clinically stable, the capacity returns to normal.

3.2.3 Offline operational level

This section describes the offline operational level of the healthcare planning and control framework. The ED workload during the week and anticipation on the workload during the week are discussed within this level.

The ED workload during the week

For 2018, the ED workload is given per urgency during the week. *Figure 3.7* and Appendix A: Context analysis *Table A.5* represent the number of ED arrivals per day and per urgency (HOH, 2018b). The average number of ED arrivals was 94 arrivals per day with a standard deviation of 3.4 arrivals. This results into a 95% confidence interval of 91.8 – 96.8. There were significantly more patient visits on Sundays. On Tuesdays and Thursdays, there were significantly fewer patient visits based on the number of days in 2018 (53 Mondays, 52 for the other days).

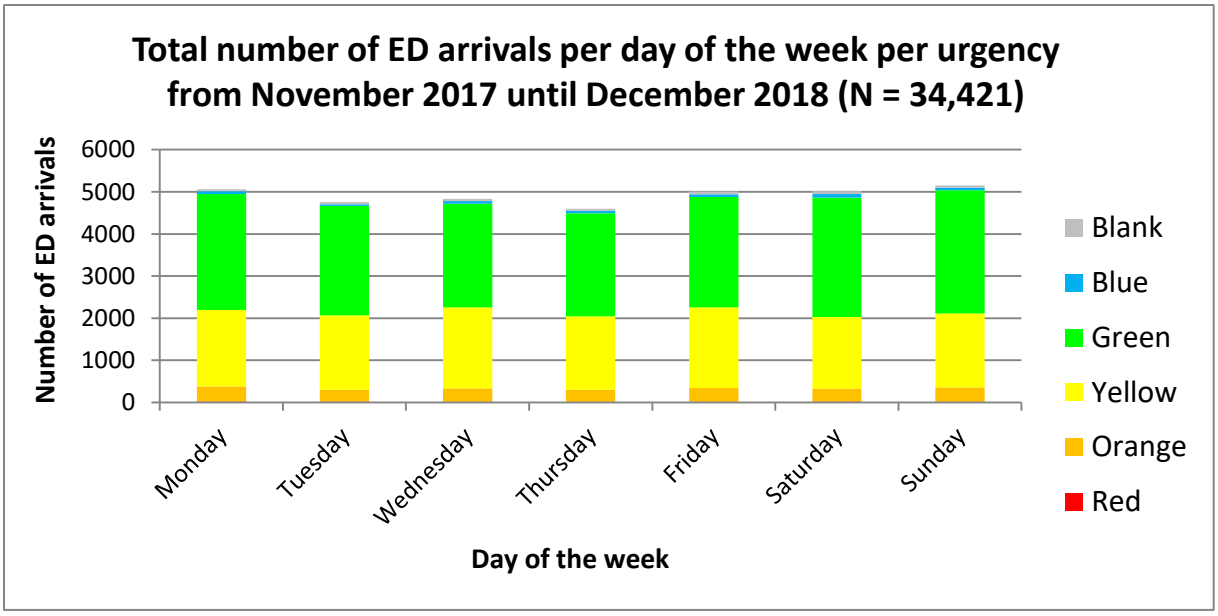

Figure 3.7: ED workload per urgency per day from November 2017 until December 2018 (N = 34,421).

Figure 3.7 and Appendix A: Context *Table A.5* show that, there is variation present for the different days of the week. Most ED arrivals occurred on Sundays. The number of patients per day was, from lowest to highest: Thursday, Tuesday, Wednesday, Friday, Saturday, Monday and Sunday. A higher number of ED arrivals during the weekends makes sense because the GPs are not opened and the GPS is only partly opened. It can also be seen that most patients are triaged with urgency level: 'green', followed by: yellow, orange, blue, blank and red.

Anticipating the workload during the week

The hospital tries to anticipate the workload during the week. During the weekends, they strive to have one additional doctor present from 20:00 to 04:00 because the workload is perceived to be higher. However, during the other days of the week and other parts of the weekends, there is no anticipation regarding the workload.

3.2.4 Online operational level

This section describes the online operational level of the healthcare planning and control framework. The ED workload during the day per urgency, urgent patients and the additional capacity at the ED are discussed within this level.

The ED workload during the day per urgency

For 2018, the ED workload is given per hour of the day and per urgency in *Figure 3.8* and Appendix A: Context analysis *Table A.6. Figure 3.8* and Appendix A: Context analysis *Table A.6* represent the number of ED arrivals during the day per urgency. The figure and table show that during the night, the number of patients is the lowest. Urgency 'green', followed by 'yellow', was always the urgency that occurred the most during the different hours (HOH, 2018b).

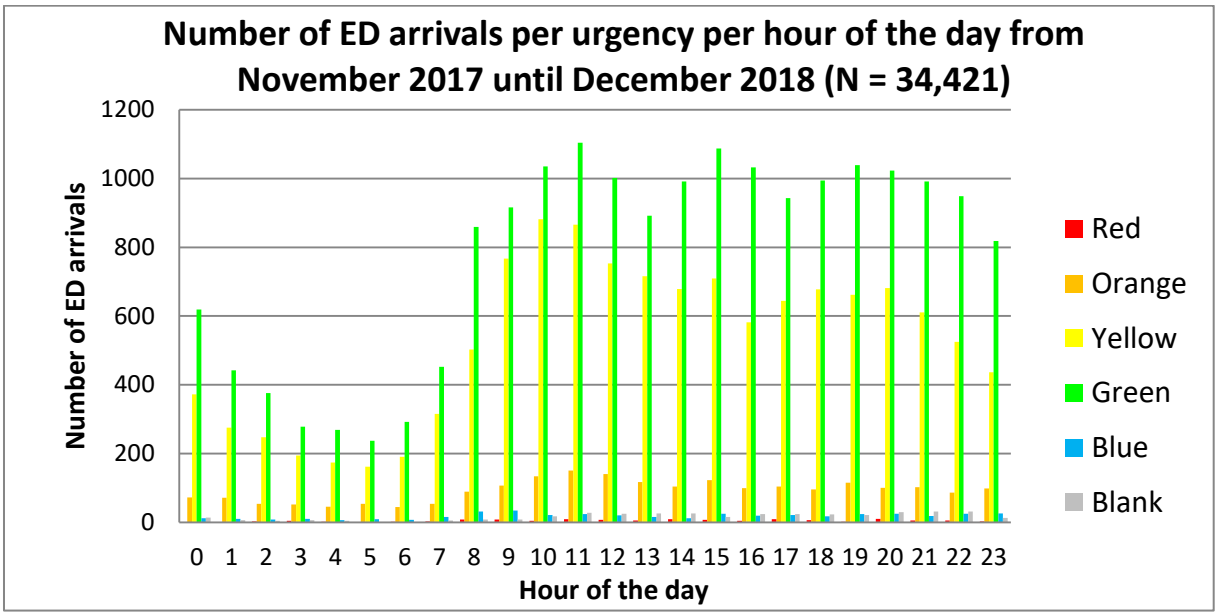

Figure 3.8: ED workload per urgency per hour from November 2017 until December 2018 (N = 34,421)

Urgent patients

The ED and GPS provide urgent care. Patients can arrive at any time with any urgency possible. This means that the ED and the GPS are actively occupied within this level and need to actively change processes in order to provide fast and good care to visiting patients.

Additional capacity at the ED

There is no additional ED capacity present or on hold when there are more arrivals or when higher urgency arrivals visit the ED. The rule of thumb within the ED is that when there are more than six unstable patients within a level of urgency assigned by the MTS of orange or above, the nurses contact colleagues for additional capacity.

Patients who leave without triage

There are several patients that leave the ED before being triaged. Totally, 47,067 ED arrivals visited the ED during the period of July 2017 until November 2018. A total of 1,216 ED arrivals did not stay until the triage during this period. During the shifts of this period, these ED arrivals who do not wait for triage were distributed as follows (HOH, 2018a):

- Day shift (07:00 – 15:00): a total of 470 ED arrivals did not stay until the triage. On average, this is almost 1 (0.9) arrival per day shift, who does not stay until the triage.
- Evening shift (15:00 – 23:00): a total of 551 ED arrivals did not stay until the triage. On average, this is 1 arrival per evening shift who does not stay until the triage.
- Night shift (23:00 – 07:00): a total of 195 ED arrivals did not stay until the triage. On average, this is 0.3 arrival per night shift who does not stay until the triage. Every three days one ED arrival does not stay until the triage during the night shift.

Arrivals that leave before ED bed admission or have abnormal flow

There are several patients who leave the ED before being admitted to a bed or have abnormal flow. Abnormal flow is classified as ED arrivals who do not follow the normal flow stated in Section 4.1.3. A total of 35,128 patients were included in this calculation during the period of July 2017 until November 2018. A total of 11,907 patients did not stay until the ED bed admission or had abnormal flow during this period. During the shifts of this period, these patients were distributed as follows:

- Day shift: 3,862 (32%) arrivals left before bed admission or had abnormal flow.
- Evening shift: 5,557 (47%) arrivals left before bed admission or had abnormal flow.
- Night shift: of 2,488 (21%) arrivals left before bed admission or had abnormal flow.

3.2.5 Bottlenecks

Using the healthcare planning and control framework, the following bottlenecks were identified:

- HAVA does not want more patients to visit the GPS or to offer longer opening hours. However, some GPs and GP nurses do want the GPS to be open longer because this might reduce ED waiting times and throughput times.
- Patients perceive long ED waiting times, which probably leads to lower patient satisfaction.

- Patients can visit the ED an unlimited number of times without paying deductibles. This means that there is no incentive to choose the right healthcare provider for their health problems. This may lead to high ED waiting times and throughput time.
- The ED planning does not fully anticipate the variation in demand during the months, weeks and days. This may lead to variation in ED waiting times and throughput times.
- Because of high variation in ED arrivals, the staff members of the ED sometimes perceive a heavy workload.

4 Quantitative performance analysis: the current situation

The quantitative performance analysis of the current situation describes the current ED performance based on selected KPIs. Section 4.1 presents the selection of KPIs using input from stakeholders, the mission and vision of HOH and literature. Section 4.2 considers the conclusion concerning the first research question. Section 4.3 provides the results of the ED performance based on the selected KPIs and the relations between the KPIs. Section 4.4 discusses the conclusion on the second research question.

The fourth chapter aims to answer the second research question stated in Section 1.3:

- *To what extent are Key performance indicators (KPIs) of the ED performance defined and what is the current ED performance?*

4.1 Selection of key Performance Indicators

This paragraph discusses the stakeholders (Section 4.1.1), the selection of KPIs (Section 4.1.2), definition of KPIs (Section 4.1.3) and bottlenecks (Section 4.1.4).

4.1.1 Stakeholders

Section 2.2 describes how to identify stakeholders according to the stakeholder theory. Several stakeholders are involved in the selection and definition phase of the KPIs. The stakeholders are:

- The government that wants the ED to fulfil legal requirements and quality standards.
- (assistant) ED manager, who wants all arrivals to receive care using available resources.
- The ED nurse who wants a workable workload and working circumstances.
- The ED doctor who wants a workable workload and working circumstances.
- The patient who wants to be treated as fast and as effectively as possible.
- HOH that wants to earn income in the most efficient way and fulfil its care tasks for the population of Aruba.
- AZV, the insurance company that procures healthcare in Aruba.

4.1.2 Selection of KPIs

Section 2.3 describes how to create KPIs and which KPIs were selected to measure the ED performance. In this section, the KPIs are selected.

Currently, the ED management has not yet defined the ED's KPIs, which results in an incomplete assessment of the ED's performance. However, according to *'Hunto Miho',* there should be statistical insight in order to make decisions and implement interventions. This means that before the ED performance is measured, the KPIs need to be selected and defined.

The KPIs need to connect to the mission and vision of HOH, as described in Section 1.1.4. Six core pillars were defined with their corresponding long term goals that are crucial to the service provided by the hospital. The KPIs were selected according to the research literature, the stakeholders and the mission and vision of HOH. The core pillars are measured using the KPIs. *Table 4.1* provides the core pillars and their linked KPIs.

Table 4.1: Core pillars linked to selected KPIs.

Core pillar:	**Measured by the KPI(s):**
Reliable care	Throughput time: patients should not have a longer ED stay than needed. Waiting time 1: patients should be treated as soon as possible. Waiting time 2: patients should be treated as soon as possible. Waiting time 3: patients should be treated as soon as possible. ED arrivals being seen by an ED physician: patients should not leave without treatment or referral.
Patient-centred	Throughput time: the throughput time should be as low as possible while still providing care with good quality. Waiting time 1: the waiting time should be as low as possible while still providing care with good quality. Waiting time 2: the waiting time should be as low as possible while still providing care with good quality. ED arrivals being seen by an ED physician: patients visit the ED with a care need, patients should not leave the ED without treatment or referral.
Professional	Throughput time: employees should make effort in order to keep throughput time as low as possible. Waiting time 1: employees should make effort in order to keep waiting time as low as possible.

	Waiting time 2: employees should make effort in order to keep waiting time as low as possible.
Together	ED arrivals who can be treated by GP(S) care: only patients that do need ED care should visit, otherwise there should be a possibility to refer to other healthcare providers.
Healthy business environment	Throughput time: the longer a patient is admitted to a an ED bed, the more this patient costs. Room utilisation: provides insight on how effectively resources are used. Nurse and doctor utilisation: provides insight on how effectively the resources are used. ED arrivals who can be treated by GP(S) care: patients that do not need ED care should not visit the ED in order to ensure efficient use resources.
We, the HOH	Nurse and doctor utilisation: the employees should not perceive the workload as too high in order to be an attractive employer. ED arrivals who can be treated by GP(S) care: patients should only visit the ED when ED care is needed.

4.1.3 Definition of the KPIs

The KPIs will be defined according to the time events at the ED stated by HOH (HOH, 2018a). *Figure 4.1* shows these time events.

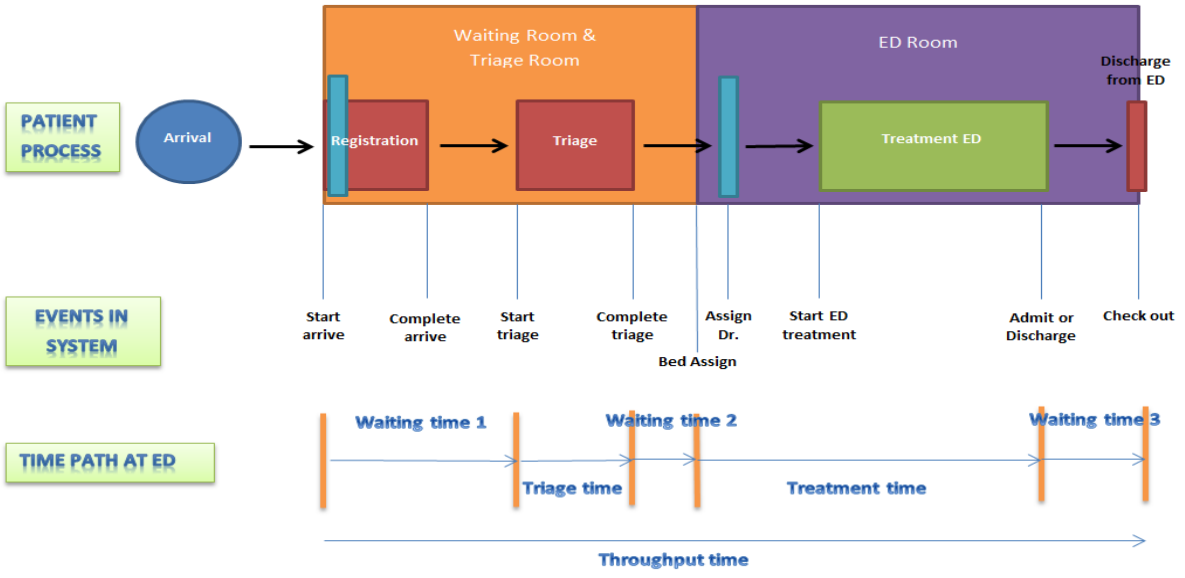

Figure 4.1: Defined time events at the ED of HOH (HOH, 2018a).

The patient process, events in the system and the time path at ED are presented in *Figure 4.1*. The ED's patient process has already been described in Section 3.1. The events in the EMR are all events that are registered into the ED system. The events in the EMR are:

- Start arrive: the patients' registration starts in the EMR
- Complete arrive: the patients' registration is completed in the EMR.
- Start triage: the patients' triage starts in the EMR.
- Complete triage: the patients' triage is completed in the EMR.
- Bed assign: the patient is assigned to a bed in the EMR.
- Assign Dr.: the patient is assigned to a doctor in the EMR.
- Start ED treatment: the patient starts treatment in the EMR.
- Admit or discharge: the patient completes treatment in the EMR.
- Check out: the patient checks out of the ED; the patient leaves the ED bed physically.

These events in the EMR ultimately provide the EDs' time path. The EDs' time path is:

- Waiting time 1: the time between start arrive until start triage.
- Triage time: the time between start triage until complete triage.
- Waiting time 2: the time between complete triage and bed assign.
- Treatment time: the time between bed assign until admit or discharge.
- Waiting time 3: the time between admit or discharge until check out.
- Throughput time: the time between start arrive and check out.

1. Throughput time

Definition: Throughput time is defined as the time between the first registration at the receptionist and the moment the patient checks out of the ED.

Motivation: Throughput time was one of the important KPIs to take into account when measuring the ED performance (Abo-Hamad & Arisha, 2013; Sørup, Jacobsen & Forberg, 2013; Wilson & Nguyen, 2004). This indicator was selected because the throughput time provides information about the total time that a patient is present at the ED. In *Figure 4.1* this is called: 'Throughput time'.

Indicator: Percentage of arrivals who have their throughput time within the norm.
Numerator: Number of arrivals who have their throughput time within the norm.
Denominator: Total number of ED arrivals.

Norm: The norm for throughput time was determined by the stakeholders. The norm is: the MTS norm for waiting time 2 plus 2 hours and 30 minutes. This results in the following norms for the urgencies: red: 2 hours and 30 minutes; orange: 2 hours and 40 minutes; yellow: 3 hours and 30 minutes; green: 4 hours and 30 minutes; and blue: 6 hours and 30 minutes.

Important for calculation: Because the throughput time varies per urgency level, the indicator is calculated per urgency level. Excluding:

- patients who were not admitted to an ED bed.
- double registrations, when there are accidental double registrations present, only the first registration was included.
- patients who were not triaged.

Period: January 2018 until April 2019.

2. Waiting time 1

Definition: Waiting time 1 is defined as the percentage of arrivals that start triage within 15 minutes. HOH states that an arrival should start triage within 15 minutes.

Motivation: This indicator was selected because the main ED problem is that there is too much waiting time perceived by the patient. Waiting time 1 has been described to be one of the KPIs to measure ED performance (Abo-Hamad & Arisha, 2013; Sørup, Jacobsen & Forberg, 2013; Wilson & Nguyen, 2004). Waiting time 1 is not desirable for the ED since HOH wants to help arrivals as soon as possible. The triage is the first moment arrivals are examined by an ED-employee with medical knowledge, which is another reason that waiting time 1 is not desirable. In *Figure 4.1* called: 'Waiting time 1'.

Indicator: Percentage of arrivals who start with triage within 15 minutes.

Numerator: Number of arrivals who start with triage within 15 minutes.

Denominator: Total number of ED arrivals.

Important for calculation: Excluding:

- double registrations, when there are accidental double registrations present, only the first registration was included.
- patients who were not triaged.

Period: January 2018 until April 2019.

3. *Waiting time 2*

Definition: Waiting time 2 is defined as the percentage of arrivals who do not wait longer than the maximum waiting time after triage according to the MTS.

Motivation: Waiting time 2 was selected as a KPI because the main ED problem is that the patient perceives too much waiting time. Waiting time 2 has been described to be one of the KPIs to measure the ED performance (Abo-Hamad & Arisha 2013; Sørup, Jacobsen & Forberg, 2013; Wilson & Nguyen, 2004). Waiting time 2 is not desirable since HOH wants to help their patients as soon as possible after determining their health problems during the triage. In *Figure 4.1* called: 'Waiting time 2'.

Indicator: Percentage of arrivals who do not wait longer than the MTS norm after triage.
Numerator: Number of arrivals who do not wait longer than the MTS norm after triage.
Denominator: Total number of ED arrivals.
Important for calculation: Waiting time 2 is calculated per urgency level. Excluding:

- patients who were not admitted to an ED bed.
- double registrations, when there are accidental double registrations present, only the first registration was included.
- patients who were not triaged.

Period: January 2018 until April 2019.

4. *Waiting time 3*

Definition: Waiting time 3 is defined as the time that a patient has to wait for admission to a ward of HOH until the physical check out.

Motivation: Waiting time 3 was selected as an indicator because the main ED problem is that there is too much waiting time perceived by the patient. Waiting time 3 has been described as one of the KPIs to measure the ED performance (Abo-Hamad & Arisha, 2013; Sørup, Jacobsen & Forberg, 2013; Wilson & Nguyen, 2004). Waiting time 3 is present when the patient receives ED treatment but needs additional care on a ward. If waiting time 3 is present, the patient, unnecessarily, occupies an ED bed. This means that waiting time 3 is not desirable. In *Figure 4.1* called: 'Waiting time 3'.

Indicator: Average waiting time 3.

Calculation: the average time between the admission to a ward until the patient gets physically checked out of the ED and brought to a ward.

Important for calculation: Excluding:

- patients who were not admitted to an ED bed.
- double registrations, when there are accidental double registrations present, only the first registration was included.
- patients who were not triaged.
- patients who were not admitted to a ward at HOH.

Period: January 2018 until April 2019.

5. Room utilisation

Definition: Room utilisation is defined as the percentage of time that ED rooms are being occupied by patients divided by the ED's total time available.

Motivation: According to a systematic review by Sørup, Jacobsen and Forberg (2013) on the evaluation of ED performance, room utilisation is one of the KPIs that is important to take into account when measuring the ED performance. A high utilisation can result in high waiting and throughput times (Abo-Hamad & Arisha, 2013). Additionally, this KPI was selected to be part of the calculations because the room utilisation of the total available time at the ED provides information about the actual usage of the total time that is available at the ED.

Indicator: Percentage of net room utilisation.

Numerator: Treatment time plus waiting time 3.

Denominator: Total time available at the ED per type of room (* 100%).

Important for the calculation: The ED is open 24 hours per day. In total, the ED consists of 13 rooms. There are 8 general rooms, 3 fast-track rooms and 2 cardiac and trauma rooms for patients with high urgency levels. This indicator is calculated per type of room. Excluding:

- patients who were not admitted to an ED bed.
- double registrations, when there are accidental double registrations present, only the first registration was included.
- patients who were not triaged.

Period: January 2018 until April 2019

6. *Nurse and doctor utilisation*

Definition: Nurse and doctor utilisation is defined as the ratio between the average number of rooms occupied by patients and the number of employees providing care to patients that are admitted to an ED bed.

Motivation: Generally, utilisation was one of the KPIs that was important to measure the ED performance. There are different types of utilisation. Because HOH suffers from a shortage of ED employees, it was important to also measure nurse and doctor utilisation to gain insight into the ED workload. This KPI was selected to protect employees from the consequences of a (too) low room utilisation result, which was caused by shortage of employees.

Indicator: Ratio of net nurse and doctor utilisation.

Numerator: Room utilisation * 13 (total number of ED rooms).

Denominator: Average number of nurses or doctors providing care at the ED, excluding the triage nurse because this nurse is not assigned to ED patients.

Important for calculation: The ED is open 24 hours per day. In total, the ED consists of 13 rooms. This indicator is specified per nurse and doctor. Excluding:

- patients who were not admitted to an ED bed.
- double registrations, when there are accidental double registrations present, only the first registration was included.
- patients who were not triaged.

Period: January 2018 until April 2019

7. *ED arrivals who can be treated by GP(S) care*

This KPI consists of three parts: patients referred to their GP or GPS during triage, patients admitted to a bed but who could be treated through GP(S) care and the total number of patients who need GP(S) care. *Table 4.2* elaborates on these parts of the KPI. This KPI was not registered in the EMR. This KPI was measured manually by nurses and doctors. The nurses and doctors were asked to write down whether an arrival needed GP(S) care or ED care for one week.

Table 4.2: Calculation of ED arrivals who can be treated by GP(S) care.

	Arrivals referred to their GP or GPS during triage.	Arrivals admitted to a bed but who could be treated through GP(S) care.	Total number of arrivals that need GP(S) care.
Definition:	Arrivals that are recognised as GP/GP(S) arrivals during triage.	Arrivals that are recognised as GP(S) arrivals after ED bed admission.	Arrivals that should visit their GP or the GPS in order to receive treatment.
Motivation:	Arrivals that can be treated by GP(S) care and therefore do not need to visit the ED or need care provided by the ED was also an important KPI. The ED wants to lower the burden by only treating arrivals that are actually in need of ED care. Arrivals that need GP care should visit a GP or the GPS.		
Indicator:	Percentage of arrivals who are referred to their GP or GP(S) during triage.	Percentage of arrivals who are admitted to a bed but could be treated by the GP(S).	Percentage of arrivals who should visit their GP or the GPS in order to receive treatment.
Numerator:	Number of arrivals that were referred to a GP or GPS during triage.	Number of arrivals that were assigned to a bed but could also be treated by GP care.	Total number of arrivals that can be treated by GP(S) care.
Denominator:	Total number of arrivals triaged.	Total number of arrivals assigned to a bed.	Total number of arrivals triaged.
Important for calculation:	Calculated per urgency level. Excluding: - arrivals who were not admitted to an ED bed. - double registrations, when there are accidental double registrations present, only the first registration was included. - arrivals who were not triaged.		
Period:	06-05-2019 07:00 to 13-05-2019 07:00	06-05-2019 07:00 to 13-05-2019 07:00	06-05-2019 07:00 to 13-05-2019 07:00

8. ED arrivals being seen by an ED physician

Definition: This KPI is defined as patients who were examined by an ED physician.

Motivation: The number of ED arrivals that ultimately were examined by a physician was an important KPI (Wilson & Nguyen, 2004). Leaving could be because of waiting times, patient reception or triage problems (Sørup, Jacobsen & Forberg, 2013).

Indicator: Percentage of arrivals that were being seen by an ED physician.

Numerator: Number of arrivals that registered at the reception and were later assigned to an ED bed.

Denominator: The total number of arrivals visiting the ED (*100%).

Important for calculation: Excluding:

- double registrations, when there are accidental double registrations present, only the first registration was included.

Period: January 2018 until April 2019

4.1.4 Bottlenecks

During the selection and description of the KPIs, the following bottlenecks were identified:

- The current ED performance was partly unknown. However, ED waiting times and throughput time were known.
- The KPIs were not defined. This means that was is not clear what and how to measure the performance. The ED was only partly able to steer on performance.
- The management decisions were harder to make because there were no acceptable targets or goals defined for the KPIs.

4.2 Conclusion

In Sections 3.1, 3.2 and 4.1, the aim was to answer the first research question stated in Section 1.3:

- *What bottlenecks are perceived by the ED regarding the entire patient process at the ED of HOH and GPS and what resources are used?*

Several bottlenecks were identified based on the previous discussion. The bottlenecks were divided into four categories: patient, GPS, planning and steering on performance. Per

category, the bottlenecks were described. An overview of the description of each bottleneck are provided in Sections 3.1.4, 3.2.5 and 4.1.4.

Patient

- Over 73% of ED arrivals are self-referrals who often do not need ED care.
- Patients can visit the ED an unlimited number of times without paying deductibles.
- Patients perceive long ED waiting times.
- The Manchester triage system (MTS) is not fully able to recognise whether the patient needs ED care or is could be cared for by another healthcare provider.

General Practitioner's Station (GPS)

- The GPS sometimes closes before closing time.
- Huisartsenvereniging Aruba (HAVA) does not want more patients to visit the GPS or to have longer opening hours.
- There is insufficient collaboration between the GPS and ED.
- It is complex to share the results of diagnostic tests between the GPS and ED.

Planning

- Staff members of the ED sometimes perceive a great working load.
- ED planning does not fully anticipate variation in demand.

Steering on performance

- The current ED performance is partly unknown.
- The KPIs were not defined.
- There are no acceptable goals defined for the KPIs.

4.3 Results of the ED performance based on selected KPIs

Within this section, the data (Section 4.3.1), demographics (Section 4.3.2) and the calculation of the selected KPIs (Section 4.3.3) are described.

4.3.1 Data

To measure ED performance, two data files were used. The first dataset was HOH's ED data from 1 January 2018 until 30 April 2019, which was used for all KPIs, except the KPI: 'ED arrivals who can be treated by GP(S) care'. This dataset is referred to as: dataset 1. For this

one exceptional KPI, data from 6 May 2019 07:00 until 13 May 2019 07:00 was used. This dataset is referred to as: dataset 2. All data in dataset 1 was registered by HOH in the EMR. The data in dataset 2 was obtained manually because this was not registered in the EMR. Dataset 2 was measured for one week by ED nurses and doctors to identify the percentage of ED arrivals who need ED care. The following adjustments were made per dataset:

- Dataset 1 consisted of 46,383 raw data entries of which 46,086 remain. Data entries with the same Encounter ID were removed because these data entries are considered to be double registrations. This resulted in the removal of 297 data entries.
- Dataset 2 consisted of 701 raw data entries of which 636 remain. Removing data entries was also based on the same Encounter ID. This resulted in the removal of 65 data entries.

The data was further adjusted in order to be suitable to measure the specific KPI. The following adjustments were made:

- For the KPIs throughput time, waiting time 2, waiting time 3, room utilisation and nurse and doctor utilisation, data entries that were not admitted to a bed were removed since only data entries admitted to a bed need to be included.
- For all KPIs except ED arrivals being seen by an ED physician, data entries that were not triaged were removed since only patients that were triaged were included.
- For the KPI 'waiting time 3', data entries that were not admitted to a bed at a ward were removed, since they do not have this type of waiting time.

The data entries removed with these adjustments and included in the calculations of the KPI are presented in *Table 4.3.*

Table 4.3: Included number of data entries per dataset after mentioned adjustments

	Dataset:	Total data entries removed:	Total data entries included:
Throughput time	1	13,238	33,145
Waiting time 1	1	835	45,548
Waiting time 2	1	13,238	33,145
Waiting time 3	1	38,393	7,990
Room utilisation	1	13,238	33,145

Nurse and doctor utilisation	1	13,238	33,145
ED arrivals who can be treated by GP(S) care	2	65	636
ED arrivals being seen by an ED physician	1	297	46,086

4.3.2 Demographics

The demographics of dataset 1 (N = 46,086) and dataset 2 (N = 636), excluding doubled patients (N = 46,086), are described in *Table 4.4*. It can be concluded that the two datasets are comparable based on their demographics.

Table 4.4: Demographics of Dataset 1 and 2

	Dataset 1 (N = 46,086)	**Dataset 2 (N = 636)**
Age	Mean: 42 years, SD: 24 years	Mean: 42 years, SD: 24 years
Gender	51.6% female, 48.4% male	51.5% female, 48.5% male
Type of patient	82.2% emergency, 17.8% inpatient	82.2% emergency, 17.8% inpatient
Nationality	83.5% Aruban, 13.9% Dutch, 0.9% Colombian, 0.5% Venezuelan, 0.4% Dominican and 0.7% other nationality.	85.7% Aruban, 11.5% Dutch, 1.3% Colombian, 0.5% Venezuelan, 0.3% Dominican and 0.7% other nationality.

4.3.3 Calculation of the selected KPIs

Combining the opinions of all stakeholders, the mission and vision of HOH and literature, the KPIs were selected and defined to be applicable to measure the ED performance (Abo-Hamad & Arisha, 2013; Sørup, Jacobsen & Forberg, 2013; Wilson & Ngyuen, 2004). In this section, these KPIs are measured and calculated. Appendix B: Measurement of KPIs provides further insight into the executed calculations per KPI.

1. Throughput time

Throughput time was calculated per urgency level. *Table 4.5* shows the calculation of the KPI: 'Throughput time'. In total, 71.2% of the ED arrivals do have their throughput time within the norm. However, this KPI variates strongly per urgency level. When the urgency lowers, the percentage of arrivals within the norm increased except for the red urgency. This was because red urgency patients were mostly arrivals who did not survive their ED visit.

Table 4.5: Calculation KPI 1: 'Throughput time' (N = 33,145)

Urgency level	Number of arrivals who have their throughput time within the norm.	Total number of ED arrivals	Percentage of arrivals who have their throughput time within the norm.
Red	105	164	64.0%
Orange	1,493	3,004	49.7%
Yellow	9,979	16,398	60.9%
Green	11,973	13,527	88.5%
Blue	51	52	98.1%
Total	23,601	33,145	71.2%

The average throughput time per urgency level with the standard deviation is given in *Table 4.6*. The average throughput time was 2 hours and 58 minutes with a standard deviation of 1 hour and 28 minutes.

Table 4.6: Average and standard deviation per urgency level of KPI 1: 'Throughput time' (N = 33,145)

Urgency level	Average throughput time	Standard deviation
Red	2 hours and 16 minutes	1 hour and 16 minutes
Orange	2 hours and 51 minutes	1 hour and 18 minutes
Yellow	3 hours and 14 minutes	1 hour and 28 minutes
Green	2 hours and 41 minutes	1 hour and 25 minutes
Blue	1 hour and 43 minutes	1 hour and 33 minutes
Total	2 hours and 58 minutes	1 hour and 28 minutes

The distribution of throughput time is visualized in *Figure 4.2*. This figure shows that most patients' throughput time was 120 – 150 minutes (13.4%) or 150 – 180 minutes (13.4%). However, many ED arrivals experience longer throughput times, which is undesirable.

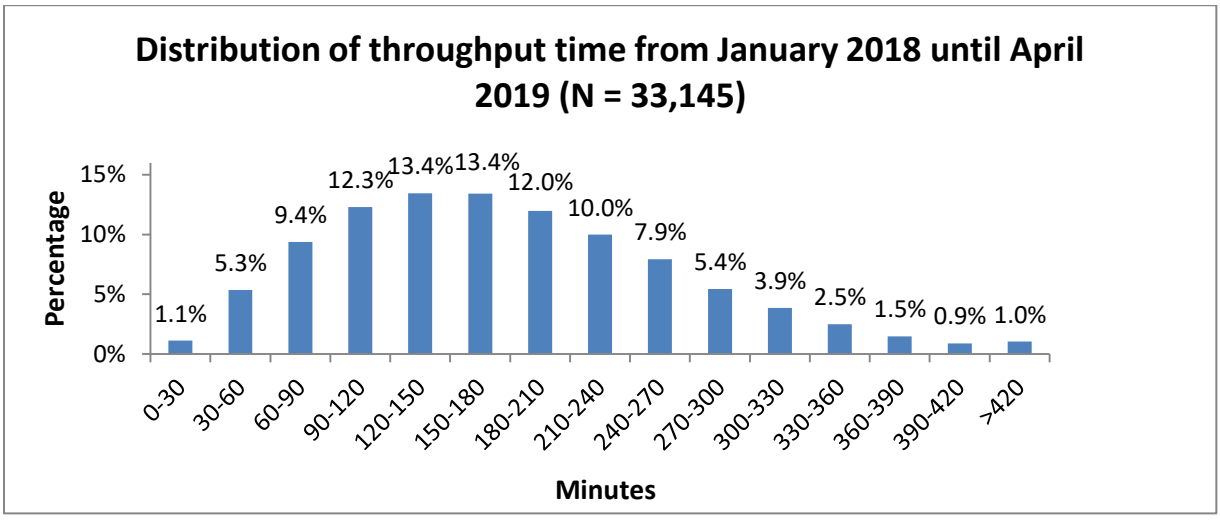

Figure 4.2: Distribution of KPI 1: 'Throughput time' from January 2018 until April 2019 (N = 33,145)

The calculations per month, day and hour of the average throughput time and the norm throughput time are available in Appendix B: Measurement of KPIs, *Tables and Figures B.1 – B.6*. These tables and figures show that the KPI throughput time:

- scored worse as the urgency increased except for urgency red, which seems logical because patients with higher urgencies need more care and red patients mostly do not survive their ED visit.
- scored different per month: the throughput time varied per month. The best month was July 2018, when 84.6% of the ED arrivals scored within the norm throughput time. The worst month was April 2019 (60.4%). However, it seems that after implementation of the EMR in January 2019, the throughput time scored worse in January 2019 until April 2019 (65.1%; 65.3%; 70.6% and 60.4%) compared to January 2018 until April 2018 (74.1%; 74.0%; 66.8% and 70.2%).
- scored better during the weekends: 76.8% (Saturday) and 77.5% (Sunday) compared to the working days which ranged from 66.0% to 70.3%. During the weekends, more ED arrivals have lower urgencies, so it is easier to treat them within the norm time.
- had a worsening tendency for all urgencies from 02:00 (89.1%) until 14:59 (61.5%) and an improving tendency from 14:00 (61.5%) until 02:59 (89.1%).

In conclusion, this KPI performs badly. However, the results of this KPI were expected by HOH. There was a tendency for the throughput time to worsen with fewer patients treated within norm time after implementation of the EMR. A bottleneck was that patients perceived too much waiting time and the waiting times, which are part of the KPI: 'Throughput time'. The three types of waiting times were calculated to confirm this bottleneck.

2. *Waiting time 1*

Waiting time 1 was calculated. *Table 4.7* shows that 43.0% of ED arrivals start with triage within 15 minutes.

Table 4.7: Calculation KPI 2: 'Waiting time 1' (N = 45,541).

Number of arrivals starting with triage within 15 minutes	Total number of ED arrivals	Percentage of arrivals who are triaged within 15 minutes.
19,586	45,541	43.0%

The average waiting time 1 was 21 minutes with a standard deviation of 17 minutes. The distribution of waiting time 1 is visualized in *Figure 4.3.* This figure shows that most ED arrivals are in the categories 5 to 10 (17.6%) and 10 to 15 minutes (17.6%). However, waiting time 1 of 57.0% of the ED arrivals was too long and 24.0% had a waiting time of more than two times the norm (30 minutes). HOH did not expect the percentage to be this low. It could be because the ED nurse was busy triaging other ED arrivals or the ED already had a lot of patients admitted to an ED bed with high urgencies.

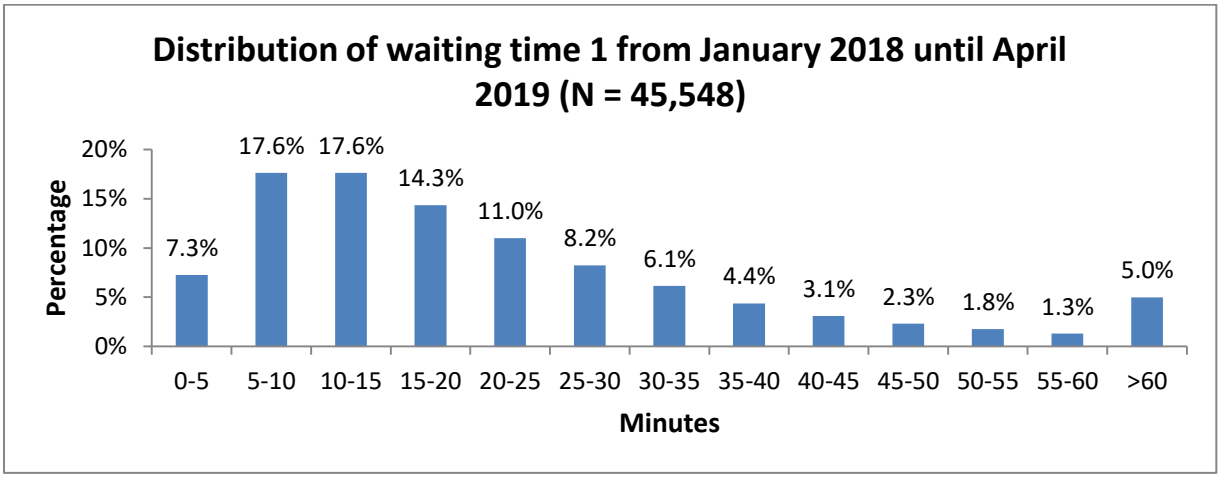

Figure 4.3: Distribution of KPI 2: 'Waiting time 1' from January 2018 until April 2019 (N = 33,145)

The calculations per month, day and hour of the average waiting time 1 and the norm waiting time 1 are available in Appendix B: Measurement of KPIs, *Tables B.7 – B.9 and Figures B.7 – B.12*. These tables and figures show that waiting time 1:

- had a great range between January 2018 until September 2018, ranging from 33.1% (March 2018) to 53.3% (July 2018). However, this KPI was more stable from October 2018 to April 2019: 39.3% in January 2019 and 44.1% in November 2018. There was a slight tendency that after September 2018, the waiting time 1 scores worsened.
- did not vary much per day of the week, and ranged between 41.3% (Monday) and 45.5% (Thursday).
- had an improving tendency between 0:00 (37.0%) and 8:59 (63.9%), a worsening tendency between 8:00 (63.9%) and 14:59 (33.9%), an improving tendency between 14:00 (33.9%) and 17:59 (46.2%) and a worsening tendency between 17:00 (46.2%) and 23:59 (30.6%).

In conclusion, waiting time 1 was relatively constant during the last months. However, the KPI performed badly. The first time an ED arrival is examined by a qualified healthcare professional is during triage, making it very important to triage arrivals within norm time. Waiting time 1 partly confirmed the bottleneck that patients perceive long waiting times.

3. Waiting time 2

Waiting time 2 was calculated per urgency level. *Table 4.8* shows that the percentage of arrivals who do not wait longer than the MTS prescribes was 43.4%. It can be seen that the norm in urgency red was almost always met in 98.2%. However, other urgencies were performing worse. Surprisingly, the urgencies orange (13.9%) and yellow (32.8%) performed worse while these patients are severely ill and need ED care.

Table 4.8: Calculation KPI 3: 'Waiting time 2' (N = 33,145)

Urgency level	Number of arrivals who do not wait longer than the MTS prescribes after triage.	Total number of arrivals	Percentage of arrivals who do not wait longer than the MTS prescribes after triage.
Red	161	164	98.2%
Orange	418	3,004	13.9%
Yellow	5,381	16,398	32.8%

Green	8,390	13,527	62.0%
Blue	22	52	42.3%
Total	14,372	33,145	43.4%

The average waiting time 2 per urgency level with the standard deviation is given in *Table 4.9*. The average waiting time 2 was 1 hour and 12 minutes with a standard deviation of 1 hour and 7 minutes.

Table 4.9: Average and standard deviation per urgency level of KPI 3: 'Waiting time 2' (N = 33,145)

Urgency level	Average waiting time 2	Standard deviation
Red	0 minutes	1 minute
Orange	12 minutes	26 minutes
Yellow	1 hour and 7 minutes	1 hour and 7 minutes
Green	1 hour and 21 minutes	1 hour and 5 minutes
Blue	1 hour and 15 minutes	1 hour and 33 minutes
Average	1 hour and 12 minutes	1 hour and 7 minutes

Figure 4.4 shows the distribution of waiting time 2. This figure shows that the category of 0 – 30 minutes is the biggest category (13.9%). However, this does mean that 86.1% of the patients wait longer than 30 minutes. According to the MTS, the longest waiting time 2 should be 240 minutes (urgency blue). The waiting time 2 of 17.2% of all ED arrivals is even longer than 240 minutes, which means that HOH was not complying to the norm time.

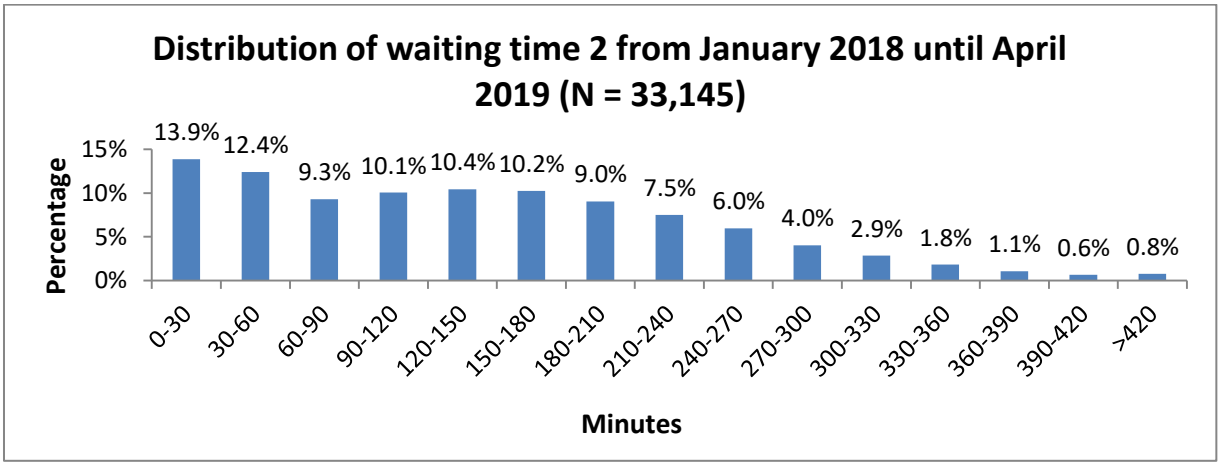

Figure 4.4: Distribution of KPI 3: 'Waiting time 2' from January 2018 until April 2019 (N = 33,145)

The calculations per month, day and hour of the average waiting time 2 and the norm waiting time 1 are available in Appendix B: Measurement of KPIs, *Tables B.10 – B.15 and Figures B.13 – B.18*. These tables and figures show that waiting time 2:

- strongly variates per urgency level. Urgency red performed the best at 98.2%. However, surprisingly, yellow performed worse (32.9%) and orange performed the worst (13.9%).
- showed some variation per month, ranging from 38.2% (March 2019) to 53.1% (July 2018). After implementation of the EMR, waiting time 2 scored worse.
- does not variate much per day of arrival, range: 41.4% (Wednesday) to 45.1% (Tuesday).
- had an improving tendency between 05:00 (30.1%) to 08:59 (63.6%) and a worsening tendency between 08:00 (63.6%) and 05:59 (30.1%).

In conclusion, waiting time 2 was relatively constant during the months of this study. However, the KPI performed badly on every urgency except for urgency red. After the triage, ED arrivals waited too long in 56.6% of the cases, where the ED was unable to act upon the urgency levels of the arrivals because the higher the urgency, the lower the probability that waiting time 2 was within the norm time. Waiting time 2 confirmed the bottleneck that patients perceive long waiting times.

4. Waiting time 3

Waiting time 3 was calculated. The average waiting time 3, the time between admission until the patients was checked out of the ED, was 48 minutes with a standard deviation of 42 minutes. This means that a patient, on average, occupied a bed for 48 minutes, while this patient did not need an ED bed.

The distribution of waiting time 3 is visualized in *Figure 4.5*. This figure shows that most patients were in the category 15 – 30 minutes (23.1%). The percentage of patients that had waiting time 3 of less than 30 minutes was 39.3%.

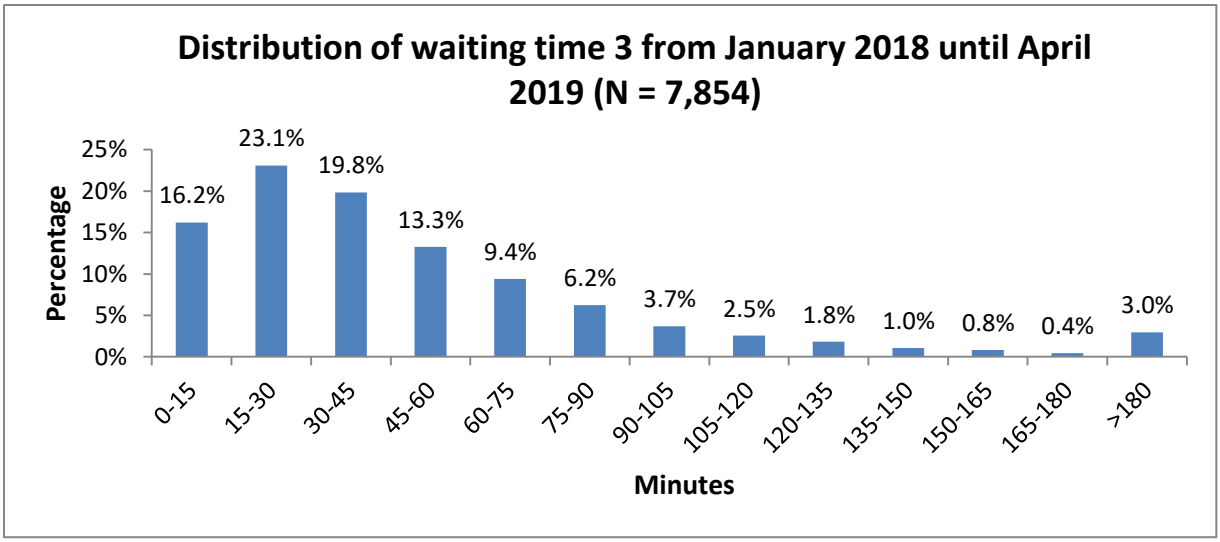

Figure 4.5: Distribution of KPI 4: 'Waiting time 3' from January 2018 until April 2019 (N = 7,854)

The calculations per month, day and hour of waiting time 3 are available in Appendix B: Measurement of KPIs, *Tables B.16 – B.18* and *Figures B.19 – B.21*. These show that waiting time 3:

- ranged from 42 minutes to 59 minutes per month.
- was lower on Saturdays (44 minutes) and Sundays (40 minutes). This is probably because it was less busy on the wards during the weekends.
- varied per hour, however during the nightshift, there was a tendency that waiting time 3 was lower on average.

In conclusion, waiting time 3 varied a little during the months of this study. However, this KPI could be improved, so that the ED beds are not unnecessary occupied. Waiting time 3 performed better during the weekends and during the night, probably because there were less urgent ED arrivals who need additional care at a ward during the weekends and nights. Waiting time 3 confirmed the bottleneck that patients perceive long waiting times.

Overall, all waiting times confirmed this bottleneck. On average, a patient, who was only triaged waited 21 minutes, a patient who was triaged and admitted to a bed waits 1 hour and 33 minutes and a patient who needed additional care at a ward waited a total of 2 hours and 21 minutes.

5. *Room utilisation*

Room utilisation was calculated per type of ED room. The ED has eight general rooms, two rooms for cardiac and trauma patients with high urgencies and three fast-track rooms for patients that can be helped quickly with low urgencies. *Table 4.10* shows that the total average room utilisation was 40.4%. For general rooms, cardiac and trauma with high urgencies and fast track, the room utilisation was respectively 46.3%; 19.9% and 38.3%. The room utilisation for cardiac and trauma patients with high urgencies seems logical because these types of patients are uncommon and fast-track rooms were not used for fast-track patients.

Table 4.10: Calculation KPI 5: 'Room utilisation' (N = 33,145)

	Average treatment time plus waiting time 3 per day	Number of rooms	Total time available at the ED per type of room per day[1]	Percentage of net room utilisation [2]
General rooms	88.9 hours	8	192 hours	46.3%
Cardiac and trauma with high urgencies	9.5 hours	2	48 hours	19.9%
Fast track	27.6 hours	3	72 hours	38.3%
Total	126	13	312 hours	40.4%

[1] Calculated as the number of rooms multiplied by 24 hours available per room.
[2] Calculated as the treatment time plus waiting time 3 divided by the total time available at the ED per type of room per day * 100%.

Figure 4.6 provides an insight in the heat map that was used to illustrate *Figure 4.7*. *Figure 4.7* provides the percentage of time that a specific number of ED beds were occupied by patients from January 2018 until April 2019. This figure shows that in 0.02% of the time, all 13 ED beds were occupied by patients. The ED was fully occupied by patients in a total time of two hours from January 2018 to April 2019, which is almost never.

	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
1-1-2018	0	2	3	3	5	3	3	5	5	4	2	4	6	5	7	5	7	8	8	8	6	8	5	7
2-1-2018	6	4	4	3	2	3	6	4	5	7	7	6	4	6	7	5	8	6	9	5	4	5	5	5
3-1-2018	5	3	5	4	6	3	4	3	7	8	8	8	8	6	8	6	9	8	7	5	7	3	6	7
4-1-2018	4	5	5	5	5	5	8	4	4	5	4	5	7	8	4	8	5	5	6	6	6	4	5	5
5-1-2018	5	3	2	1	0	3	2	0	0	2	6	8	6	5	6	3	6	7	5	6	7	4	7	8
6-1-2018	6	7	4	2	0	1	1	1	0	0	2	2	5	3	6	2	6	5	6	5	7	7	4	4
7-1-2018	4	4	3	5	3	3	3	1	0	3	3	5	7	10	6	7	7	3	4	4	6	8	5	5

Figure 4.6: Heatmap used to determine how many rooms are occupied by patients per hour from January 2018 until April 2019 (N = 33,415)

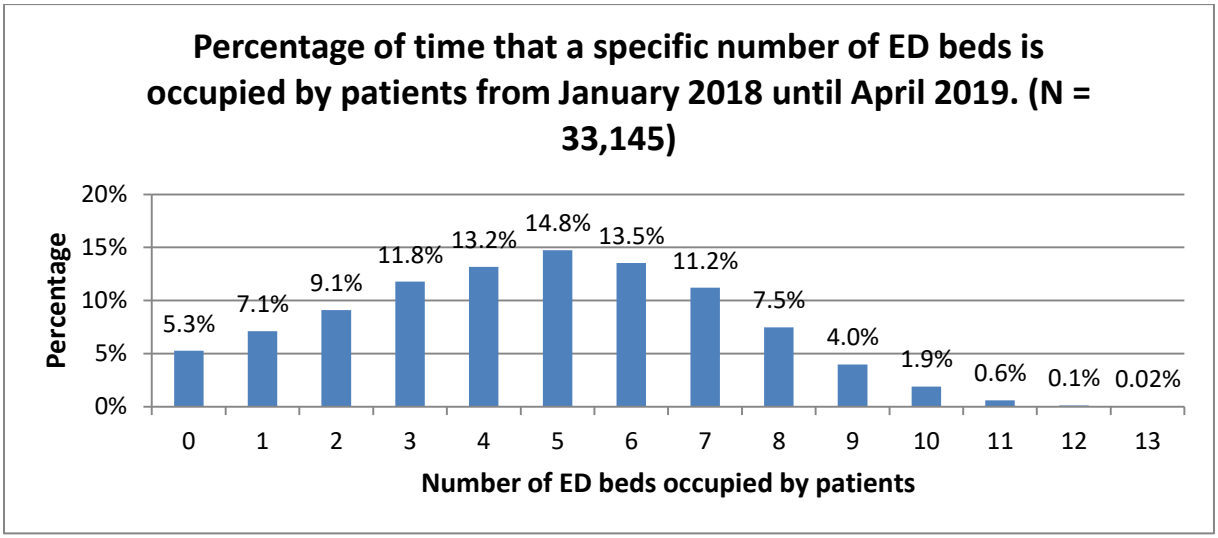

Figure 4.7: Percentage of time that a specific number of ED beds is occupied by patients from January 2019 until April 2019 (N = 33,145)

The calculations per month, day and hour of room utilisation are in Appendix B: Measurement of KPIs, *Tables B.19 – B.21* and *Figures B.22 – B.24*. These tables and figures show that room utilisation:

- ranged between 32.7% (July 2018) and 46.3% (November 2018).
- was lower during the weekend (35.9% and 37.1%) compared to other days of the week (42.6%; 41.0%; 44.1%; 40.2% and 41.6%).
- varied strongly per hour, as seen in *Figure 4.8*, which shows that the room utilisation was high during the day shift (range: 28.5% to 73.1%), lower during the evening shift (range: 32.6% to 55.4%) and much lower during the night shift (range: 13.9% to 32.6%). The room utilisation peaked, on average, between 10:00 and 11:00 (73.1%).

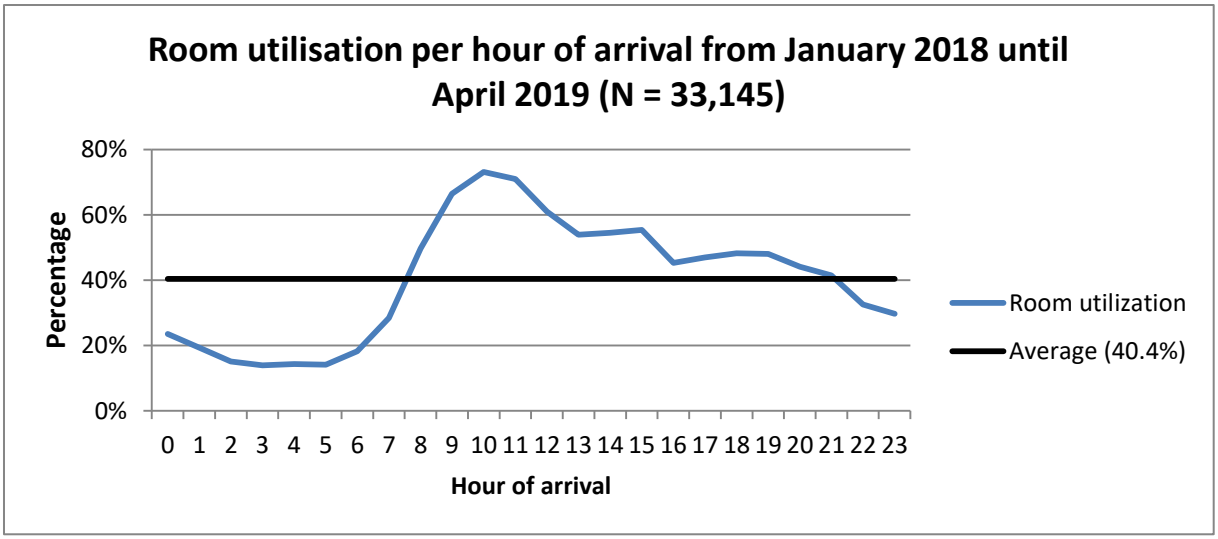

Figure 4.8: KPI 5: 'Room utilisation' per hour of arrival from January 2018 until April 2019 (N = 33,145)

In conclusion, the average room utilisation seems to be low. However, the room utilisation varied strongly during the day. The problem of low scores on throughput time and waiting times does not appear to have been caused by a limited number of rooms.

6. Nurse and doctor utilisation

The nurse and doctor utilisation was calculated. The employees providing ED care were nurses and doctors. The average number of nurses and doctors per time unit was determined by the number of employees per time unit. *Table 4.11* shows that the average nurse utilisation and doctor utilisation were respectively: 1.6 and 2.9. For a nurse, this number means that a nurse took care of 1.6 patients on average with a standard deviation of 1.3. For a doctor, this number was 2.9 on average with a standard deviation of 2.3. Based on these average numbers, little can be concluded because there are no norms for the nurse and doctor utilization defined.

Table 4.11: Calculation KPI 6: 'Nurse and doctor utilisation' (N = 33,145)

	Room utilisation	Average number of nurses or doctors providing care at the ED based on the current capacity and shifts.	Ratio of net nurse and doctor utilisation [1]
Nurse	40.4%	2.9	1.6
Doctor	40.4%	1.6	2.9

1 Calculated as the room utilisation multiplied by 13 divided by the number of nurses or doctors providing care at the ED * 100%.

The calculations per month, day and hour of the nurse and doctor utilisation are available in Appendix B: Measurement of KPIs, *Tables B.22 – B.24 and Figures B.25 – B.27*. These tables and figures show that nurse and doctor utilisation:

- varied per month for nurses (range: 1.3 to 1.8) and doctors (2.4 to 3.4). This means that the workload per month is unevenly distributed.
- was lower during the weekends (Saturdays: 1.4 (nurses), 2.3 (doctors) and Sundays: 1.5 (nurses) and doctors (2.6). Doctors do had additional capacity during the weekends but nurses had equal capacity during the week. However, the nurse utilisation also decreased at the weekends.
- strongly varied per hour, as seen in *Figure 4.9*, which shows that the nurse and doctor utilisation had high variation during the day, peaking between 10:00 and 10:59 with 2.4 for nurses and 4.8 for doctors.

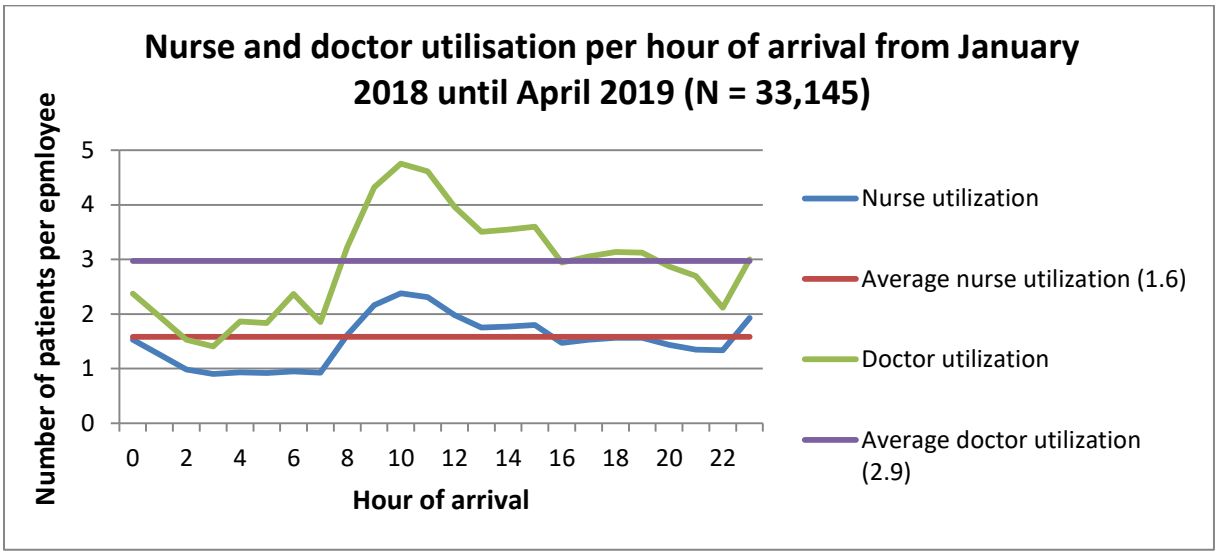

Figure 4.9: KPI 6: 'Nurse- and doctor utilisation' per hour of arrival from January 2018 until April 2019 (N = 33,145)

The nurse- and doctor utilisation was considered to be low on average by HOH's management. However, there was much variation present in nurse- and doctor, which probably caused the ED employees to perceive high workloads in some parts of the day. One reason for this perceived high workload is that the current capacity and shifts are not supporting an more evenly distributed workload.

7. ED arrivals who can be treated by GP(S) care

The KPI: ED arrivals who can be treated by GP(S) care was calculated per urgency level. *Table 4.12* shows that 21.1% of ED arrivals can be treated by GP(S) care. A total of 80.6% of these

ED arrivals are filtered and referred to a GP(S) during triage by an ED nurse. However 19.4% of the arrivals that can be treated by GP(S) care do receive ED bed admission. ED arrivals in urgencies yellow (4.8%), green (35.8%) and blue (80.0%) are identified as GP(S) arrivals.

Table 4.12: Calculation KPI 7: 'ED arrivals who can be treated by GP(S) care' (N = 636)

	Red	Orange	Yellow	Green	Blue	Blank	Total
Number of arrivals who were referred to a GP or GPS during triage.	0	0	3	99	4	2	108
Number of arrivals who were assigned to a bed but could also be treated by GP care.	0	0	7	18	0	1	26
Total number of arrivals who can be treated by a GP(S)[1]	0	0	10	117	4	3	134
Total number of arrivals triaged.	5	59	207	327	5	33	636
Total number of arrivals assigned to a bed.	5	4	197	210	1	30	447
Percentage of arrivals who are referred to their GP or GP(S) during triage.[2]	0%	0%	1.4%	30.3%	80.0%	6.1%	16.7%
Percentage of arrivals who are admitted to a bed but could be treated by the GP(S).[3]	0%	0%	3.6%	8.6%	0%	3.0%	5.6%
Percentage of arrivals who should visit their GP or the GPS in order to receive treatment.[4]	0%	0%	4.8%	35.8%	80.0%	9.1%	21.1%

[1] Calculated by the number of arrivals that were referred to a GP or GPS during triage plus the number of arrivals that were assigned to a bed but could also be treated by GP care.

[2] Calculated by the number of arrivals that were referred to a GP or GPS during triage divided by total number of arrivals triaged (*100%).

[3] Calculated by the number of arrivals were assigned to a bed but could also be treated by GP care divided by the total number of arrivals assigned to a bed (*100%).

[4] Calculated by the total number of arrivals that could be treated by a GP(S) divided by the total number of arrivals triaged (*100%).

The calculations per day and hour of ED arrivals who can be treated by GP(S) care are available in Appendix B: Measurement of KPIs, *Tables B.25 – B.26 and Figures B.28 – B.29*. These tables and figures show that ED arrivals who can be treated by GP(S) care:

- differed per day: ranges from 10% on Thursday to 28% on Tuesday. The measurement of this KPI was performed manually during one week, which could be a reason for the variation per day.
- was different per hour. After the closure of the GPS the percentage of arrivals that needed GP(S) care increased to 41% at 23:00. During the opening hour of the GPS, the percentage of ED arrivals that needed GP(S) care decreased between 19:00 and 21:00 to 15% and 14%. This does mean that during the current opening hours of the GP(S), less GP(S) patients visit the ED.

In conclusion, this KPI seems to confirm the following bottlenecks:

- The MTS is not fully able to recognise whether the patient needs ED care or could have their needs satisfied with the care provided by another healthcare provider.
- There was insufficient collaboration between the GPS and ED.
- Over 73% of ED arrivals were self-referrals who often do not need ED care.

8. ED arrivals being seen by an ED physician

ED arrivals being seen by an ED physician was calculated. *Table 4.13* shows that the percentage of patients that were seen by an ED physician was 72.8% in 2018.

Table 4.13: Calculation KPI 8: 'Leaving before being seen by a physician'.

Number of ED arrivals that were assigned to an ED physician in the EMR	33,300
The total number of ED arrivals	45,758
Percentage of arrivals being seen by an ED physician[1]	72.8%

[1] Number of arrivals that were assigned to a physician in the EMR divided by the total number of arrivals that were treated at the ED (*100%).

The calculations per day and hour of ED arrivals who could be treated by GP(S) care are available in Appendix B: Measurement of KPIs, *Tables B.27 – B.29 and Figures B.30 – B.32*. These tables and figures show that ED arrivals being seen by an ED physician:

- slightly differed per month (range: 69.3% (August 2018) until 73.9% (November 2018).
- was lower during the weekends (68.6% and 69.7%)
- was higher during the dayshift (77%) than during the evening (66%) and night shift (70%). This may be because waiting time 1 and waiting time 2 are performing better and peaking in performance during day shifts but can also be because there were more severe patients visiting the ED during day shifts.

4.4 Conclusion

In Sections 4.1 and 4.3, the aim was to answer the second research question stated in Section 1.3:

- *To what extent are Key performance indicators (KPIs) of the ED performance defined and what is the current ED performance?*

The hospital has not yet defined KPIs in order to measure the ED performance. This resulted in the selection of eight KPIs that were applicable to measure the current ED performance. The selection was based on stakeholders' opinions, research literature and the mission and vision of HOH.

The following KPIs were selected:

- Throughput time
- Waiting time 1
- Waiting time 2
- Waiting time 3
- Room utilisation
- Nurse and doctor utilisation
- ED arrivals who can be treated by GP(S) care
- ED arrivals being seen by an ED physician

Throughput time

After the selection, the KPIs were measured. The KPI: 'Throughput time' shows that 71.2% of the arrivals have throughput time within the norm of 2 hours and 30 minutes plus additional MTS norms for waiting time 2. The average throughput time was 2 hours and 58 minutes with a standard deviation of 1 hour and 28 minutes between January 2018 and April 2019. The score of 71.2% within the norm is a score that is considered to be bad to moderate because 28.8% of the ED arrivals still have a throughput time that is too long.

Waiting times 1, 2 and 3

Waiting times 1, 2 and 3 are KPIs that determine throughput time. In 43.0% and 43.4% the norms of respectively waiting time 1 and waiting time 2 were met. Waiting time 3 showed an average of 48 minutes with a standard deviation of 42 minutes. When the aim was to have waiting time 3 under 30 minutes, it scored 39.3%. The throughput time was determined to be higher because of more than half of the arrivals not meeting norms of waiting times 1 and 2 and an increase of throughput time of, on average, 48 minutes per patient who needed to be admitted to a ward. The waiting times 1, 2 and 3 scores are considered to were bad. The bottleneck of a patient perceiving too much waiting time was confirmed.

Room utilisation and nurse and doctor utilisation

The room and nurse and doctor utilisation were perceived KPIs to explain the scores on the throughput time, waiting times 1, 2 and 3. The average room utilisation was 40.4% and varied per type of room. Additionally, from January 2018 to April 2019, all rooms were occupied by patients for only two hours (0.02% of the time). The nurse and doctor utilisation

varied per hour of the day and was on average: 1.6 (range: 0.9 – 2.4) for nurses and 2.9 (range 1.5 – 4.8) for doctors. HOH's management stated the averages as low but because of high variation in workload, ED employees still perceived great workloads. According to the room utilisation, there was no reason for the throughput time, waiting times 1, 2 and 3 to score as these KPIs scored. It was concluded that there was no capacity problem in terms of space. It was almost never the case that all rooms were occupied by patients. There was no literature available concerning a norm for nurse and doctor utilisation but, considering the shortage of ED staff, throughput time, waiting times 1, 2 and 3 were probably scoring worse because of the shortage in staff and the unevenly distribution of the workload during the day.

ED arrivals who can be treated by GP(S) care

A high share (21.1%) of the ED arrivals were patients who could be treated by GP(S) care. These patients should visit their GP or the GP(S) in order to reduce the ED workload. If not referred to the GP(S), these patients are assumed to be the patients that have highest throughput time and wait longest because of their low urgency to be treated. This results in a lower ED performance while these patients are not, in fact, ED patients. However, 80.6% of ED arrivals who could be treated by GP(S) care were already referred to their GP or the GPS during ED triage. A total of 80.6% ED arrivals were referred to their GP or the GPS during triage, which is a good score and meant that ED nurses are capable of filtering different types of ED arrivals.

ED arrivals being seen by an ED physician

A result of high throughput times and waiting times is that patients leave before being seen by an ED physician. Currently, 27.2% of the arrivals leave before being seen by a physician. This percentage might be reduced by optimising the throughput time and waiting times 1, 2 and 3.

5 Overview of possible interventions

This chapter presents suitable interventions to optimise the ED performance. This chapter aims to answer the third research question:

- *What are the three most suitable interventions to optimise the ED performance according to stakeholders?*

Section 5.1 provides three possible interventions according to the stakeholders while considering the previously mentioned bottlenecks (Section 4.2) and the results of the current ED performance (Section 4.3). Section 5.2 indicates the effects of the possible interventions. Section 5.3 presents the conclusion of this chapter.

5.1 Possible interventions according to stakeholders

In this section, the possible interventions according to the previously identified stakeholders are described. The following interventions are described extending the opening hours of the GPS (Section 5.1.1), appropriate use of fast-track rooms (Section 5.1.2) and more personnel and different shifts (Section 5.1.3).

5.1.1 Extending the opening hours of the GPS

According to the stakeholders, the first possible intervention is to extend the opening hours of the GPS. During the evening, the highest workload is perceived by the ED employees. In Section 4.3.3, this is workload is quantified. The GPS is currently open from 18:30 to 22:30 during working days, from 09:00 to 13:00 and from 18:00 to 22:00 during the weekends and holidays. By extending the opening hours of the GPS, the stakeholders expect that the ED throughput time and waiting times could possibly be reduced.

Some stakeholders suggest that the GPS should be open when the patients' GP are not open. The GPs are mostly open five days per week from 08:00 to 17:00. This means that the GPS should be open from 17:00 to 08:00 from Monday to Thursday and from Friday 17:00 to Monday 08:00 in order to fulfil the needs of the stakeholders regarding this first intervention. However, this seems impossible considering the current number of GPS employees, the willingness to treat more patients and the extended opening hours.

According to the quantitative performance analysis, the ED would be relieved the most if GP(S) was open from 16:00 to 00:00. The quantitative performance analysis, demonstrates

that the majority of patients requiring GP(S) care visit the ED within the hours of arrival: 16:00, 17:00 and 23:00. This would suggest that the GP(S) extends opening hours to 16:00 to 00:00 in order to reduce ED workload. Stakeholders added that the GP(S) should stay open, regardless of how many patients visit the GP(S).

5.1.2 Appropriate use of fast-track rooms

The second possible intervention is the appropriate use of fast-track rooms. Currently, there is no differentiation in the fast-track type of patients. Fast-track rooms are not used for fast-track patients but for all patients who are not classified as a cardiac or trauma patient with high urgency. This means that no patients are treated by fast-track care. The expectation is that appropriate use of fast-track could result in lower waiting times and throughput times for patients triaged with low (blue and green) urgency levels.

According to the stakeholders, this intervention could result in lower ED throughput time and waiting times. However, in order to succeed, it should be determined if more ED personnel should be present in order to provide fast-track care because the ED already has fast-track rooms but due to shortness of staff, it is not possible to provide this type of care. According to the stakeholders, this is possible with the proposed number of nurses and doctors in the next possible intervention where more capacity in the evening and night is proposed.

5.1.3 More personnel and different shifts

The third possible intervention is the effective use of more personnel and different shifts. The expectation of stakeholders is that more personnel and different shifts could result in better ED performance measurements. In total, four different personnel and shifts situations are described to be applicable to the current ED situation.

1. The current situation

In this first situation, the capacity levels of employees remain the same. The first situation is the current situation with the number of employees per shift and is provided in *Table 5.1*.

Table 5.1: Current situation with the number of employees per shift

	Current number of nurses	Current number of doctors
Day shift	5 (06:50 – 14:50)	2 (07:00 – 15:00)
Evening shift	5 (14:40 – 22:40)	2 (15:00 – 23:00)
Night shift	3 (22:30 – 07:00)	1 (23:00 – 07:00)
Extra night shift during weekends	0	1 (20:00 – 04:00)

2. The optimised current situation

In the second situation, the current situation was optimised by increasing capacity of employees during the times of the day where the workload is the highest. By using Excel, the capacity levels were adjusted during different times of the day. In *Figure 4.9*, the workload is visualized and the peak in workload is perceived at 10:00. The capacity levels of employees remain the same as the current situation. Because HOH has a shortage of staff, swift increases in employees seems to be unrealistic. This is why, the second situation is the optimised current situation and does not increase or decrease nurse or doctor capacity and consists of different shifts mentioned in *Table 5.2*. However, the scheduling of the doctors could not be changed because of HOH's regulations concerning how many doctors should be present at each moment of the day.

Table 5.2: The optimised current situation with number of employees per shift

	Current number of nurses	Current number of doctors
Day shift	5 (06:50 – 14:50)	2 (07:00 – 15:00)
	1 (09:00 – 13:00)	
Evening shift	4 (14:40 – 22:40)	2 (15:00 – 23:00)
	1 (15:15 – 19:15)	
Night shift	3 (22:30 – 07:00)	1 (23:00 – 07:00)
Extra night shift during weekends	0	1 (20:00 – 04:00)

3. The stakeholders' situation

In this third situation, the capacity levels of employees increase. This proposed situation is the view of the stakeholders. The management of the ED already stated that with the current number of nurses and doctors per shift, the ED is understaffed. During the evening shift additional capacity is needed because the workload is high. During the night shift a set

number of employees is needed for a resuscitation. *Table 5.3* shows the desired number of employees per shift determined by stakeholders including the ED management.

Table 5.3: The stakeholders' situation with number of employees per shift

	Desired number of nurses	Desired number of doctors
Day shift	5 (06:50 – 14:50)	2 (07:00 – 15:00)
Evening shift	6 (14:40 – 22:40)	3 (15:00 – 23:00)
Night shift	4 (22:30 – 07:00)	2 (23:00 – 07:00)

4. The situation based on the quantitative performance analysis

In the fourth situation, the capacity levels of employees increase. This situation is based on the quantitative performance analysis. According to the quantitative performance analysis of the ED performance, the nurse and doctor utilisation increases after 09:00 and is above average until 20:00. This would mean that the additional capacity is needed from 10:00 to 18:00 in order to first help the day shift with the upcoming peak in nurse and doctor utilisation and the evening shift in order to decrease the workload peak before heading home. A full shift is most desirable. *Table 5.4* shows the desired number of employees per shift determined by the quantitative performance analysis.

Table 5.4: The situation based on the quantitative performance analysis with number of employees per shift

	Quantitative performance analysis number of nurses	Quantitative performance analysis number of doctors
Day shift	5 (06:50 – 14:50)	2 (07:00 – 15:00)
	1 (10:00 – 18:00)	1 (10:00 – 18:00)
Evening shift	5 (14:40 – 22:40)	2 (15:00 – 23:00)
Night shift	4 (22:30 – 07:00)	2 (23:00 – 07:00)

5.2 Effects of the interventions

In this section, the effects of the possible interventions according to the previously identified stakeholders are described. The effects of the following interventions are described: extending the opening hours of the GPS (Section 5.2.1), appropriate use of fast-track rooms (Section 5.2.2) and more personnel and different shifts (Section 5.2.3).

5.2.1 Extending the opening hours of the GPS

According to the stakeholders and the quantitative performance analysis, the GP(S) should be open from 16:00 to 00:00. *Table 5.5* provides the percentages of patients who need GP(S) care and the recognition by type of employee. Additional calculations can be found in Appendix C: Effects of most suitable interventions, *Table C.1*.

Table 5.5: Percentages of patients who need GP(S) care and the recognition by type of employee.

	Percentage of patients that need GP(S) care	Percentage of patients recognised by the nurse as GPS patients and sent to the GPS	Percentage of patients recognised by the doctor as GPS patients after bed admission
00:00 – 23:59	21.1%	80.6%	19.4%
16:00 – 18:00	25.3%	58.8%	41.2%
18:00 – 22:00	19.7%	92.3%	7.7%
22:00 – 00:00	31.3%	90.0%	10.0%

During the current opening hours of the GPS, 19.7% of ED arrivals need GPS care. A total of 92.3% of these patients are recognised as GPS patients and referred to the GPS. A further figure of 7.7% of these GPS patients are admitted to an ED bed. The assumption is made that when the GPS extends opening hours, the number of GPS patients with ED bed admission would be the same during 16:00 to 18:00 and 22:00 to 00:00 (7.7%). This would result in a lower percentage of GPS patients with ED bed admission from 16:00 to 18:00 (from 41.2% to 7.7%) and a lower percentage of GPS patients with ED bed admission from 22:00 to 00:00 (from 10.0% to 7.7%).

According to dataset 2, from 6 May 2019 7:00 to 13 May 2019 07:00 between 16:00 and 18:00, 67 ED arrivals occurred. A total of 17 (25.3%) of these ED arrivals needed GPS care. In the previous situation, 41.2% of the ED arrivals were admitted to an ED bed. In the new situation it is assumed to be the same as during the current opening hours of the GPS, namely 7.7%. This 16:00 to 18:00 extension of GPS opening hours could mean that the number of GPS patients admitted to an ED bed would lower from 7 per week (41.2% of 17) with the previous opening hours to 1.3 per week (7.7% of 17) with the new opening hours.

This would mean that, based on this dataset, the number of ED arrivals that need GP(S) care admitted to a bed would possibly decrease by 81.4% during these hours.

According to dataset 2, from 6 May 2019 07:00 to 13 May 2019 07:00 between 22:00 and 00:00, 64 ED arrivals arrived. A total of 20 (31.3%) of these ED arrivals needed GPS care. In the previous situation, 10.0% of the ED arrivals were admitted to an ED bed. In the new situation it is assumed to be the same as during the current opening hours of the GPS, namely 7.7%. This 22:00 to 00:00 extension of GPS opening hours could mean that the number of GPS patients admitted to an ED bed would lower from 2 per week (10.0% of 20) with the previous opening hours to 1.5 per week (7.7% of 20) with the new opening hours. This would mean that, based on this dataset, the number of ED arrivals admitted to a bed could decrease by 25% during these hours.

Concluding that, extending the opening hours of the GPS from 18:00 to 22:00 to 16:00 to 00:00 would decrease the number of GPS patients admitted to a bed from approximately 9 per week to approximately 3 in this specific week. For GPS patients, this is a reduction of 66% in ED bed admission within these hours. In total, 94 patients had ED bed admission within this week and selected hours. Based on this study it is concluded that the total reduction was 6.4% during this week and selected hours. This could result in a lower workload for the ED employees. The average treatment time after ED bed admission is 1 hour and 50 minutes. If 6.4% of 21.1% (1,4%) ED arrivals that need GP(S) care are not admitted to an ED bed. This would result in 637 less ED bed admissions per 16 months. This is between 1 and 2 per day resulting in a decrease of treatment time of between 1 hour and 50 minutes and 3 hours and 40 minutes, which is not a relevant decrease because the extension of GPS opening hours is 4 hours and the result is that there is a decrease in treatment time of between 1 hour and 50 minutes and 3 hours and 40 minutes.

Effect of visiting the right healthcare provider

In total, 21.1% (134) of all ED arrivals were patients who needed GP(S) care. If these ED arrivals would visit the right healthcare provider, in this case the GPS, 21.1% of the ED arrivals would not visit the ED.

If all 134 ED arrivals (21.1%) that need GP(S) care would visit the right healthcare provider, 21.1% less ED arrivals would need to be triaged and 4.1% would not be admitted to an ED

bed. These percentages are assumed to be the same for the other dataset, where the average triage time is approximately 5 minutes (N = 45,539). This means that 21.1% of 45,539 (9,608) ED arrivals do not have to be triaged. The reduction in time is then 800 hours in 16 months, where the total triage time is 3844 hours. This results in a decrease of 20.8% in total triage time which means a decrease of approximately 1 hour and 40 minutes in triage time per day if all ED arrivals that need GP(S) care would visit the correct healthcare provider. The average throughput time was 2 hours and 58 minutes, if 4.1% (1867) of the arrivals are not admitted to an ED bed, this results in a total throughput time decrease of 5,539 hours in 16 months which is a total decrease of 6.5% in throughput time, which is approximately 12 hours per day.

A systematic review, with EDs included from all over the world, has reported on extending the opening hours of the GPS (Flores-Mateo, Violan-Fors, Carillo-Stantisteve, Peiró & Argimon, 2012). This systematic review has reported that after extending the opening hours of the GPS, the ED utilisation decreased.

Additionally, a systematic review on the effectiveness of organizational interventions to reduce ED utilisation has reviewed ten studies (Morgan, Chang, Alqatari & Pines, 2013). Countries included were: the United States, England, Ireland, the Netherlands and others. Three studies considered expanding capacity through new community clinics. Seven studies considered expanding the appointments and hours of care where four studies found significant differences. Four studies found significant decreases in the use of the ED after increasing the opening hours of non-ED providers, such as the GPS (ranging from 9% to 54%). Five studies showed non-significant results. However, one study found a non-significant increase of ED usage with 21%.

5.2.2 Appropriate use of fast-track rooms

According to the stakeholders, one intervention possibility is that the fast-track rooms could be appropriately used because this could positively affect the throughput time and waiting times.

According to a systematic review of overcrowding in emergency departments, the appropriate use of fast-track rooms is an effective intervention (Yarmohammadian, Rezaei, Haghshenas & Tavakoli, 2017). However, only patients with urgencies blue and green can be

treated in a fast-track setting. In total, the ED of HOH triages 53.9% of the ED arrivals with urgencies green or blue. The systematic review stated that 10 to 30% of the total ED patients are suitable for fast-track. One advantage is that the utilisation and throughput time decrease and patient satisfaction increases. One disadvantage is that it is mostly applicable during peak hours and fast-track is mostly not possible during nights because of limited staffing, which is also the case in HOH.

The total number of ED arrivals with bed admission between 07:00 and 23:00 was 27,630 from January 2018 to April 2019. If 10 to 30% of the total ED arrivals are suitable for fast-track during the fast-track hours stated in the protocol of the HOH (07:00 – 23:00), the total number of ED arrivals that could be placed in a fast-track setting is between 2,763 and 8,289 the ED arrivals are visiting

Providing fast-track care has proven to significantly improve patient satisfaction with waiting times from 68% to 88% (Hwang, Lipman & Kane, 2015). Other effects have been described in a literature review by O'Neill et al., (2018) based on research in the United States, Australia, Canada, United Kingdom and 13 other countries. This literature review showed that fast-track interventions all decreased throughput time. Additionally, in more than half of the studies reviewed, it has been stated that the decrease on throughput time was greater than 30%. In half of the studies, the waiting time was decreased by over 35%. The other half found improvements, but only ranging from 5 to 10%. Patients who leave without being seen were also measured, fast-track showed a decrease ranging from 0 – 65%. There were strong positive and negative results reported on this last KPI.

Another study by Sanchez, Smally, Grant and Jacobs (2006) based on an American hospital, treated approximately 75,000 ED patients per year. Before and after fast-track implementation, several KPIs were measured. This led to:

- a significant decrease of 50% in waiting time on average and decreased variation.
- a significant decrease of 9.8% in throughput time average and decreased variation.
- a significant decrease of 52.2% in patients leaving before being seen average and decreased variation.
- a significant increase of 4.4% in number of ED visits

According to this study, HOH is able to improve ED performance by using the fast-track appropriately. However, the number of ED visits is going to increase significantly after appropriately using the fast-track rooms and it has to be determined if the current capacity is able to provide fast-track care.

5.2.3 More personnel and different shifts

According to the stakeholders and quantitative performance analysis, another intervention possibility is that there are more personnel and different shifts available. *Table 5.6* shows the effects of the (optimised) current situation, the desired situation suggested by stakeholders and the desired situation based on the quantitative performance analysis of the average nurse- and doctor utilisation.

Table 5.6: Effects of the four proposed situations on the average nurse- and doctor utilisation.

	(optimised) current situation	Desired situation by stakeholders	Desired situation based on the quantitative performance analysis
Nurse utilisation	1.6	1.3	1.3
Doctor utilisation	2.9	2.2	2.2

The averages are equal in the desired situation from stakeholders and the desired situation based on the quantitative performance analysis because the number of hours in the additional shifts are the same. The distributions of the current situation, the optimised current situation, the stakeholders' situation and the quantitative performance analysis' situation are provided in the following parts of this section. Appendix C: Effects of most suitable interventions, *Tables C.2 – C.4* provide more insight into the calculations of the figures presented in this section.

1. *The current situation*

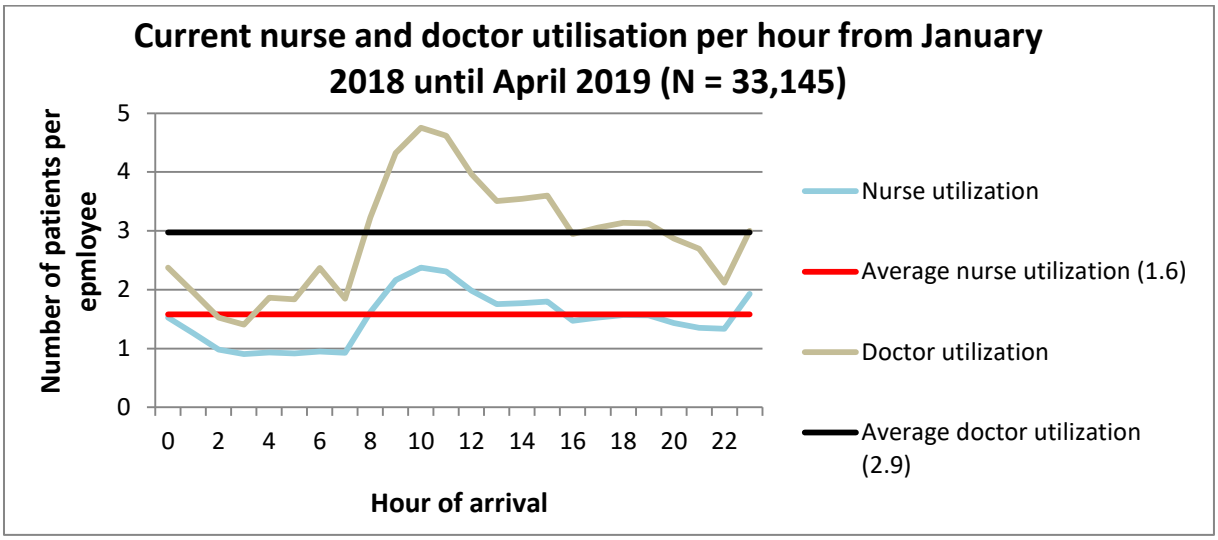

Figure 5.1: Effects of the current situation on the distribution of ED workload for nurses and doctors (N = 33,145)

Figure 5.1 illustrates the current nurse and doctor utilisation per hour. A great increase in the number of patients per employee is visible, peaking between 10:00 and 11:00 (nurse: 2.4 and doctor: 4.8). This means that the ED employees are perceiving a heavy workload during these hours. Since ED arrivals are still visiting, the number of ED arrivals that wait for triage and bed assignment increases. This is the reason why stakeholders perceive the periods after 11:00 to 17:00 as the busiest period of the day.

2. *The optimised current situation*

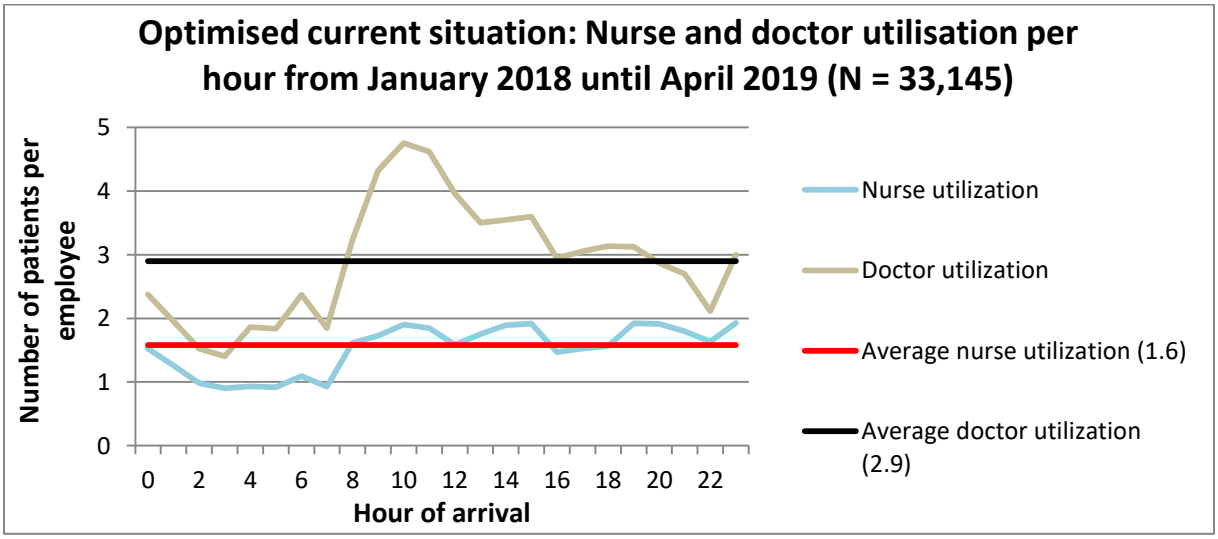

Figure 5.2: Effects of the optimised current situation on the distribution of ED workload for nurses and doctors (N = 33,145)

Figure 5.2 illustrates the current optimised nurse and doctor utilisation per hour. In this situation, the capacity levels remain the same. The nurse utilisation was distributed better with the new shifts. However, the peak number of employees per patients situated between 18:00 and 20:00 for the nurses (1.9). Compared to the old situation, the peak in number of patients per employee was 2.4. The doctor utilisation remained the same because due to restrictions in the number of doctors per hour, the doctor utilisation could not be optimised.

3. *The stakeholders' situation*

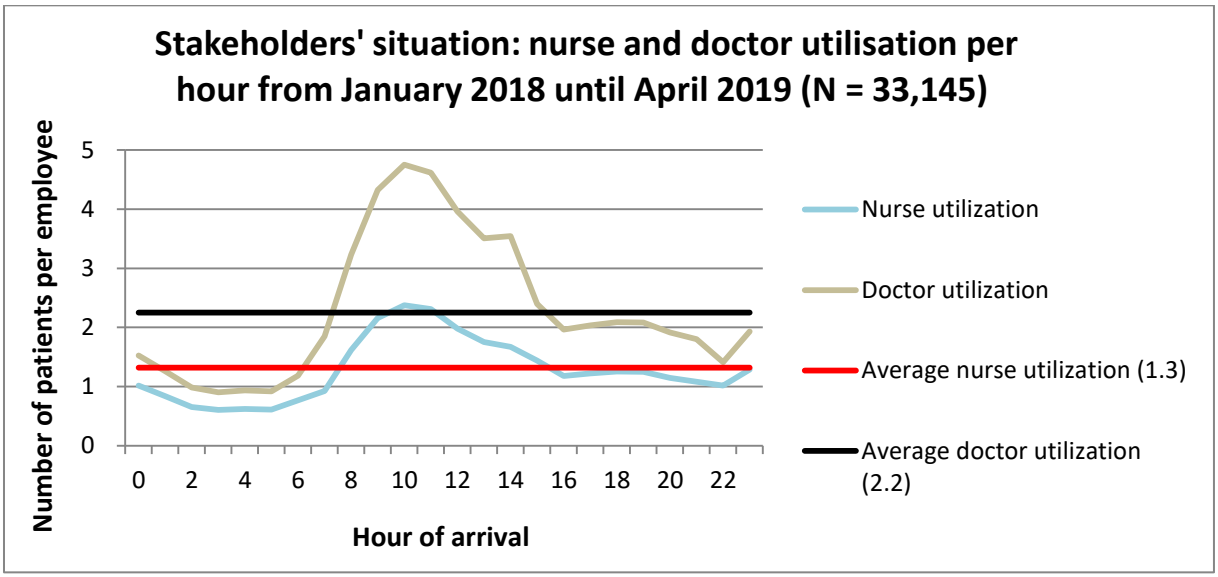

Figure 5.3: Effects of the stakeholders' situation on the distribution of ED workload for nurses and doctors (N = 33,145)

The stakeholders wanted to increase the nurse- and doctor capacity during the evening and during the night. This has already been proven to be needed by the management of HOH. Using these capacity levels, the number of patients per employee is decreasing during the evening shift and during the night shift. However, the peak is situated between 10:00 and 11:00 (nurse: 2.4 and doctor: 4.8). The stakeholders' decision does not solve the high waiting times and throughput times during the day shift. This means that the evening shift should restore these ED waiting times and throughput times by the increased capacity. This is illustrated in *Figure 5.3.*

4. *The situation based on the quantitative performance analysis*

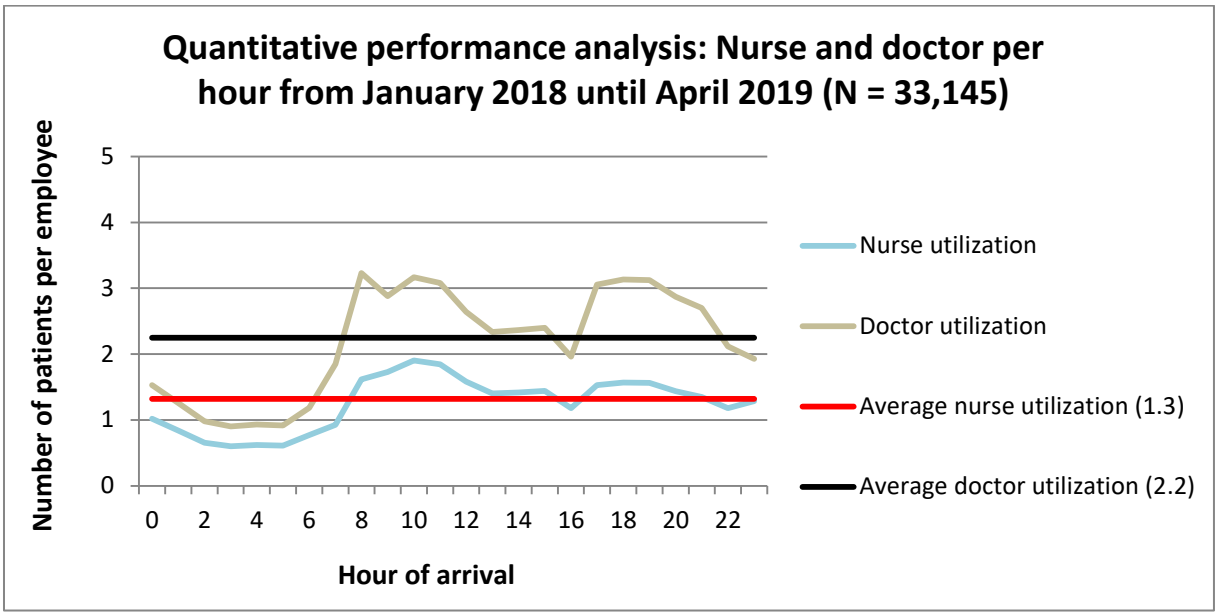

Figure 5.4: Effects of the quantitative performance analysis situation on the distribution of ED workload for nurses and doctors (N = 33,145)

Figure 5.4 provides the effects of the quantitative performance analysis on the distribution of the ED workload. The capacity levels should adhere to the demand provided by the ED arrivals. The quantitative performance analysis already stated a peak between 10:00 and 11:00 (nurse: 1.9 and doctor: 3.2). By using the capacity levels according to the quantitative performance analysis where the capacity is increased during the nightshift and between 10:00 and 18:00, the nurse and doctor utilisation results in a better distributed workload as seen in the graph. The nurse and doctor utilisation is better distributed during the day.

There should be attention to job satisfaction in the desired situation based on the quantitative performance analysis. According to Boyle, Beniuk, Higginson and Atkinson (2012), flexible scheduling regarding the ED's medical and nursing staff have been previously proposed in different EDs. Different shifts often leads to problems with job satisfaction and personal commitments in the private lives of employees. This is important to HOH because it is already having problems attracting and retaining employees.

5.3 Conclusion

In this section, the conclusion of Chapter 5 is provided. The third research question, mentioned in Section 1.3 is:

- *What are the three most suitable interventions to optimise the ED performance according to stakeholders?*

The three possible interventions to optimise the ED performance are discussed: extending the opening hours of the GPS, appropriate use of the fast-track rooms and more personnel and different shifts. All interventions are expected to optimise the ED performance.

1. *Extending the opening hours of the GPS*

Extending the opening hours of the GPS resulted in the decrease of 6 ED bed admissions per week. The percentage of ED arrivals who need GPS care that do not have ED bed admission probably decreases by 66%. However, this means that the total workload during 16:00 to 18:00 and 22:00 to 00:00 could possibly decrease with 6.4% if the opening hours extend. This intervention is, based on the manual measurement, not a relevant intervention because the extension of opening hours by four hours and the result, that there is a decrease in treatment time of between 1 hour and 50 minutes and 3 hours and 40 minutes. However, it seems to be more important to invest in arrivals visiting the right healthcare provider. if all GP(S) patients would visit the right healthcare provider, this would result in: 21.1% less ED arrivals, a decrease of approximately 1 hour and 40 minutes (20.8%) in triage time per day, a decrease of approximately 12 (6.5%) hours per day in total throughput time.

2. *Appropriate use of the fast-track rooms*

Appropriate use of the fast-track rooms is expected to result in higher patient satisfaction with waiting times. This would be a good outcome because the ED arrivals perceive too much waiting time according to the bottlenecks. Other effects on KPIs were reported, namely: a decrease in throughput time with 30%, a waiting time decrease by over 35%, a decrease in patients who leave without being seen ranging from 0 – 65%. There were strong positive and negative results reported on this last KPI. However, there was a significant increase in number of ED visits reported in one of the studies, namely: 4,4% but considering the rapid decrease in throughput time and waiting times, this is an intervention that should be considered for the ED.

3. *More personnel and different shifts*

It can be concluded that the current number of personnel and current shifts do not correspond with the workload. It is logical that the ED employees perceive this high workload because the distribution of workload is different during the day. The current situation should be optimised, where the current capacity of employees is considered and the desired capacity of employees is considered. The best two options are:

- the optimisation of the current situation where the nurse- and doctor capacity do not increase. This situation resulted in a more even workload distribution of the nurses. However, the doctors are unable to shift because of HOH's regulations.
- the quantitative performance analysis' ideal situation where the nurse and doctor capacity increased according to the necessary nurse- and doctor capacity levels stated by HOH's management. This situation resulted in a more even workload for both nurses and doctors. This situation does have a lower peak workload at 10:00 to 11:00, where it is thought that higher perceived workload in the evening will be resolved because of earlier anticipation on the upcoming workload.

6 Implementation

In this chapter, the implementation of the possible and suitable interventions is provided. Therefore, this chapter answers the last research question:

- *How should HOH apply the best suitable interventions in practice?*

The implementation of the three suitable interventions according to the stakeholders mentioned in Chapter 5 is described in Section 6.1. The implementation concerns what type of changes should be made in the current situation and what the HOH should change in order to obtain a better ED performance. In Section 6.2, there is a step-by-step plan for the implementation of the possible interventions mentioned in Chapter 5. Section 6.3 provides the conclusion of this chapter.

6.1 Implementation of the most suitable interventions

The implementation plan of the three most suitable interventions are extending the opening hours of the GPS (Section 6.1.1), appropriate use of fast-track rooms (Section 6.1.2) and more personnel and different shifts (Section 6.1.3).

6.1.1 Extending the opening hours of the GPS

The results of this study suggest that the ED might improve its performance on the selected KPIs if the GPS extends its opening hours. If HOH wants the GPS to extend its opening hours, it should consider deliberating with the HAVA and the employees of the GPS about the opening hours of the GPS. However, resistance is expected against this decision because not all employees of the GPS want the GPS to extend opening hours. This does mean that the ED employees can refer the patient to the right healthcare provider. In order to partly succeed, the ED needs to educate the population of Aruba on which healthcare provider should be visited in which case. There are several challenges is order to implement this intervention, regarding:

- Collaboration with the GPS
- Deliberating with the HAVA
- Increase of number of GPS employees
- Resistance of GPS employees

6.1.2 Appropriate use of fast-track rooms

The results of this study suggest that the ED can improve its performance if a doctor and nurse are planned to take care of only the fast-track rooms. The fast-track rooms should be appropriately used when possible. The patients that can be treated fast with low urgency and a need for ED care should be placed into the fast-track rooms at the ED in order to decrease waiting times and throughput time. Currently, there are fast-track rooms but these rooms are, in practice, not used for fast-track patients. This would mean that the fast-track protocol of HOH should be complied. Nurses and doctors should be allocated to different rooms. For the three fast-track rooms one nurse and one doctor should take care of these patients in order to guarantee fast-track. This may be seen as a high workload, but the throughput time and waiting time ultimately decrease drastically. By a decrease of throughput time, the nurse and doctor utilisation decreases. However, it should be examined whether more personnel are needed to provide fast-track care. There are several challenges in order to implement this intervention, regarding:

- Planning of ED employees
- Attracting and retaining (new) employees
- Compliance with the fast-track protocol by all employees

6.1.3 More personnel and different shifts

The results of this study suggest that the ED can improve its performance on the selected KPIs if the ED has more personnel and/or different shifts. The ED currently does not fully anticipate the workload during the days. By making smarter choices regarding shifts, the ED personnel perceive less workload and by anticipating the workload, patients could perceive less waiting times and throughput times. There are several challenges is order to implement this intervention, regarding:

- Stakeholders' point of view regarding the most effective way of deploying personnel and outcomes based on analytical data differ
- Employee satisfaction
- Attracting and retaining (new) employees

6.2 Step-by-step plan

To implement the suggested changes, a step-by-step plan is proposed with the following steps:

1. Create a roadmap together with the stakeholders

Since the stakeholders are all concerned with the decisions made regarding the ED performance, stakeholders should have a central role in the implementation. The sequence of implementing the changes and the time span for realising these changes could be visualised in a roadmap. The context analysis and bottlenecks (Chapter 3), the results of the current performance (Chapter 4) and the proposed solutions with effects (Chapter 5) are presented to the stakeholders. The roadmap should at least include how the employees at the ED and GPS are involved in the implementation.

2. Involve ED and GPS employees

The ED and GPS employees are represented in the group of stakeholders. However, all of the ED and GPS employees should be involved in the implementation of the solution(s). The staff meetings, that already take place, are suitable in order to involve ED and GPS employees. Also, meetings should be organized where the GPS and ED employees are both present.

3. Start with the selected changes

The ED and GPS should start with the changes when there is enough support present for the changes.

4. Evaluate the changes

During the implementation process, there should be several moments when the changes are evaluated with the stakeholders to monitor the progress of the implementation. During these sessions, the stakeholders can decide whether the implementation process should go into another direction.

6.3 Conclusion

This chapter provides insight in the implementation of the most suitable interventions to optimise the ED performance. This chapter aims to answer the fourth research question, mentioned in Section 1.3:

- *How should HOH apply the best suitable interventions in practice?*

The hospital has to make a few changes if it wants to implement the most suitable interventions. The first suitable intervention, extending the opening hours of the GPS, should be implemented while deliberating with HAVA and the GPS employees in order to succeed. Resistance is expected to be present because not all GPS employees want the GPS to extend opening hours. The second suitable intervention, appropriate use of the fast-track rooms, should be implemented while considering the current ED planning. One nurse and one doctor should be planned to occupy the fast-track rooms in order to successfully implement this intervention. This intervention requires compliance with the fast-track protocols. The third suitable intervention, more personnel and different shifts, should be implemented while considering the given workload during the days. New shifts should be created in order to anticipate the workload. To realise these interventions, the suggestion is to use a step-by-step plan that contains the following steps:

1. Create a roadmap together with the stakeholders
2. Involve ED and GPS employees
3. Start with the selected changes
4. Evaluate the changes

7 Conclusions

In this chapter, the most important findings of all previous chapters are summarized to answer the research questions presented in Section 1.3. The research objective was:

> ***Providing insight into the current performance of the ED in the Dr. Horacio E. Obduber Hospital, resulting in recommendations on how to optimise the ED performance.***

1. *What bottlenecks are perceived by the ED regarding the entire patient process at the ED of HOH and GPS and what resources are used?*

By providing the ED and GPS patients' processes and applying the healthcare framework (Hans et al., 2011) on HOH, HOH's planning and control was identified in Chapter 3. In Section 4.1, KPIs were selected and defined based on stakeholders opinions. Additionally, bottlenecks were identified. The bottlenecks were divided into four categories: patient, GPS, planning and steering on performance.

Patient

- Over 73% of ED arrivals are self-referrals who often do not need ED care.
- Patients can visit the ED an unlimited number of times without paying deductibles.
- Patients perceive long ED waiting times.
- The Manchester triage system (MTS) is not fully able to recognise whether the patient needs ED care or is could be cared for by another healthcare provider.

General Practitioner's Station (GPS)

- The GPS sometimes closes before closing time.
- Huisartsenvereniging Aruba (HAVA) does not want more patients to visit the GPS or to have longer opening hours.
- There is insufficient collaboration between the GPS and ED.
- It is complex to share the results of diagnostic tests between the GPS and ED**.**

Planning

- Staff members of the ED sometimes perceive a great working load.
- ED planning does not fully anticipate variation in demand.

Steering on performance

- The current ED performance is partly unknown.
- The KPIs were not defined.
- There are no acceptable goals defined for the KPIs.

2. *To what extent are Key performance indicators (KPIs) of the ED performance defined and what is the current ED performance?*

The hospital has not yet defined KPIs to measure the ED performance. This resulted in the selection and definition of eight KPIs that were applicable to measure the current ED performance mentioned in *Table 7.1*.

Table 7.1: selected KPIs and their current performance.

KPI:	Current performance:
Throughput time	71.2%
Waiting time 1	43.0%
Waiting time 2	43.4%
Waiting time 3	48 minutes (39.3% under 30 minutes)
Room utilisation	40.4%
Nurse- and doctor utilisation	Nurse: 1.6; Doctor: 2.9.
ED arrivals who can be treated by GP(S) care	21.1%
ED arrivals being seen by an ED physician	72.8%

3. *What are the three most suitable interventions to optimise the ED performance according to stakeholders?*

According to the stakeholders, the three most suitable interventions to optimise the ED performance are:

1. Extend opening hours of the GPS: the GPS opens from 16:00 to 00:00 instead of 18:00 to 22:00. This results in the decrease of six ED bed admissions per week. The total workload during these the additional hours decreases by 6.4%. If all GP(S) patients would visit GP(S), this would result in: 21.1% less ED arrivals, a decrease of approximately 1 hour and 40 minutes (20.8%) in triage time per day, a decrease of approximately 12 (6.5%) hours per day in total throughput time.
2. Appropriate use of the fast-track rooms results in higher patient satisfaction, a decrease in throughput time with 30%, a waiting time decrease by over 35% and a

decrease in patients who leave without being seen ranging from 0 – 65%. However, also resulting in an increase in the number of ED visits, namely: 4.4%. However, the feasibility with the current employee capacity should be considered.

3. More personnel and different shifts. Two options distributed the workload the best.

- the optimisation of the current situation where the nurse- and doctor capacity did not increase. This situation resulted in a more even workload distribution of the nurses. However, the doctors were unable to shift because of HOH's regulations.
- the quantitative performance analysis' ideal situation where the nurse and doctor capacity increased according to the necessary nurse- and doctor capacity levels stated by HOHs management. This situation resulted in a more even workload for both nurses and doctors.

4. *How should HOH apply the best suitable interventions in practice?*

The hospital has to change if it wants to implement the most suitable interventions. The first suitable intervention, extending the opening hours of the GPS, should be implemented while deliberating with HAVA and the GPS employees in order to succeed. Resistance is expected to be present because not all GPS employees want the GPS to extend opening hours. The second suitable intervention, appropriate use of the fast-track rooms, should be implemented while considering the current ED planning. One nurse and one doctor should be planned to occupy the fast-track rooms in order to successfully implement this intervention considering the current capacity of employees. This intervention requires compliance with the fast-track protocol. The third suitable intervention, more personnel and different shifts, should be implemented while considering the given workload during the days. New shifts should be created in order to anticipate on the workload. To implement these interventions, the suggestion is to use a step-by-step plan that contains the following steps:

1. Create a roadmap together with the stakeholders
2. Involve ED and GPS employees
3. Start with the selected changes
4. Evaluate the changes

By answering the research questions, the research goal was accomplished.

8 Discussion

This chapter presents a discussion of the research. In Section 8.1, the strengths of this research are outlined. In Section 8.2, the limitations of this research are considered. In Section 8.3, the added value of this research to practice and literature is provided. In Section 8.4, proposed topics and implications for further research are provided.

8.1 Strengths

In this section, the strengths of this research are discussed.

Stakeholders were involved during the research

The first strength of this research was that the stakeholders were strongly involved during this research. Relevant bottlenecks, KPIs and possible interventions were selected by taking into account the stakeholders' point of view. According to Mitchell et al. (1997), involving stakeholders results in a research that is more applicable to the organization and has more probability of succeeding. By involving the stakeholders, the research became more applicable to the ED's current situation.

KPIs were selected and defined for the first time

The hospital has not yet selected or defined KPIs that were relevant for the ED. Another strength was that, in order to steer to better ED performance, this was performed within this study. In this research, KPIs for the ED were selected and defined for the first time in Section 4.1.

ED performance was identified for the first time

Because HOH did not yet select or define KPIs that were relevant for the ED, the ED performance was never previously measured until this research was performed. This research was the first to measure the ED performance. Section 4.3 presents an opportunity for HOH to analytically steer on ED performance, which is part of the multi-annual improvement programme: '*Hunto Miho'.*

Most suitable interventions are provided with their corresponding effects

This research provides the most suitable interventions with their corresponding effects in Chapter 5. This enables HOH to steer on the ED performance.

Large amounts of data

In this research, large amounts of data during a long period were used to measure seven out of eight stated KPIs. The quality of the data was not always perfect as described in Section 82.

8.2 Limitations

In this section, the limitations of this research are discussed.

Data are not always perfect

The first limitation that should be specified is the data used for this research. First of all, the adjusted datasets seemed quite accurate. However, the registration of the data was not always perfect, for example: some ED arrivals were registered twice. Data are never perfect and it is always a puzzle to handle it properly. According to van Keulen (2012), there is a method that accepts data uncertainties and assigns probabilities to data entries. This is a method were a confidence interval for the results is calculated. This is a method to cope with data uncertainties, which should have been taken into account. Examples are variation in months, weeks and during the hours of the day.

All KPIs were calculated according to the ED arrival time

Another limitation of this study is that KPIs were calculated according to the time that an ED arrival visited the ED. This could lead to different representation of the data because not all KPIs should be calculated with the time of an ED arrival.

Introduction of the new EMR

The new EMR was introduced in HOH in January 2019. This means that the data are partly from the old EMR and partly from the new EMR. The introduction of the new EMR could lead to lower ED performance because employees need to get used to the EMR. This could have influenced the results of the ED performance. It was concluded that the introduction of the EMR lead to lower ED performance, for example: increasing waiting times. However, it is expected that the ED performance rises when the ED employees are used to the new EMR.

KPI: ED arrivals who need GP(S) care

The seventh KPI, ED arrivals who need GP(S) care, was measured manually by the nurses and doctors during one week. Due to the short timeframe and manual measurement, the KPI is

more uncertain than other KPIs. During the measurement of this KPI, the nurses had to write down when they referred an ED arrival and the doctors had to write down if an ED bed admission also could be treated by GP(S) care. However, nurses and doctors already perceived a high workload, which could mean that it was not always correctly recorded, so the percentage of ED arrivals that need GP(S) care is higher than stated in this research, which should mean that the proposed intervention of the extension of the GPS opening hours has a higher effect than calculated in this research.

Results of the effect of the suitable interventions

The effects of the suitable interventions were minimally analysed based on available data, literature reviews and systematic reviews. The literature reviews and systematic reviews were performed in other hospitals, which may not be applicable for the current situation of the ED of Aruba. This means that the effects may be different in HOH. For example: no studies were performed on an island with one ED. This example influences the effect of the suitable interventions because the ED of HOH can not refer ED arrivals to other EDs.

Difficult possibility to benchmark

The ED of HOH is based on an island: Aruba. It is the only ED on Aruba that is always open and should always be prepared to provide acute care with high complexity. Additionally, other hospitals may not be measuring the ED performance or may not be willing to share the information with HOH. Because of the situation, it is hard for the ED to find possibilities to benchmark and to learn from other hospitals' approaches.

8.3 Contributions to practice and literature

This research provides HOH:

- insight in the selection and definition of KPIs that measure the ED performance.
- the current ED performance based on these KPIs
- possible implementable interventions to optimise the ED performance
- a number of suggestions for further research, so that the ongoing improvement programme, *Hunto Miho,* can continue.

The most important contribution to the literature is that this research is an ED optimisation case-study, where KPIs were selected, defined and measured. When measuring these KPIs

and comparing these with other hospitals, it becomes easier to benchmark with other comparable EDs.

8.4 Further research

This research is the first step in the process of measuring the ED performance based on KPIs and making decisions based on the results of the KPIs. In addition to the results presented, this research suggests that further research is needed in a number of areas. These are discussed in this section.

Effectiveness of interventions

In Chapter 5, the most suitable interventions were selected according to stakeholders. There might be other interventions that are also applicable for optimising the ED performance. These interventions and the effects of all these interventions should be further researched using a simulation study. Other components, other than the effectiveness, determine if an intervention might eventually be implemented. Examples of other components are costs and ease of implementation. These additional influences should be researched.

Patients and high waiting times

According to the bottlenecks stated in Section 4.2, patients perceived high ED waiting times. Additionally, according to the results of the KPIs in Section 4.3, the norms of waiting time 1 and 2 are met in respectively 43.0% and 43.4%. This means that there should be research regarding these waiting times and the optimisation of these waiting times. However, this research should focus on ED arrivals that perceive high waiting times and if these ED arrivals wait longer than the norm prescribes. The results show that patients with lower urgency are more likely to be helped within norm waiting time 2. However, these ED arrivals are the arrivals that are most likely to complain about waiting times. The research should also focus on the perception of the ED arrival regarding waiting time and how to influence this perception.

ED arrivals who need GP(S) care

According to the results of the KPIs in Section 4.3, there is a high percentage of ED arrivals who need GP(S) care. However, this was measured manually and during one week. These measurements should be part of the EMR in order to be certain about this percentage throughout a longer period of time. If this KPI, ED arrivals who need GP(S) care, is measured

again, the percentage of ED arrivals who need GP(S) care is more certain and research should focus on how to influence these types of ED arrivals to visit their GP and the GP(S). Knowing how many of the ED arrivals need GP(S) care and how to influence these groups of ED arrivals in their choice for an ED visit or GPS visit is significant. Further research should focus on how this influences the other KPIs and ultimately, the ED performance.

The KPI, ED arrivals who need GP(S) care, resulted in which ED arrivals needed GP(S) care. For the different MTS urgencies: red, orange, yellow, green and blue, the percentage that needed GP(S) care was respectively: 0%; 0%; 4.8%; 35.8% and 80.0%. However, a study by Koster (2014) conducted in the Medisch Spectrum Twente (MST) in Enschede, has stated that the distribution should be: 0%; 10%; 30%; 50% and 100%. This means that actually more ED arrivals in HOH could receive GPS care. However, the structure of the GPS is different in the MST compared to the GPS in Aruba. If this distribution of Koster (2014) and the current distribution of urgencies are used to calculate the total percentage of ED arrivals that should visit the GPS, this percentage is 40.1% instead of the 21.1% calculated in this research.

Retain employees and attract new employees

As stated by the stakeholders, the ED is experiencing difficulty in retaining and attracting employees with the right qualifications, which ultimately leads to the ED capacity problem in terms of nurses and doctors. Additionally, the ED's management has stated that the number of ED employees per day should be higher according to the workload. Research should be performed on how HOH can attract more new employees and assure these new employees stay working at the ED of HOH.

References

Abo-Hamad, W., & Arisha, A. (2013). Simulation-based framework to improve patient experience in an emergency department. *European Journal of Operational Research*, *224*(1), 154–166. https://doi.org/10.1016/j.ejor.2012.07.028

Andringa, R. J. (2018). *OR Optimisation at Dr. Horacio E. Oduber Hospitaal.* Retrieved from https://essay.utwente.nl/74976/

Arah, O. (2005). *Performance reexamined. concepts, content and practice of measuring health system performance.* Academisch medisch centrum.

Boyle, A., Beniuk, K., Higginson, I., & Atkinson, P. (2012). Emergency Department Crowding: Time for Interventions and Policy Evaluations. *Emergency Medicine International*, *2012*, 1–8. https://doi.org/10.1155/2012/838610

Carter, N. (1991). Learning to measure performance: the use of indicators in organisations. *Public Administration*, *69*(1), 85–101. https://doi.org/10.1111/j.1467-9299.1991.tb00783.x

Central Intelligence Agency [CIA]. (2019). The World Factbook - Aruba. Retrieved February 6, 2019, from https://www.cia.gov/library/publications/the-world-factbook/geos/aa.html

Dr. Horacio E. Oduber Hospital [HOH]. (2019). *About HOH.* Retrieved February 6, 2019, from http://arubahospital.com/about-hoh/

Flores-Mateo, G., Violan-Fors, C., Carrillo-Santisteve, P., Peiró, S., & Argimon, J.-M. (2012). Effectiveness of Organizational Interventions to Reduce Emergency Department Utilisation: A Systematic Review. *PLoS ONE*, *7*(5). https://doi.org/10.1371/journal.pone.0035903

Hamers, Z F.M. (1996). *Besturen in theorie en organisatie*. Fontys Hogescholen.

Hans, E. W., van Houdenhoven, M., & Hulshof, P. J. H. (2011). A Framework for Healthcare Planning and Control. *Handbook of Healthcare System Scheduling*, 303–320. https://doi.org/10.1007/978-1-4614-1734-7_12

Heerkens, J. M. G., & van Winden, A. (2012). *Geen probleem: een aanpak voor alle bedrijfskundige vragen en mysteries : met stevige stagnatie in de kunststoffabriek*. Van Winden Communicatie.

HOH. (2018a). *Samenvatting gemiddelde doorlooptijden per dag en tijdstip.*

HOH. (2018b). *Samenvatting wachttijd 1 en wachttijd 2.*

HOH. (2019). *International Patients.* Retrieved February 8, 2019, from http://www.arubahospital.com/practical-info/international-patients/

HOH. (w.d.). *Meerjarenbeleidsplan HOH 2014 – 2017.*

Hwang, C., Lipman, G., & Kane, M. (2015). Effect of an Emergency Department Fast Track on Press-Ganey Patient Satisfaction Scores. *Western Journal of Emergency Medicine*, *16*(1), 34–38. https://doi.org/10.5811/westjem.2014.11.21768

Koster, D.M. (2014). *Simulating the effect of an integrated emergency post in Enschede.* Retrieved from https://essay.utwente.nl/65913/

Mitchell, R. K., Agle, B. R., & Wood, D. J. (1997). Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts. *The Academy of Management Review*, *22*(4), 853-886. https://doi.org/10.2307/259247

Morgan, S. R., Chang, A. M., Alqatari, M., & Pines, J. M. (2013). Non-Emergency Department Interventions to Reduce ED Utilisation: A Systematic Review. *Academic Emergency Medicine*, *20*(10), 969–985. https://doi.org/10.1111/acem.12219

Neely, A. D., Gregory, M. J., & Platts, K. W. (1995). Performance measurement system design: A literature review and research agenda. *International Journal of Operations and Production Management*, 25(12), 80-116. https://doi.org/10.1108/01443570510633639

O'Neill, S. M., Miake-Lye, I., Childers, C. P., Mak, S., Beroes, J. M., Maggard-Gibbons, M., & Shekelle, P. G. (2018). Effectiveness of interventions to improve the efficiency of emergency department operations: An evidence map. *The American Journal of Emergency Medicine*, *36*(12), 2314–2317. https://doi.org/10.1016/j.ajem.2018.04.012

Rezaei, F., Yarmohammadian, M., Haghshenas, A., & Tavakoli, N. (2017). Overcrowding in emergency departments: A review of strategies to decrease future challenges. *Journal of Research in Medical Sciences*, *22*(1), 23. https://doi.org/10.4103/1735-1995.200277

Sanchez, M., Smally, A. J., Grant, R. J., & Jacobs, L. M. (2006). Effects of a fast-track area on emergency department performance. *The Journal of Emergency Medicine*, *31*(1), 117–120. https://doi.org/10.1016/j.jemermed.2005.08.019

Sørup, C. M., Jacobsen, P., & Forberg, J. L. (2013). Evaluation of emergency department performance – a systematic review on recommended performance and quality-in-care measures. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *21*(1). https://doi.org/10.1186/1757-7241-21-62

van Keulen, M. (2012). Managing Uncertainty: The Road Towards Better Data Interoperability. *It - Information Technology*, *54*(3), 138–146. https://doi.org/10.1524/itit.2012.0674

Waring, J. J. (2000). *Towards an integrated organisational framework of hospital performance*. Aston Business School Research Insitute.

Wilson, M.J., & Nguyen, K. (2004). *Bursting at the seams: Improving Patient Flow to Help America's Emergency Departments.* Urgent Matters: The George Washington University Medical Center School of Public Health and Health Services Department of Health Policy.

Zairi, M., & Leonard, P. (1994). *Practical Benchmarking: The Complete Guide: A complete guide*. Springer Netherlands.

Appendix A: Context analysis

This appendix shows the data that was used for the context analysis in Chapter 3.

ED Workload per urgency per month

This table shows the ED workload per month in 2018 (N = 34,666).

Table A.1: ED workload per urgency per month in 2018

Urgency Month	Red	Orange	Yellow	Green	Blue	Blank	Total	Number of patients per 30,4 days
Jan	9	203	1,087	1,702	49	40	3,09	3,033
Feb	10	178	1,133	1,524	35	48	2,928	3,188
Mar	15	208	1,141	1,709	50	42	3,165	3,106
Apr	13	219	988	1,482	35	46	2,783	2,822
May	13	218	1,098	1,522	28	32	2,911	2,867
Jun	6	181	953	1,475	44	32	2,691	2,729
Jul	7	174	979	1,512	30	29	2,731	2,681
Aug	14	131	1,052	1,504	30	45	2,776	2,724
Sep	16	147	1,044	1,437	22	28	2,694	2,732
Oct	9	185	1,058	1,571	36	23	2,882	2,829
Nov	11	213	1,212	1,527	40	26	3,029	3,071
Dec	7	217	1,094	1,607	28	33	2,986	2,932
Total	130	2,274	12,839	18,572	427	424	34,666	-
Average	11	196	1,012	1,523	34	36	2,889	2,892

ED and GPS capacity and shifts for nurses and doctors

These tables show the ED and GPS capacity and shifts for nurses and doctors.

Table A.2: ED capacity and shifts of ED nurses

	From	To	Break (minutes)	Workable minutes per nurse	Number of nurses present	Total workable minutes per day	Total workable minutes per week
Day shift	6:50	14:50	30	450	5	2,400	16,800
Evening shift	14:40	22:40	30	450	5	2,400	16,800
Night shift 1	22:30	7:00	30	480	3	1,440	10,080
Total capacity per week							43,680

Table A.3: ED capacity and shifts of ED doctors

	From	To	Break (minutes)	Workable minutes per doctor	Number of doctors present	Total workable minutes per day	Total workable minutes per week
Day shift	7:00	15:00	30	450	2	900	6,300
Evening shift	15:00	23:00	30	450	2	900	6,300
Night shift 1	23:00	7:00	30	450	1	450	3,150
Night shift 2 (during weekends)	20:00	4:00	30	450	1 additional	450	900
Total capacity per week							16,650

Table A.4: GPS capacity and shifts of GPS nurses and doctors

Name	From	To	Break (minutes)	Workable minutes per employee	Number of employees present	Total workable minutes per day	Total workable minutes per week
Evening shift during working days	18:30	22:30	0	240	1	240	1,200
Day shift during weekends	9:00	13:00	0	240	1	240	480
Evening shift during weekends	18:00	22:00	0	240	1	240	480
Total capacity per week							2,160

ED Workload per urgency per month

This table shows the ED workload during the week and per hour from December 2017 until November 2018 (N = 34,421).

Table A.5: ED workload per urgency during the week from December 2017 until November 2018 (N = 34,421)

Urgency Day	Red	Orange	Yellow	Green	Blue	Blank	Total	Average patient visits	Percentage
Monday	23	352	1,823	2,746	68	49	5,061	95.5	14.5%
Tuesday	21	279	1,763	2,599	44	47	4,753	91.4	13.8%
Wednesday	12	319	1,928	2,459	62	50	4,83	92.9	14.1%
Thursday	12	287	1,745	2,456	58	45	4,597	88.4	13.4%
Friday	15	325	1,914	2,624	60	72	5,01	96.3	14.6%

Saturday	19	308	1,698	2,838	81	74	5,018	96.5	14.6%
Sunday	16	341	1,753	2,924	63	55	5,152	99.1	15.0%
Total	118	2,211	12,624	18,64	436	392	34,421	94.3	100%
Percentage	0.3%	6.4%	36.7%	54.2%	1.3%	1.1%	100%		

Table A.6: ED workload per urgency per hour from December 2017 until November 2018 (N = 34,421).

Urgency Hour	Red	Orange	Yellow	Green	Blue	Blank	Total	Percentage
0	1	72	372	619	12	14	1,090	3.2%
1	1	71	275	442	10	6	805	2.3%
2	3	54	247	376	8	4	692	2.0%
3	4	52	194	278	10	6	544	1.6%
4	2	45	174	269	6	4	500	1.5%
5	1	54	162	237	9	1	464	1.4%
6	2	44	191	292	7	1	537	1.6%
7	3	54	315	452	16	5	845	2.5%
8	8	89	503	859	31	8	1,498	4.4%
9	8	107	767	916	34	8	1,840	5.4%
10	4	134	882	1,035	21	17	2,093	6.1%
11	9	151	866	1,104	24	28	2,182	6.3%
12	7	140	753	1,002	20	25	1,947	5.7%
13	5	117	716	892	16	26	1,772	5.2%
14	9	104	679	991	12	26	1,821	5.3%
15	7	123	709	1,087	25	16	1,967	5.7%
16	4	99	582	1,032	19	24	1,760	5.1%
17	9	104	644	943	21	24	1,745	5.1%
18	6	96	678	994	17	23	1,814	5.3%
19	2	115	662	1,039	24	21	1,863	5.4%
20	10	100	681	1,023	25	30	1,869	5.4%
21	5	102	611	991	18	31	1,758	5.1%
22	5	86	525	949	25	31	1,621	4.7%
23	3	98	436	818	26	13	1,394	4.1%
Total	118	2,211	12,624	18,640	436	392	34,421	100%
Percentage	0.3%	6.4%	36.7%	54,2%	1,3%	1,1%	100%	

Appendix B: Measurement of KPIs

This appendix shows the data that was used for the measurements of the KPIs in Section 4.3.

KPI 1: Throughput time

These first six tables and figures show the average throughput time per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145). The last six tables and figures show the percentage within the norm throughput time per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145).

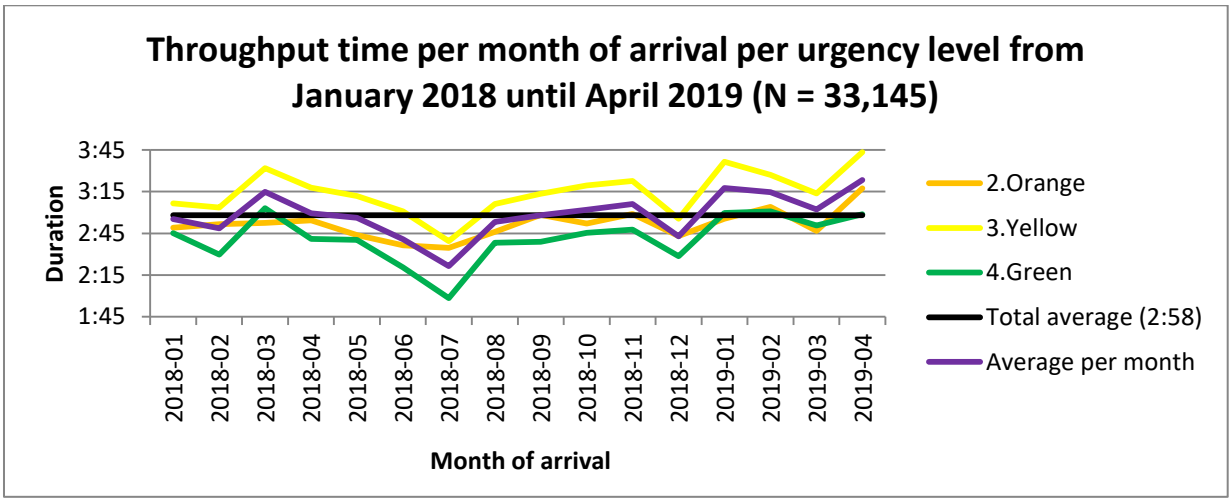

Figure B.1: Throughput time per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.1: Throughput time per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Year-Month of arrival	Red	Orange	Yellow	Green	Blue	Average
2018-01	1:55	2:48	3:06	2:45	2:20	2:55
2018-02	2:55	2:51	3:03	2:29	1:50	2:48
2018-03	1:48	2:52	3:31	3:03	1:26	3:14
2018-04	2:08	2:54	3:17	2:41	1:01	2:59
2018-05	2:14	2:43	3:11	2:40	2:32	2:56
2018-06	2:12	2:36	3:00	2:20	0:49	2:40
2018-07	1:31	2:34	2:39	1:58	1:42	2:21
2018-08	2:14	2:45	3:06	2:38	2:52	2:53
2018-09	2:52	2:58	3:13	2:38	X	2:58
2018-10	2:35	2:51	3:19	2:45	1:09	3:02
2018-11	2:17	2:58	3:22	2:47	0:43	3:06
2018-12	1:40	2:43	2:55	2:28	2:04	2:42
2019-01	2:08	2:55	3:36	2:59	1:15	3:17

2019-02	2:58	3:03	3:27	3:00	4:49	3:14
2019-03	1:55	2:46	3:13	2:50	2:41	3:02
2019-04	2:38	3:17	3:43	2:58	1:07	3:23
Average	2:16	2:51	3:14	2:41	1:43	2:58

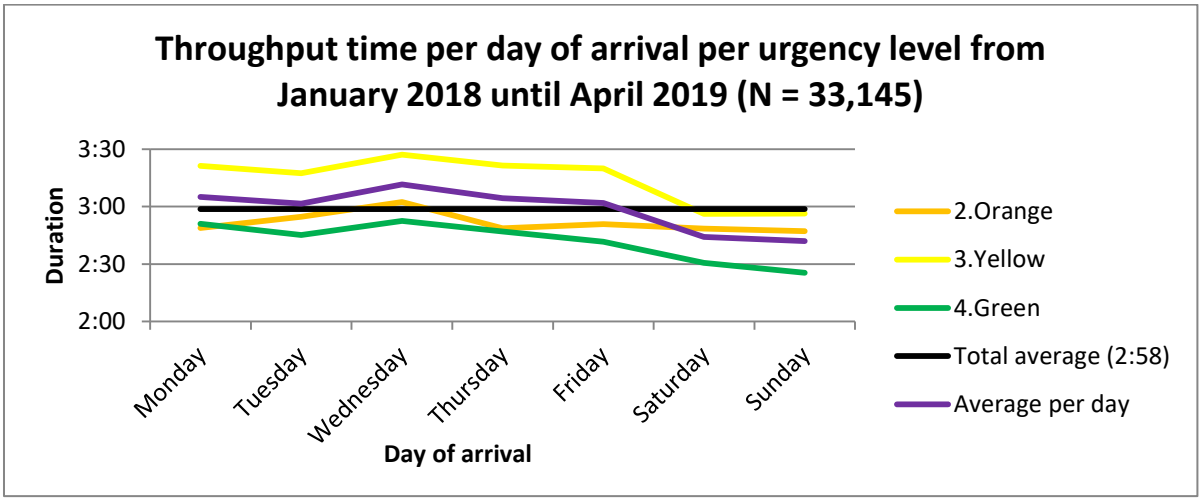

Figure B.2: Throughput time per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.2: Throughput time per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Day of arrival	Red	Orange	Yellow	Green	Blue	Average
Monday	2:04	2:48	3:21	2:51	2:04	3:05
Tuesday	2:03	2:54	3:17	2:45	2:41	3:01
Wednesday	2:34	3:02	3:27	2:52	2:02	3:11
Thursday	2:15	2:48	3:21	2:47	1:29	3:04
Friday	2:36	2:50	3:19	2:41	0:43	3:01
Saturday	2:21	2:48	2:56	2:30	1:14	2:44
Sunday	2:11	2:47	2:56	2:25	1:22	2:41
Average	2:16	2:51	3:14	2:41	1:43	2:58

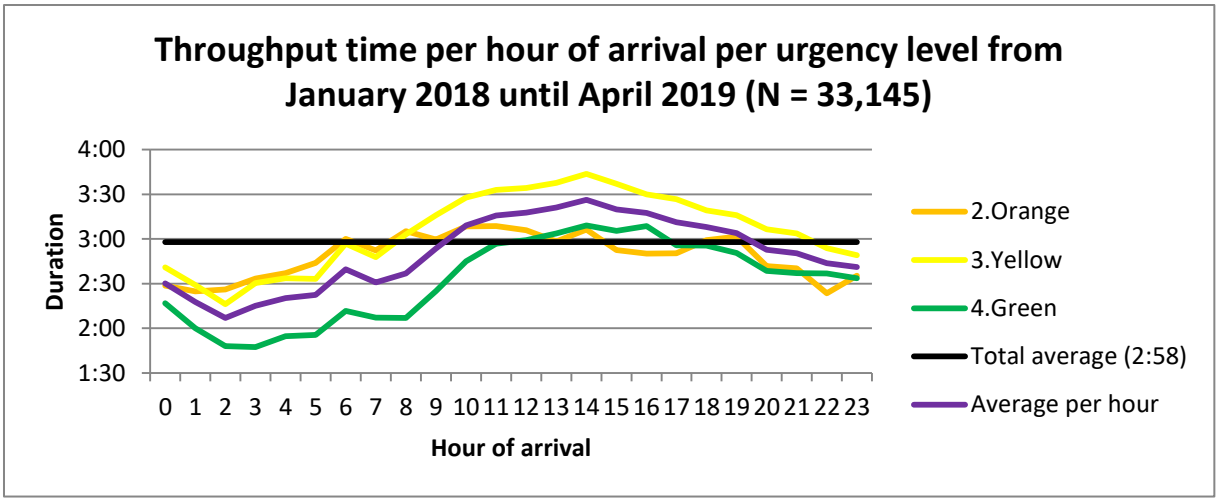

Figure B.3: Throughput time per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.3: Throughput time per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Hour of arrival	Red	Orange	Yellow	Green	Blue	Average
0:00 – 0:59	2:09	2:28	2:40	2:16	2:56	2:30
1:00 – 1:59	2:09	2:24	2:29	2:00	1:10	2:17
2:00 – 2:59	1:43	2:26	2:16	1:48	4:47	2:07
3:00 – 3:59	2:41	2:33	2:30	1:47	3:15	2:15
4:00 – 4:59	2:31	2:37	2:33	1:54	0:51	2:20
5:00 – 5:59	3:46	2:43	2:33	1:55	0:49	2:22
6:00 – 6:59	4:58	3:00	2:56	2:11	X	2:40
7:00 – 7:59	2:39	2:52	2:47	2:07	0:21	2:30
8:00 – 8:59	2:09	3:05	3:03	2:07	2:35	2:36
9:00 – 9:59	2:33	2:59	3:16	2:25	2:47	2:53
10:00 – 10:59	1:47	3:08	3:27	2:45	0:51	3:08
11:00 – 11:59	2:11	3:08	3:33	2:56	1:21	3:15
12:00 – 12:59	2:49	3:05	3:34	2:59	1:46	3:17
13:00 – 13:59	2:14	2:58	3:37	3:03	0:27	3:20
14:00 – 14:59	1:33	3:06	3:43	3:09	X	3:25
15:00 – 15:59	1:59	2:52	3:37	3:05	1:03	3:19
16:00 – 16:59	1:46	2:50	3:29	3:08	0:15	3:17
17:00 – 17:59	2:23	2:50	3:26	2:55	0:46	3:10
18:00 – 18:59	1:58	2:59	3:19	2:55	2:46	3:07
19:00 – 19:59	3:29	3:01	3:15	2:50	1:19	3:03
20:00 – 20:59	2:01	2:41	3:06	2:38	1:15	2:52
21:00 – 21:59	2:28	2:40	3:03	2:37	1:15	2:50
22:00 – 22:59	2:39	2:23	2:53	2:36	X	2:43
23:00 – 23:59	2:06	2:35	2:49	2:33	2:06	2:40
Average	2:16	2:51	3:14	2:41	1:43	2:58

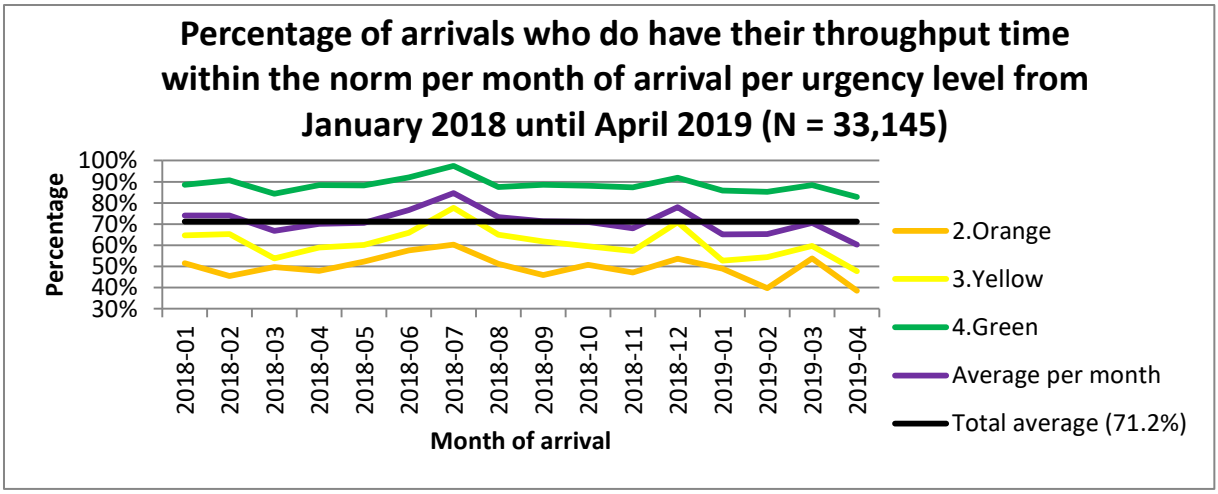

Figure B.4: Percentage of arrivals who do have their throughput time within the norm per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.4: Percentage of arrivals who do have their throughput time within the norm per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Month of arrival	Red	Orange	Yellow	Green	Blue	Average
2018-01	77.8%	51.5%	64.7%	88.6%	100%	74.1%
2018-02	40.0%	45.5%	65.4%	90.8%	100%	74.0%
2018-03	73.3%	49.8%	53.8%	84.3%	100%	66.8%
2018-04	61.5%	47.9%	59.0%	88.4%	100%	70.2%
2018-05	69.2%	52.3%	60.2%	88.3%	100%	70.6%
2018-06	83.3%	57.6%	65.9%	92.0%	100%	76.6%
2018-07	100%	60.3%	77.6%	97.6%	100%	84.6%
2018-08	61.5%	51.2%	65.1%	87.5%	100%	73.3%
2018-09	40.0%	45.9%	61.8%	88.6%	X	71.4%
2018-10	44.4%	50.8%	59.6%	88.1%	100%	71.0%
2018-11	63.6%	47.2%	57.3%	87.3%	100%	68.0%
2018-12	85.7%	53.7%	70.8%	91.9%	100%	77.9%
2019-01	70.0%	48.9%	52.8%	85.8%	100%	65.1%
2019-02	60.0%	39.8%	54.4%	85.3%	50.0%	65.3%
2019-03	71.4%	53.8%	59.7%	88.4%	100%	70.6%
2019-04	57.1%	38.5%	47.8%	82.8%	100%	60.4%
Average	64.0%	49.7%	60.9%	88.5%	91.7%	71.2%

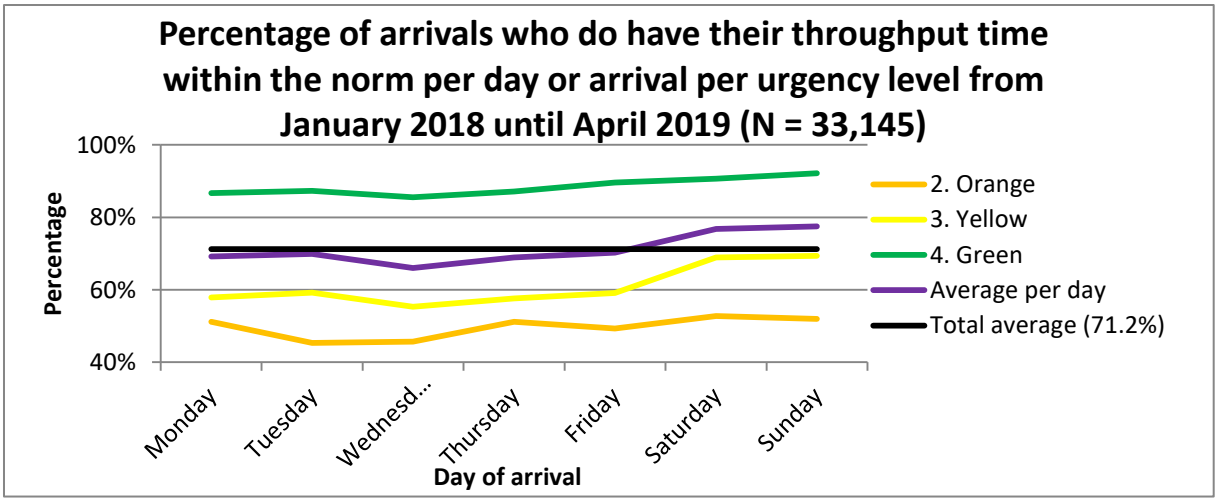

Figure B.5: Percentage of arrivals who do have their throughput time within the norm per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.5: Percentage of arrivals who do have their throughput time within the norm per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Day of arrival	Red	Orange	Yellow	Green	Blue	Average
Monday	72.4%	51.1%	57.9%	86.7%	87.5%	69.2%
Tuesday	70.0%	45.3%	59.2%	87.3%	80.0%	69.9%
Wednesday	64.7%	45.7%	55.3%	85.6%	100%	66.0%
Thursday	54.5%	51.1%	57.6%	87.1%	100%	68.9%
Friday	58.3%	49.3%	59.1%	89.6%	100%	70.3%
Saturday	59.1%	52.8%	68.9%	90.7%	100%	76.8%
Sunday	65.0%	52.0%	69.3%	92.2%	100%	77.5%
Average	64.0%	49.7%	60.9%	88.5%	91.7%	71.2%

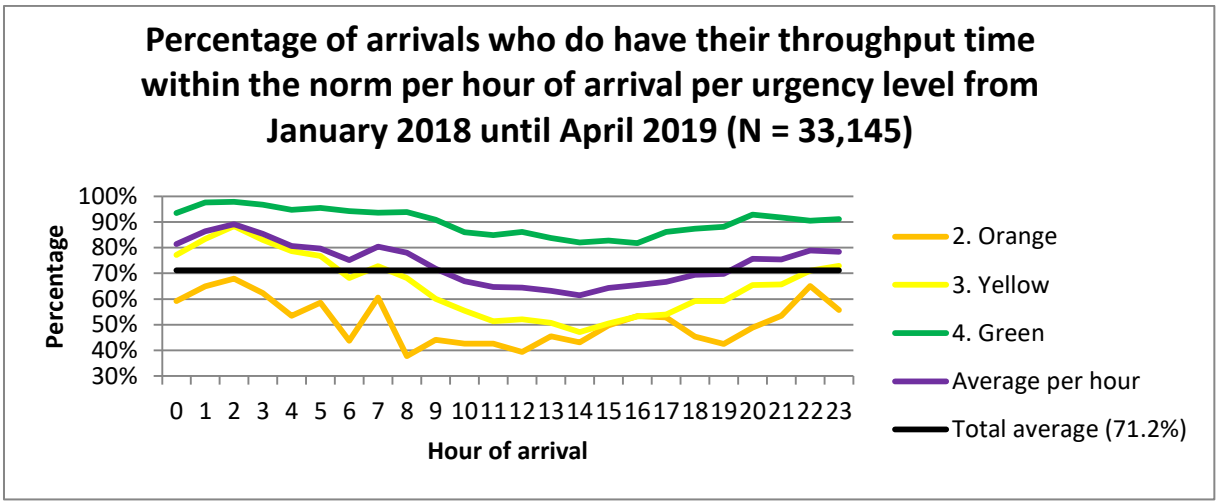

Figure B.6: Percentage of arrivals who do have their throughput time within the norm per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.6: Percentage of arrivals who do have their throughput time within the norm per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Hour of arrival	Red	Orange	Yellow	Green	Blue	Average
0:00 – 0:59	66.7%	59.2%	77.1%	93.4%	100%	81.4%
1:00 – 1:59	75.0%	64.9%	83.4%	97.6%	100%	86.4%
2:00 – 2:59	60.0%	67.9%	88.4%	97.8%	100%	89.1%
3:00 – 3:59	50.0%	62.3%	83.1%	96.8%	100%	85.3%
4:00 – 4:59	75.0%	53.5%	78.6%	94.7%	100%	80.6%
5:00 – 5:59	0.0%	58.5%	76.8%	95.5%	100%	79.7%
6:00 – 6:59	0.0%	43.8%	68.2%	94.3%	X	75.1%
7:00 – 7:59	42.9%	60.5%	72.8%	93.7%	100%	80.4%
8:00 – 8:59	70.0%	37.7%	68.2%	93.9%	100%	78.0%
9:00 – 9:59	66.7%	44.1%	60.1%	90.9%	87.5%	71.8%
10:00 – 10:59	80.0%	42.6%	55.5%	86.0%	100%	66.9%
11:00 – 11:59	75.0%	42.6%	51.3%	84.9%	100%	64.7%
12:00 – 12:59	40.0%	39.4%	52.1%	86.2%	100%	64.4%
13:00 – 13:59	66.7%	45.5%	50.7%	83.8%	100%	63.2%
14:00 – 14:59	90.9%	43.1%	47.2%	82.1%	X	61.5%
15:00 – 15:59	77.8%	49.7%	50.5%	82.8%	100%	64.4%
16:00 – 16:59	80.0%	53.4%	53.2%	81.8%	100%	65.4%
17:00 – 17:59	62.5%	52.9%	53.9%	86.1%	100%	66.6%
18:00 – 18:59	75.0%	45.3%	59.2%	87.4%	100%	69.4%
19:00 – 19:59	16.7%	42.5%	59.2%	88.1%	100%	69.7%
20:00 – 20:59	64.3%	48.9%	65.4%	92.8%	100%	75.7%
21:00 – 21:59	28.6%	53.5%	65.7%	91.7%	100%	75.4%
22:00 – 22:59	57.1%	65.0%	71.0%	90.5%	X	78.9%
23:00 – 23:59	80.0%	55.7%	72.9%	91.1%	100%	78.4%
Average	64.0%	49.7%	60.9%	88.5%	98.1%	71.2%

KPI 2: Waiting time 1

These first three figures show the average waiting time 1 per month, per day and per hour of arrival from January 2018 until April 2019 (N = 45,541). The last six tables and figures show the percentage of arrivals within the norm waiting time 1 per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145).

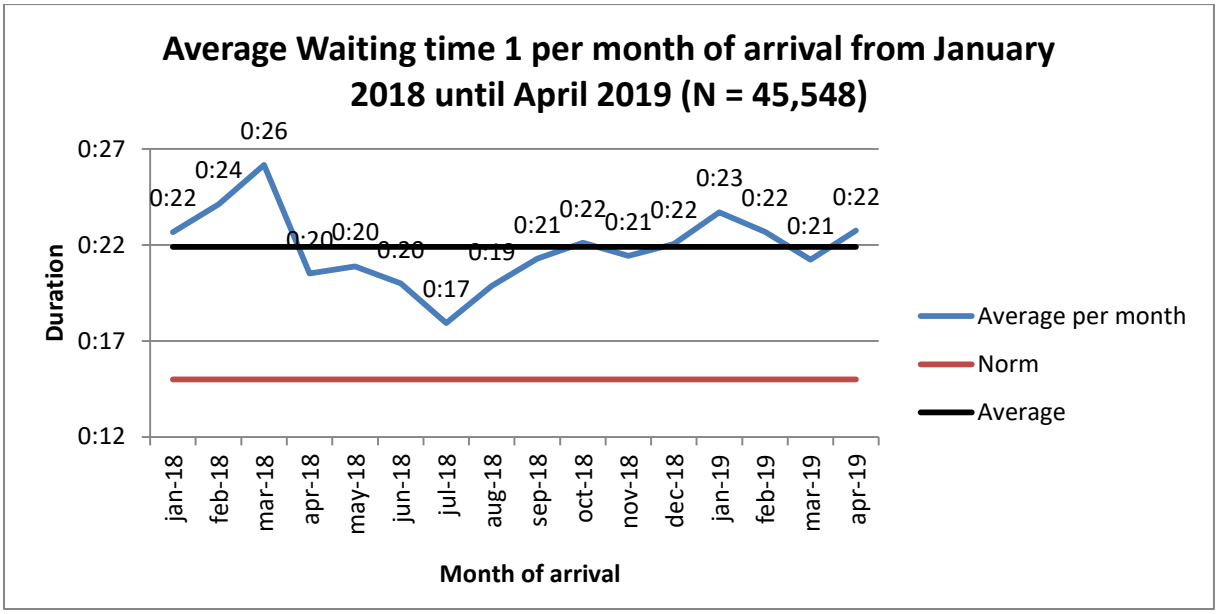

Figure B.7: Average waiting time 1 per month of arrival from January 2018 until April 2019 (N = 45,548)

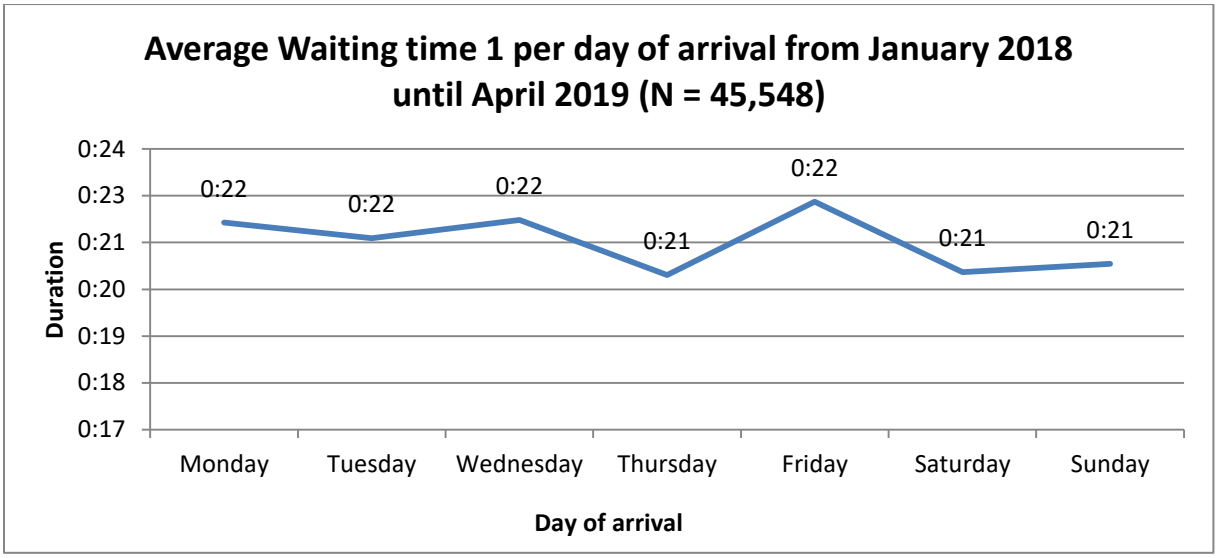

Figure B.8: Average waiting time 1 per day of arrival from January 2018 until April 2019 (N = 45,548)

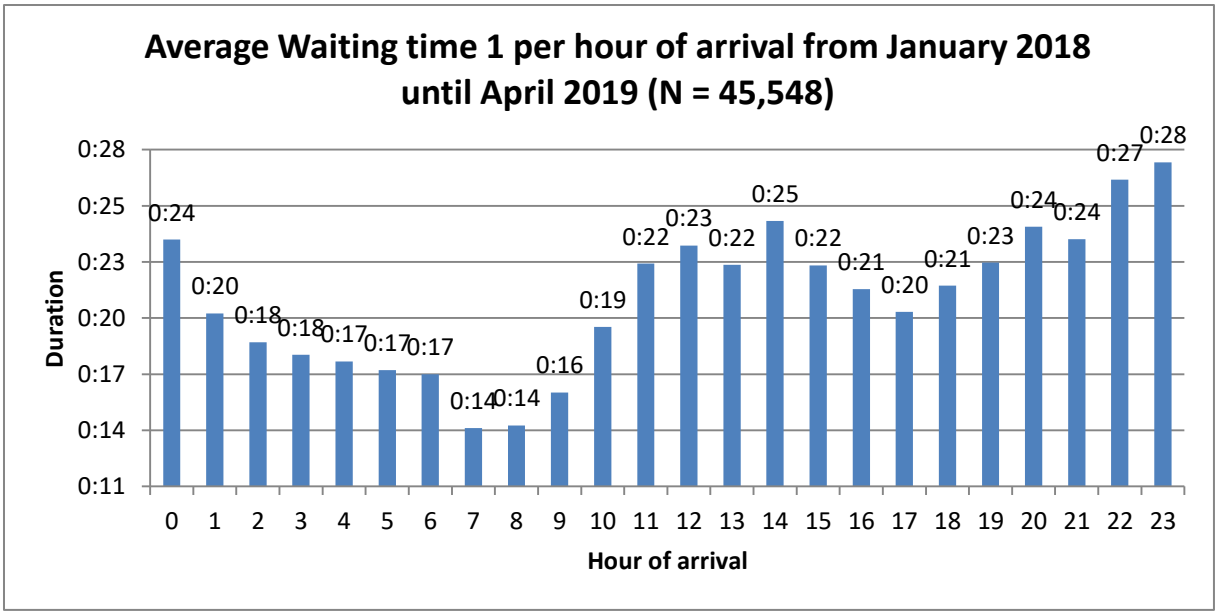

Figure B.9: Average waiting time 1 per hour of arrival from January 2018 until April 2019 (N = 45,548)

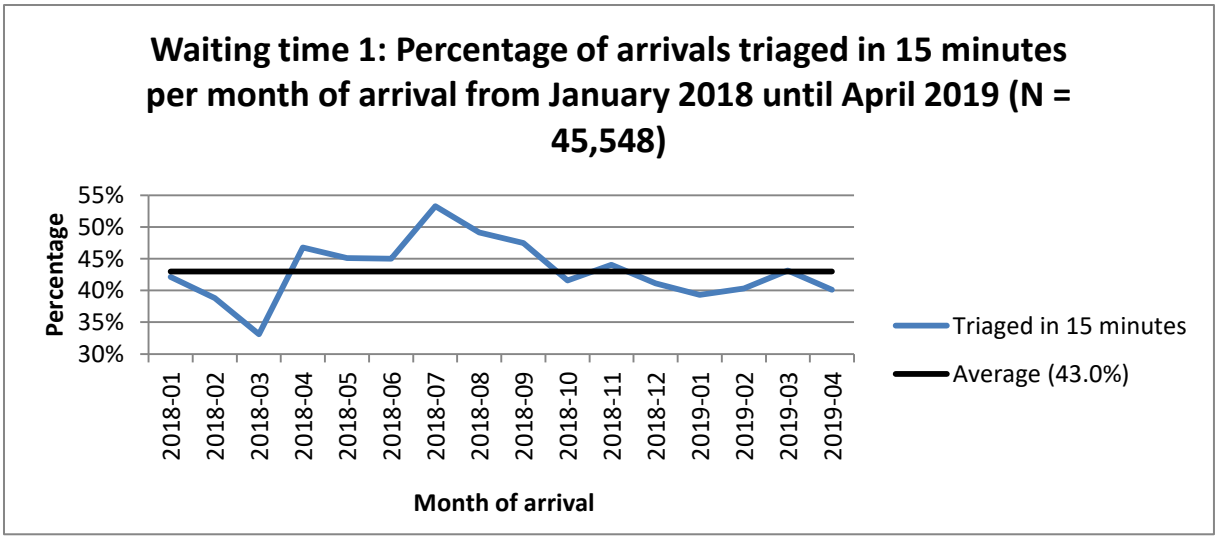

Figure B.10: Percentage of arrivals who do have their waiting time 1 within the norm per month of arrival from January 2018 until April 2019 (N = 45,458)

Table B.7: Percentage of arrivals who do have their waiting time 1 within the norm per month of arrival from January 2018 until April 2019 (N = 45,458)

Month of arrival	Not triaged in 15 minutes	Triaged in 15 minutes
2018-01	57.9%	42.1%
2018-02	61.2%	38.8%
2018-03	66.9%	33.1%
2018-04	53.3%	46.7%
2018-05	54.9%	45.1%
2018-06	55.0%	45.0%

2018-07	46.8%	53.2%
2018-08	50.9%	49.1%
2018-09	52.6%	47.4%
2018-10	58.4%	41.6%
2018-11	56.0%	44.0%
2018-12	58.9%	41.1%
2019-01	60.7%	39.3%
2019-02	59.7%	40.3%
2019-03	56.9%	43.1%
2019-04	59.9%	40.1%
Average	57.0%	43.0%

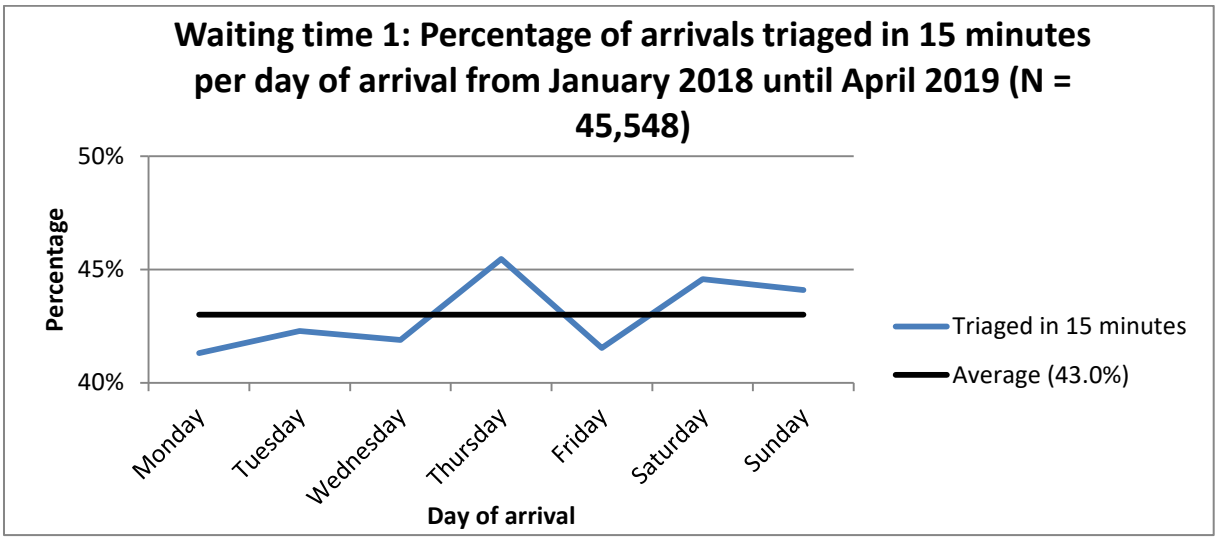

Figure B.11: Percentage of arrivals who do have their waiting time 1 within the norm per day of arrival from January 2018 until April 2019 (N = 45,458)

Table B.8: Percentage of arrivals who do have their waiting time 1 within the norm per day of arrival from January 2018 until April 2019 (N = 45,458)

Day of arrival	Not triaged in 15 minutes	Triaged in 15 minutes
Monday	58.7%	41.3%
Tuesday	57.7%	42.3%
Wednesday	58.1%	41.9%
Thursday	54.5%	45.5%
Friday	58.5%	41.5%
Saturday	55.4%	44.6%
Sunday	55.9%	44.1%
Average	57.0%	43.0%

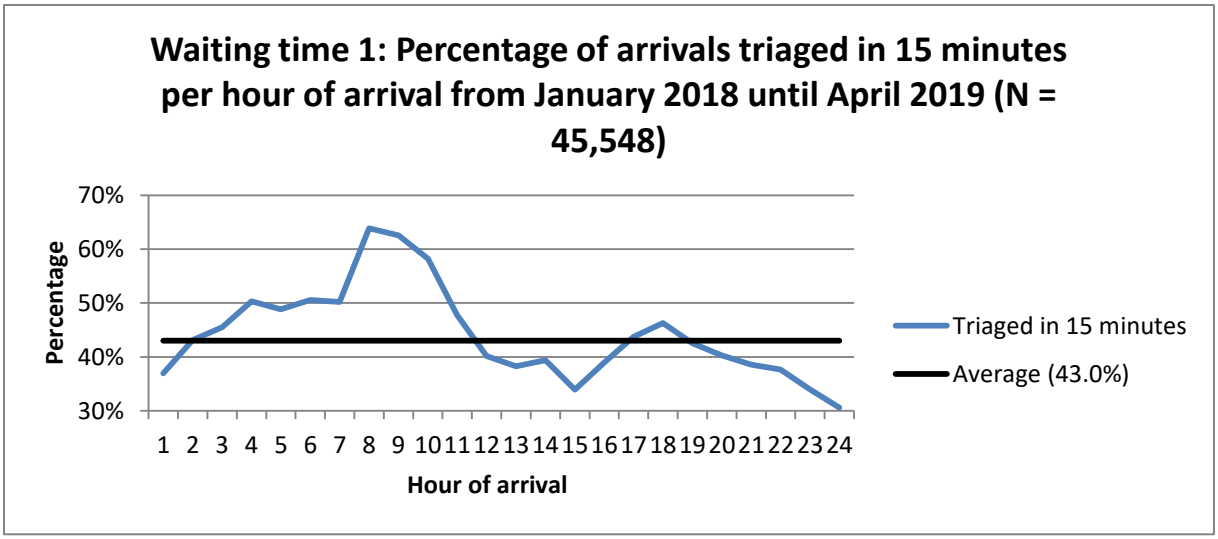

Figure B.12: Percentage of arrivals who do have their waiting time 1 within the norm per hour of arrival from January 2018 until April 2019 (N = 45,458)

Table B.9: Percentage of arrivals who do have their waiting time 1 within the norm per hour of arrival from January 2018 until April 2019 (N = 45,458)

Hour of arrival	Not triaged in 15 minutes	Triaged in 15 minutes	Total
0:00 – 0:59	63.0%	37.0%	100%
1:00 – 1:59	56.9%	43.1%	100%
2:00 – 2:59	54.5%	45.5%	100%
3:00 – 3:59	49.7%	50.3%	100%
4:00 – 4:59	51.2%	48.8%	100%
5:00 – 5:59	49.4%	50.6%	100%
6:00 – 6:59	49.8%	50.2%	100%
7:00 – 7:59	36.2%	63.8%	100%
8:00 – 8:59	37.5%	62.5%	100%
9:00 – 9:59	41.8%	58.2%	100%
10:00 – 10:59	52.2%	47.8%	100%
11:00 – 11:59	59.9%	40.1%	100%
12:00 – 12:59	61.7%	38.3%	100%
13:00 – 13:59	60.6%	39.4%	100%
14:00 – 14:59	66.1%	33.9%	100%
15:00 – 15:59	61.0%	39.0%	100%
16:00 – 16:59	56.3%	43.7%	100%
17:00 – 17:59	53.8%	46.2%	100%
18:00 – 18:59	57.5%	42.5%	100%
19:00 – 19:59	59.7%	40.3%	100%
20:00 – 20:59	61.4%	38.6%	100%
21:00 – 21:59	62.4%	37.6%	100%
22:00 – 22:59	66.0%	34.0%	100%
23:00 – 23:59	69.4%	30.6%	100%
Average	57.0%	43.0%	100%

KPI 3: Waiting time 2

These first six tables and figures show the average waiting time 2 per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145). The last six tables and figures show the percentage of arrivals within the norm waiting time 2 per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145).

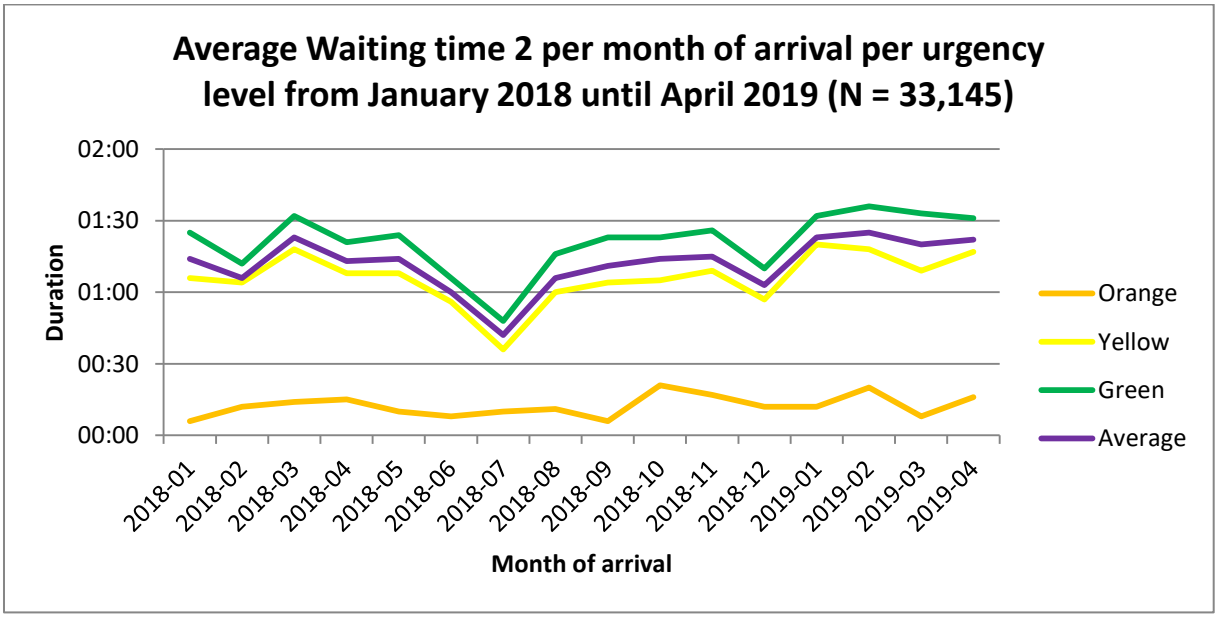

Figure B.13: Average Waiting time 2 per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.10: Average Waiting time 2 per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Month of arrival	Red	Orange	Yellow	Green	Blue	Average
2018-01	0:01	0:06	1:06	1:25	3:31	1:14
2018-02	0:00	0:12	1:04	1:12	0:13	1:06
2018-03	0:00	0:14	1:18	1:32	0:12	1:23
2018-04	0:00	0:15	1:08	1:21	X	1:13
2018-05	0:00	0:10	1:08	1:24	1:06	1:14
2018-06	0:00	0:08	0:56	1:06	X	1:00
2018-07	0:00	0:10	0:36	0:48	1:41	0:42
2018-08	0:00	0:11	1:00	1:16	0:40	1:06
2018-09	0:00	0:06	1:04	1:23	X	1:11
2018-10	0:00	0:21	1:05	1:23	0:57	1:14
2018-11	0:00	0:17	1:09	1:26	0:25	1:15
2018-12	0:00	0:12	0:57	1:10	4:54	1:03
2019-01	0:00	0:12	1:20	1:32	1:03	1:23
2019-02	0:00	0:20	1:18	1:36	3:19	1:25

2019-03	0:00	0:08	1:09	1:33	1:08	1:20
2019-04	0:00	0:16	1:17	1:31	X	1:22
Average	0:00	0:12	1:07	1:21	1:15	1:12

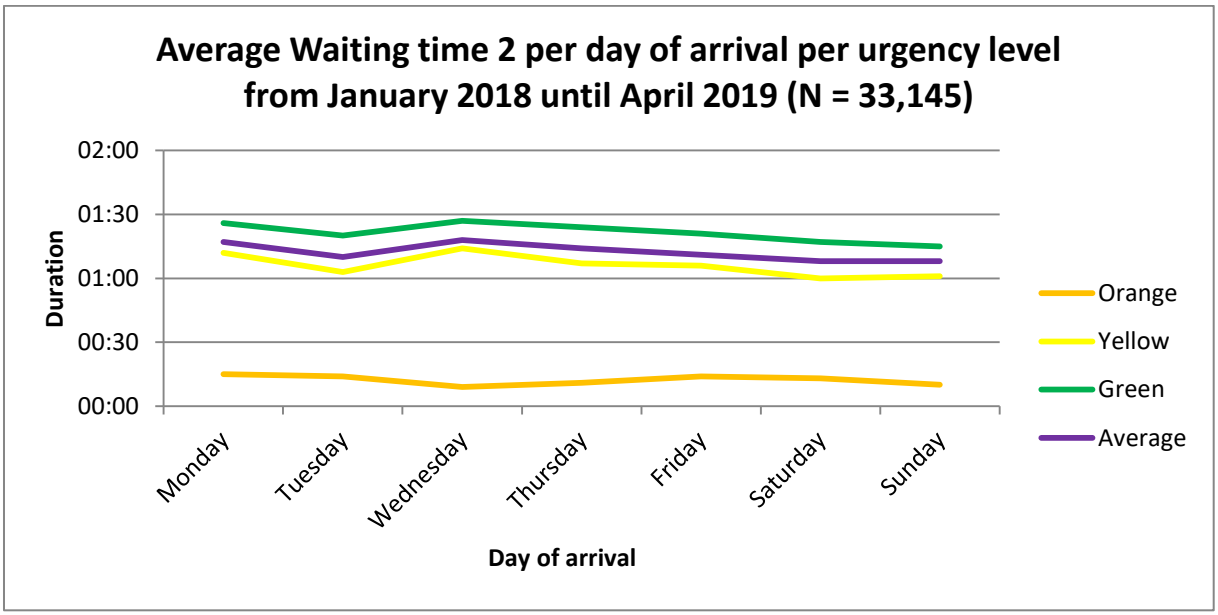

Figure B.14: Average Waiting time 2 per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.11: Average Waiting time 2 per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Day of arrival	Red	Orange	Yellow	Green	Blue	Average
Monday	0:00	0:15	1:12	1:26	1:35	1:17
Tuesday	0:00	0:14	1:03	1:20	1:53	1:10
Wednesday	0:00	0:09	1:14	1:27	1:06	1:18
Thursday	0:00	0:11	1:07	1:24	0:29	1:14
Friday	0:00	0:14	1:06	1:21	0:13	1:11
Saturday	0:00	0:13	1:00	1:17	1:33	1:08
Sunday	0:00	0:10	1:01	1:15	0:34	1:08
Average	0:00	0:12	1:07	1:21	1:15	1:12

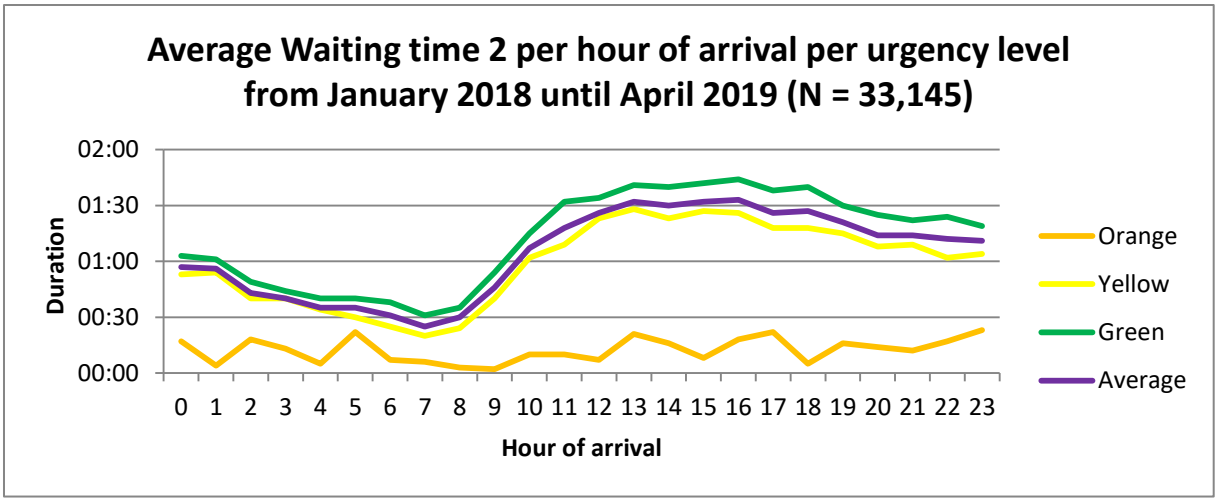

Figure B.15: Average Waiting time 2 per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.12: Average Waiting time 2 per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Hour of arrival	Red	Orange	Yellow	Green	Blue	Average
0:00 – 0:59	0:00	0:17	0:53	1:03	4:54	0:57
1:00 – 1:59	0:00	0:04	0:54	1:01	1:17	0:56
2:00 – 2:59	0:00	0:18	0:40	0:49	X	0:43
3:00 – 3:59	0:00	0:13	0:40	0:44	0:38	0:40
4:00 – 4:59	0:00	0:05	0:34	0:40	0:04	0:35
5:00 – 5:59	0:07	0:22	0:30	0:40	X	0:35
6:00 – 6:59	0:00	0:07	0:25	0:38	X	0:31
7:00 – 7:59	0:00	0:06	0:20	0:31	X	0:25
8:00 – 8:59	0:00	0:03	0:24	0:35	3:31	0:30
9:00 – 9:59	0:00	0:02	0:40	0:54	1:24	0:46
10:00 – 10:59	0:00	0:10	1:02	1:15	0:15	1:07
11:00 – 11:59	0:00	0:10	1:09	1:32	0:32	1:18
12:00 – 12:59	0:00	0:07	1:23	1:34	2:40	1:26
13:00 – 13:59	0:00	0:21	1:28	1:41	0:01	1:32
14:00 – 14:59	0:00	0:16	1:23	1:40	X	1:30
15:00 – 15:59	0:00	0:08	1:27	1:42	X	1:32
16:00 – 16:59	0:02	0:18	1:26	1:44	X	1:33
17:00 – 17:59	0:00	0:22	1:18	1:38	X	1:26
18:00 – 18:59	0:00	0:05	1:18	1:40	1:19	1:27
19:00 – 19:59	0:00	0:16	1:15	1:30	0:12	1:21
20:00 – 20:59	0:00	0:14	1:08	1:25	X	1:14
21:00 – 21:59	0:00	0:12	1:09	1:22	X	1:14
22:00 – 22:59	0:00	0:17	1:02	1:24	X	1:12
23:00 – 23:59	0:00	0:23	1:04	1:19	1:41	1:11
Average	0:00	0:12	1:07	1:21	1:15	1:12

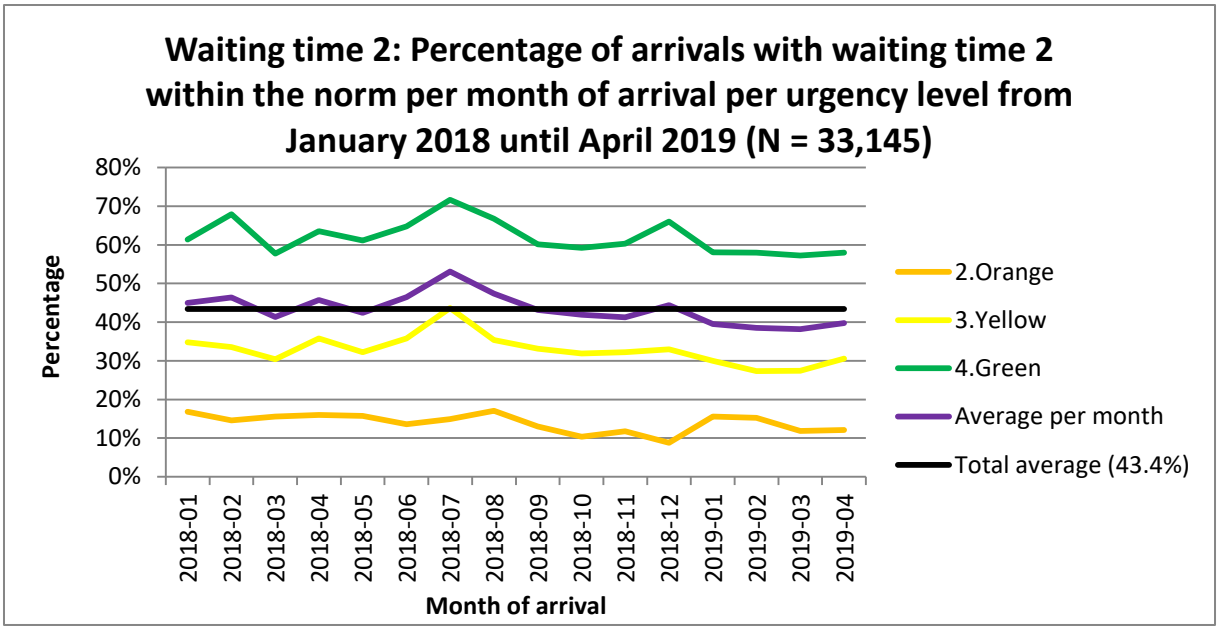

Figure B.16: Percentage of arrivals with waiting time 2 within the norm per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.13: Percentage of arrivals with waiting time 2 within the norm per month of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Month of arrival	Red	2.Orange	3.Yellow	4.Green	Blue	Average
2018-01	89.0%	16.8%	34.8%	61.4%	33.3%	45.0%
2018-02	100%	14.6%	33.5%	67.9%	80.0%	46.4%
2018-03	100%	15.6%	30.4%	57.8%	40.0%	41.3%
2018-04	100%	16.0%	35.8%	63.6%	0.0%	45.7%
2018-05	100%	15.7%	32.2%	61.1%	50.0%	42.4%
2018-06	100%	13.6%	35.8%	64.8%	0.0%	46.5%
2018-07	100%	14.9%	43.6%	71.7%	50.0%	53.1%
2018-08	100%	17.1%	35.3%	66.8%	100%	47.4%
2018-09	100%	13.0%	33.1%	60.2%	X	43.2%
2018-10	89.0%	10.4%	31.9%	59.3%	20.0%	41.9%
2018-11	100%	11.8%	32.2%	60.3%	14.3%	41.3%
2018-12	100%	8.8%	33.0%	66.0%	0.0%	44.4%
2019-01	90.0%	15.6%	30.0%	58.0%	66.7%	39.6%
2019-02	100%	15.2%	27.3%	58.0%	50.0%	38.6%
2019-03	100%	11.8%	27.4%	57.3%	100%	38.2%
2019-04	100%	12.1%	30.6%	58.0%	0.0%	39.8%
Average	98.0%	13.9%	32.9%	62.0%	42.3%	43.4%

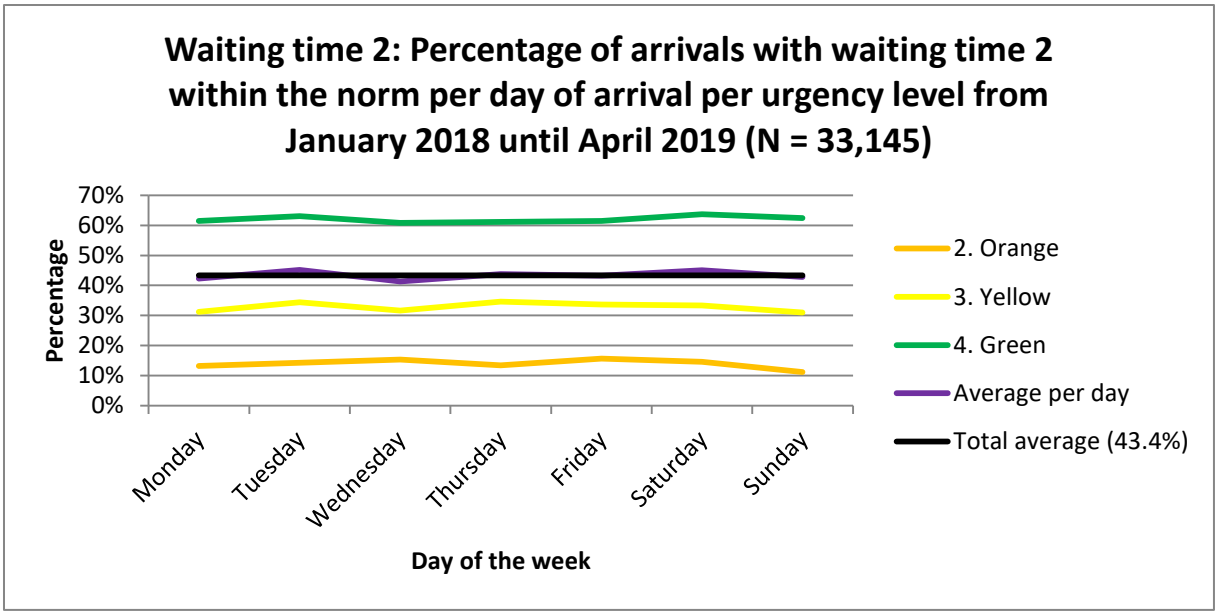

Figure B.17: Percentage of arrivals with waiting time 2 within the norm per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.14: Percentage of arrivals with waiting time 2 within the norm per day of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Day of arrival	Red	Orange	Yellow	Green	Blue	Average
Monday	96.6%	13.2%	31.3%	61.4%	87.5%	42.3%
Tuesday	100%	14.3%	34.4%	63.0%	80.0%	45.1%
Wednesday	100%	15.3%	31.6%	60.8%	100%	41.4%
Thursday	100%	13.5%	34.6%	61.2%	100%	43.7%
Friday	100%	15.7%	33.6%	61.5%	100%	43.3%
Saturday	95.5%	14.6%	33.3%	63.7%	100%	45.0%
Sunday	95.0%	11.1%	31.0%	62.4%	100%	42.9%
Average	98.2%	13.9%	32.8%	62.0%	91.7%	43.4%

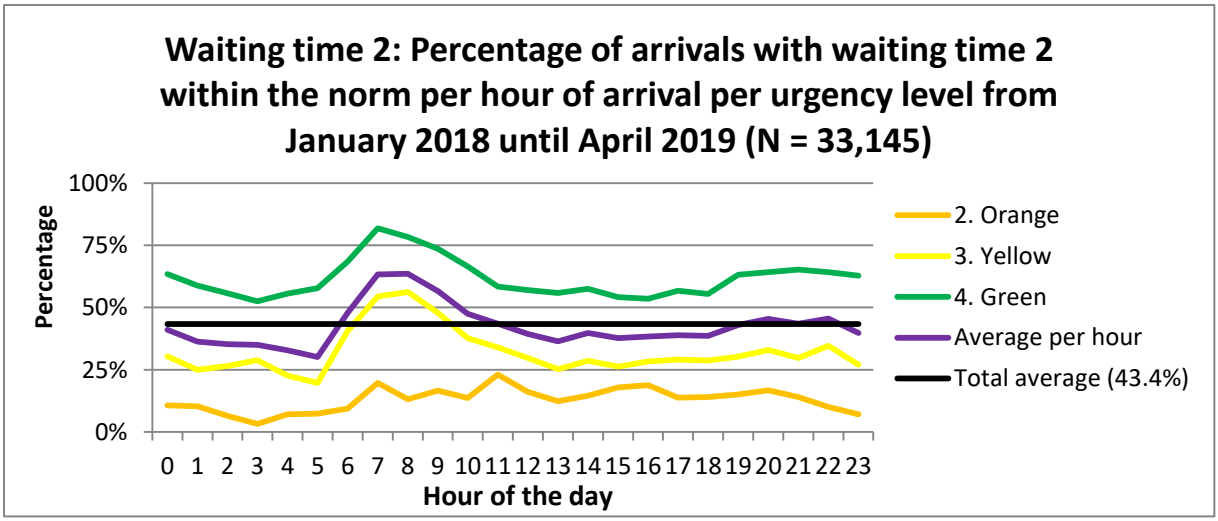

Figure B.18: Percentage of arrivals with waiting time 2 within the norm per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Table B.15: Percentage of arrivals with waiting time 2 within the norm per hour of arrival per urgency level from January 2018 until April 2019 (N = 33,145)

Urgency Hour of arrival	Red	Orange	Yellow	Green	Blue	Average
0:00 – 0:59	100%	10.7%	30.4%	63.4%	0.0%	41.0%
1:00 – 1:59	100%	10.3%	25.0%	58.8%	50.0%	36.2%
2:00 – 2:59	100%	6.4%	26.5%	55.7%	0.0%	35.2%
3:00 – 3:59	100%	3.3%	28.8%	52.4%	100%	35.0%
4:00 – 4:59	100%	7.0%	22.6%	55.6%	100%	32.8%
5:00 – 5:59	0.0%	7.3%	19.6%	57.8%	0.0%	30.1%
6:00 – 6:59	100%	9.4%	40.5%	68.4%	X	47.9%
7:00 – 7:59	100%	19.7%	54.4%	81.7%	0.0%	63.3%
8:00 – 8:59	100%	13.2%	56.2%	78.3%	33.3%	63.6%
9:00 – 9:59	100%	16.6%	47.8%	73.6%	87.5%	56.5%
10:00 – 10:59	100%	13.6%	37.7%	66.4%	40.0%	47.5%
11:00 – 11:59	91.7%	23.0%	34.0%	58.4%	80.0%	43.5%
12:00 – 12:59	100%	16.1%	29.7%	57.0%	25.0%	39.3%
13:00 – 13:59	100%	12.4%	25.2%	55.8%	100%	36.4%
14:00 – 14:59	100%	14.6%	28.5%	57.5%	X	39.8%
15:00 – 15:59	100%	17.9%	26.2%	54.2%	0.0%	37.7%
16:00 – 16:59	80.0%	18.8%	28.3%	53.5%	0.0%	38.3%
17:00 – 17:59	100%	13.8%	29.0%	56.8%	0.0%	38.9%
18:00 – 18:59	100%	14.0%	28.7%	55.4%	50.0%	38.6%
19:00 – 19:59	100%	15.0%	30.2%	63.1%	50.0%	43.0%
20:00 – 20:59	100%	16.8%	32.9%	64.1%	0.0%	45.4%
21:00 – 21:59	100%	14.1%	29.7%	65.3%	0.0%	43.5%
22:00 – 22:59	100%	10.0%	34.6%	64.2%	X	45.6%
23:00 – 23:59	100%	7.1%	27.0%	62.8%	50.0%	39.7%
Average	98.2%	13.9%	32.8%	62.0%	42.3%	43.4%

KPI 4: Waiting time 3

The thee figures and tables show the average waiting time 3 per month, per day and per hour of arrival from January 2018 until April 2019 (N = 7,854).

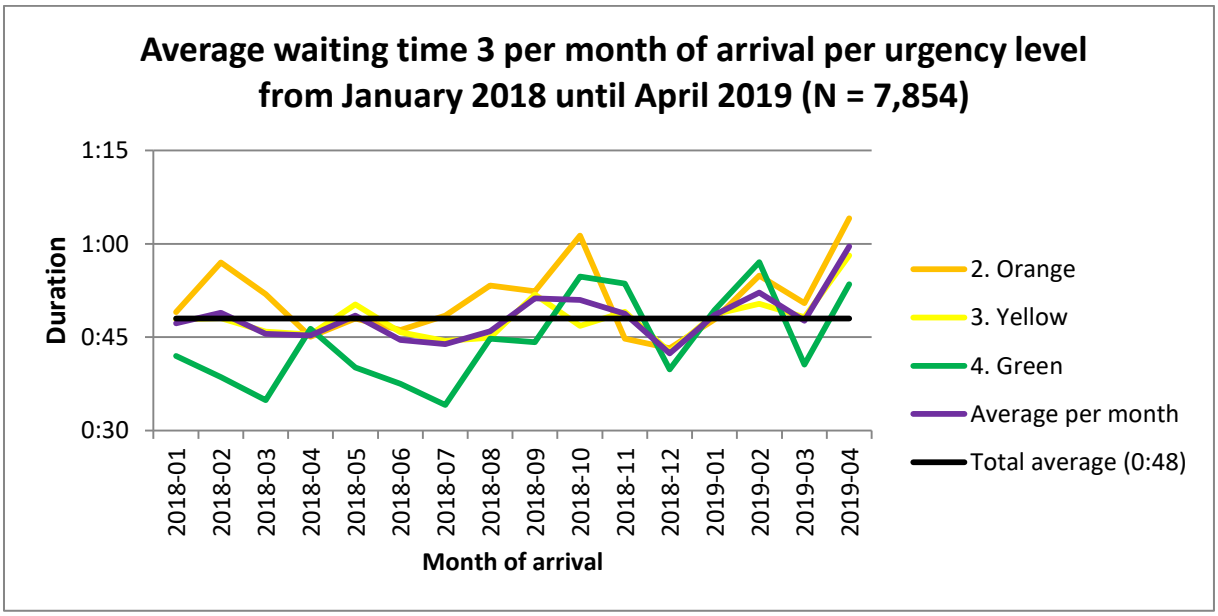

Figure B.19: Average Waiting time 3 per month of arrival per urgency level from January 2018 until April 2019 (N = 7,854)

Table B.16: Average Waiting time 3 per month of arrival per urgency level from January 2018 until April 2019 (N = 7,854)

Urgency Month of arrival	Red	Orange	Yellow	Green	Blue	Average
2018-01	0:44	0:49	0:47	0:42	0:32	0:47
2018-02	0:20	0:56	0:48	0:38	0:42	0:49
2018-03	0:37	0:51	0:45	0:34	X	0:45
2018-04	0:31	0:45	0:45	0:46	X	0:45
2018-05	0:51	0:48	0:50	0:40	X	0:48
2018-06	0:38	0:46	0:45	0:37	X	0:44
2018-07	0:28	0:48	0:44	0:34	X	0:43
2018-08	0:31	0:53	0:44	0:44	X	0:45
2018-09	1:01	0:52	0:51	0:44	X	0:51
2018-10	1:11	1:01	0:46	0:54	0:33	0:50
2018-11	0:50	0:44	0:49	0:53	0:24	0:48
2018-12	0:31	0:43	0:42	0:39	X	0:42
2019-01	0:52	0:47	0:48	0:49	X	0:48
2019-02	0:26	0:54	0:50	0:57	X	0:52
2019-03	0:12	0:50	0:48	0:40	X	0:47
2019-04	1:34	1:04	0:58	0:53	0:51	0:59
Average	0:47	0:50	0:47	0:44	0:36	0:48

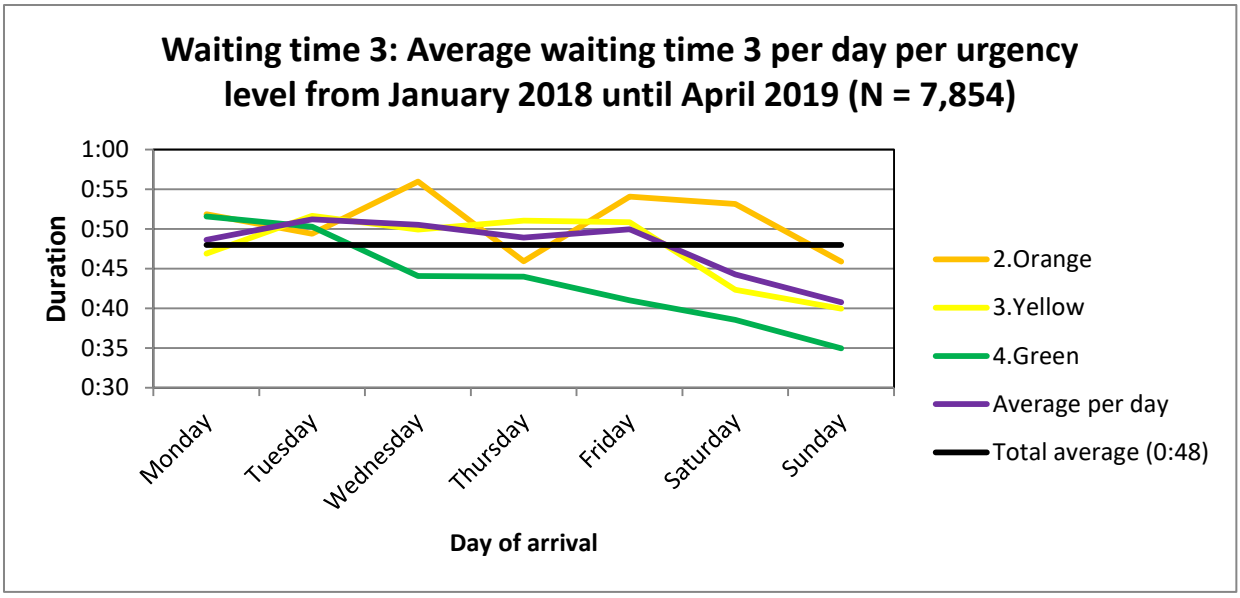

Figure B.20: Average Waiting time 3 per day of arrival per urgency level from January 2018 until April 2019 (N = 7,854)

Table B.17: Average Waiting time 3 per day of arrival per urgency level from January 2018 until April 2019 (N = 7,854)

Urgency Day of arrival	Red	Orange	Yellow	Green	Blue	Average
Monday	0:52	0:51	0:46	0:51	0:29	0:48
Tuesday	1:04	0:49	0:51	0:50	0:42	0:51
Wednesday	0:55	0:56	0:49	0:44	X	0:50
Thursday	0:48	0:45	0:51	0:43	X	0:48
Friday	0:25	0:54	0:50	0:41	0:51	0:49
Saturday	0:40	0:53	0:42	0:38	0:32	0:44
Sunday	0:39	0:45	0:39	0:34	X	0:40
Average	0:47	0:50	0:47	0:44	0:36	0:48

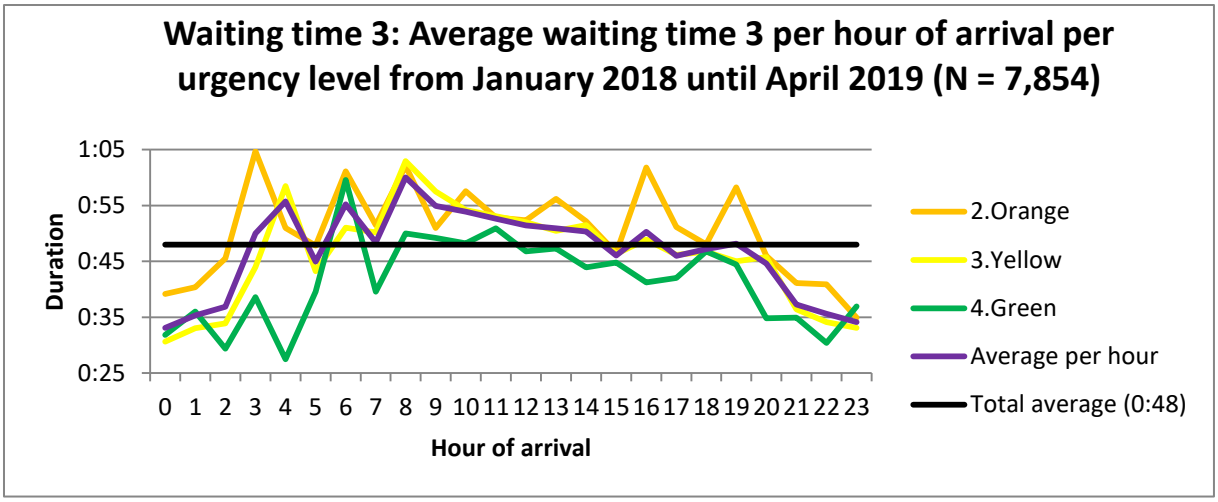

Figure B.21: Average Waiting time 3 per hour of arrival per urgency level from January 2018 until April 2019 (N = 7,854)

Table B.18: Average Waiting time 3 per hour of arrival per urgency level from January 2018 until April 2019 (N = 7,854)

Urgency Hour of arrival	Red	Orange	Yellow	Green	Blue	Average
0:00 – 0:59	0:11	0:39	0:30	0:31	X	0:33
1:00 – 1:59	X	0:40	0:33	0:36	X	0:35
2:00 – 2:59	0:37	0:45	0:34	0:29	X	0:37
3:00 – 3:59	0:54	1:04	0:43	0:38	X	0:50
4:00 – 4:59	3:00	0:50	0:58	0:27	X	0:55
5:00 – 5:59	1:29	0:47	0:43	0:39	X	0:44
6:00 – 6:59	0:48	1:01	0:51	0:59	X	0:55
7:00 – 7:59	0:41	0:51	0:50	0:38	X	0:48
8:00 – 8:59	0:26	1:02	1:02	0:51	X	1:00
9:00 – 9:59	0:46	0:51	0:57	0:49	X	0:55
10:00 – 10:59	0:29	0:57	0:54	0:47	0:38	0:53
11:00 – 11:59	0:57	0:52	0:53	0:51	X	0:52
12:00 – 12:59	1:54	0:52	0:52	0:46	X	0:51
13:00 – 13:59	0:32	0:56	0:50	0:48	X	0:51
14:00 – 14:59	0:28	0:52	0:51	0:44	X	0:50
15:00 – 15:59	0:32	0:46	0:46	0:45	X	0:46
16:00 – 16:59	0:23	1:01	0:49	0:42	X	0:50
17:00 – 17:59	0:10	0:51	0:46	0:44	0:32	0:46
18:00 – 18:59	0:58	0:48	0:46	0:48	0:42	0:47
19:00 – 19:59	1:31	0:58	0:45	0:44	X	0:48
20:00 – 20:59	0:52	0:46	0:46	0:34	X	0:44
21:00 – 21:59	0:01	0:41	0:36	0:34	X	0:37
22:00 – 22:59	0:50	0:40	0:34	0:31	X	0:35
23:00 – 23:59	X	0:34	0:33	0:38	X	0:34
Average	0:47	0:50	0:47	0:44	0:36	0:48

KPI 5: Room utilisation

The three tables and figures show the average percentage of room utilisation per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145).

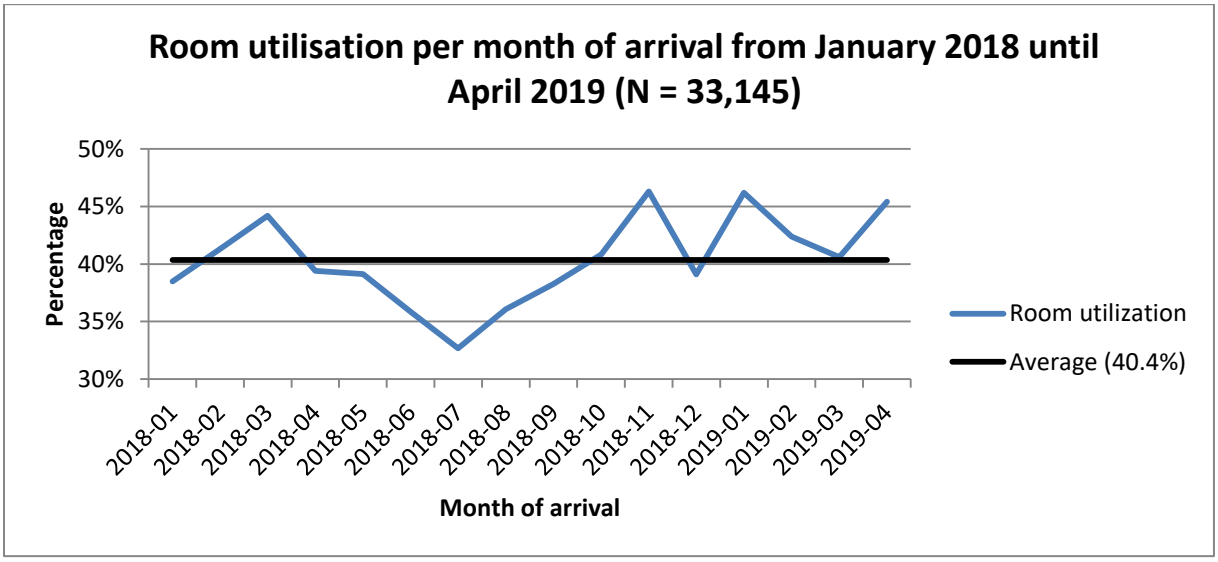

Figure B.22: Room utilisation per month of arrival from January 2018 until April 2019 (N = 33,145)

Table B.19: Room utilisation per month of arrival from January 2018 until April 2019 (N = 33,145)

Month	Sum of treatment time	Sum of waiting time 3	Total time available	Room utilisation
2018-01	3336:29:17	386:26:50	9672:00:00	38.5%
2018-02	3212:37:03	396:02:38	8736:00:00	41.3%
2018-03	3875:04:50	398:11:40	9672:00:00	44.2%
2018-04	3292:21:12	395:29:25	9360:00:00	39.4%
2018-05	3381:33:10	402:56:26	9672:00:00	39.1%
2018-06	3011:03:07	343:35:23	9360:00:00	35.8%
2018-07	2824:08:48	335:38:00	9672:00:00	32.7%
2018-08	3110:50:30	378:25:22	9672:00:00	36.1%
2018-09	3199:48:38	382:46:12	9360:00:00	38.3%
2018-10	3494:52:02	453:38:16	9672:00:00	40.8%
2018-11	3870:07:30	463:28:49	9360:00:00	46.3%
2018-12	3427:05:12	354:36:16	9672:00:00	39.1%
2019-01	4028:51:39	440:01:55	9672:00:00	46.2%
2019-02	3327:06:29	375:30:43	8736:00:00	42.4%
2019-03	3575:57:19	350:06:13	9672:00:00	40.6%
2019-04	3793:36:58	456:33:39	9360:00:00	45.4%
Total	54761:33:44	6313:27:47	151320:00:00	40.4%

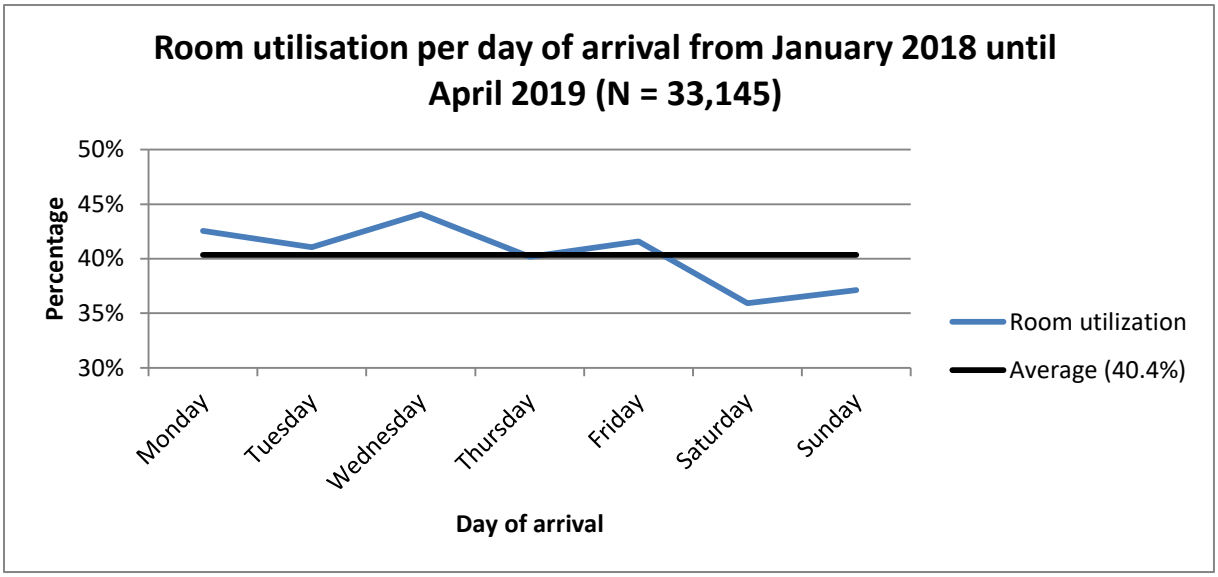

Figure B.23: Room utilisation per day of arrival from January 2018 until April 2019 (N = 33,145)

Table B.20: Room utilisation per day of arrival from January 2018 until April 2019 (N = 33,145)

Day	Sum of treatment time	Sum of waiting time 3	Total time available	Room utilisation
Monday	8293:54:30	1000:36:40	21840:00:00	42.6%
Tuesday	7975:49:44	988:51:39	21840:00:00	41.0%
Wednesday	8479:10:07	1018:22:54	21528:00:00	44.1%
Thursday	7747:17:39	899:06:31	21528:00:00	40.2%
Friday	7982:22:31	969:37:33	21528:00:00	41.6%
Saturday	7011:22:53	719:10:37	21528:00:00	35.9%
Sunday	7271:36:20	717:41:53	21528:00:00	37.1%
Total	54761:33:44	6313:27:47	151320:00:00	40.4%

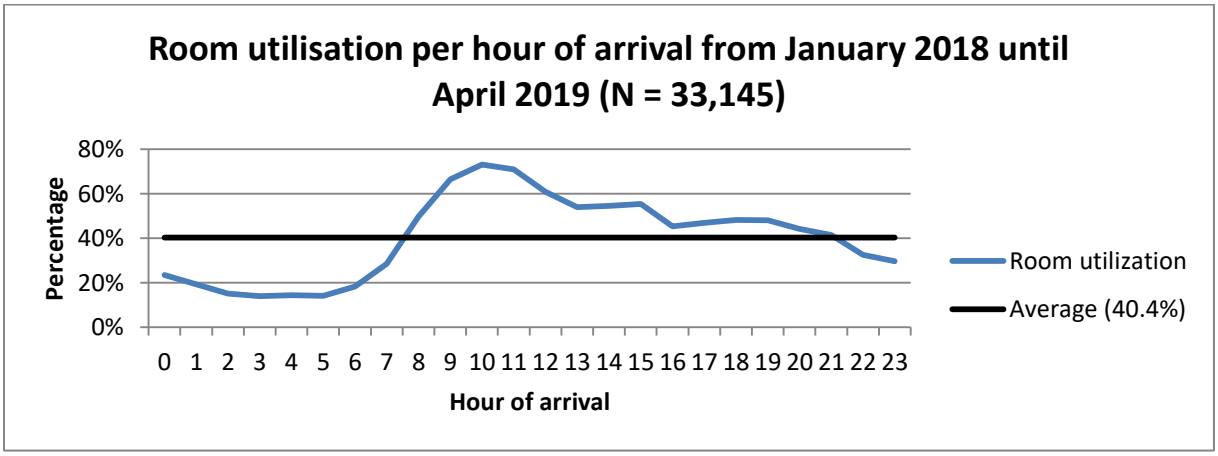

Figure B.24: Room utilisation per hour of arrival from January 2018 until April 2019 (N = 33,145)

Table B.21: Room utilisation per hour of arrival from January 2018 until April 2019 (N = 33,145)

Hour of arrival	Sum of treatment time	Sum of waiting time 3	Total time available	Room utilisation
0:00 – 0:59	1380:44:53	100:57:23	6305:00:00	23.5%
1:00 – 1:59	1120:35:14	98:53:22	6305:00:00	19.3%
2:00 – 2:59	856:12:08	96:27:33	6305:00:00	15.1%
3:00 – 3:59	765:36:54	110:02:26	6305:00:00	13.9%
4:00 – 4:59	811:33:26	92:51:49	6305:00:00	14.3%
5:00 – 5:59	805:19:23	85:23:20	6305:00:00	14.1%
6:00 – 6:59	1031:32:15	117:49:31	6305:00:00	18.2%
7:00 – 7:59	1624:12:54	169:34:05	6305:00:00	28.5%
8:00 – 8:59	2810:02:31	324:18:17	6305:00:00	49.7%
9:00 – 9:59	3743:37:14	449:00:51	6305:00:00	66.5%
10:00 – 10:59	4136:00:21	475:36:13	6305:00:00	73.1%
11:00 – 11:59	3968:05:47	510:54:01	6305:00:00	71.0%
12:00 – 12:59	3422:36:14	420:41:59	6305:00:00	61.0%
13:00 – 13:59	3009:14:35	390:21:32	6305:00:00	53.9%
14:00 – 14:59	3040:07:01	399:16:46	6305:00:00	54.6%
15:00 – 15:59	3131:24:04	359:40:00	6305:00:00	55.4%
16:00 – 16:59	2542:26:55	313:30:31	6305:00:00	45.3%
17:00 – 17:59	2645:26:14	316:59:57	6305:00:00	47.0%
18:00 – 18:59	2694:19:38	346:44:14	6305:00:00	48.2%
19:00 – 19:59	2690:22:46	340:06:48	6305:00:00	48.1%
20:00 – 20:59	2507:33:06	277:32:33	6305:00:00	44.2%
21:00 – 21:59	2404:04:35	213:23:40	6305:00:00	41.5%
22:00 – 22:59	1894:39:47	158:19:21	6305:00:00	32.6%
23:00 – 23:59	1725:45:49	145:01:35	6305:00:00	29.7%
Average	54761:33:44	6313:27:47	151320:00:00	40.4%

KPI 6: Nurse and doctor utilisation

The three tables and figures show the nurse and doctor utilisation per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145). The ED nurse that triages is not included in this calculation.

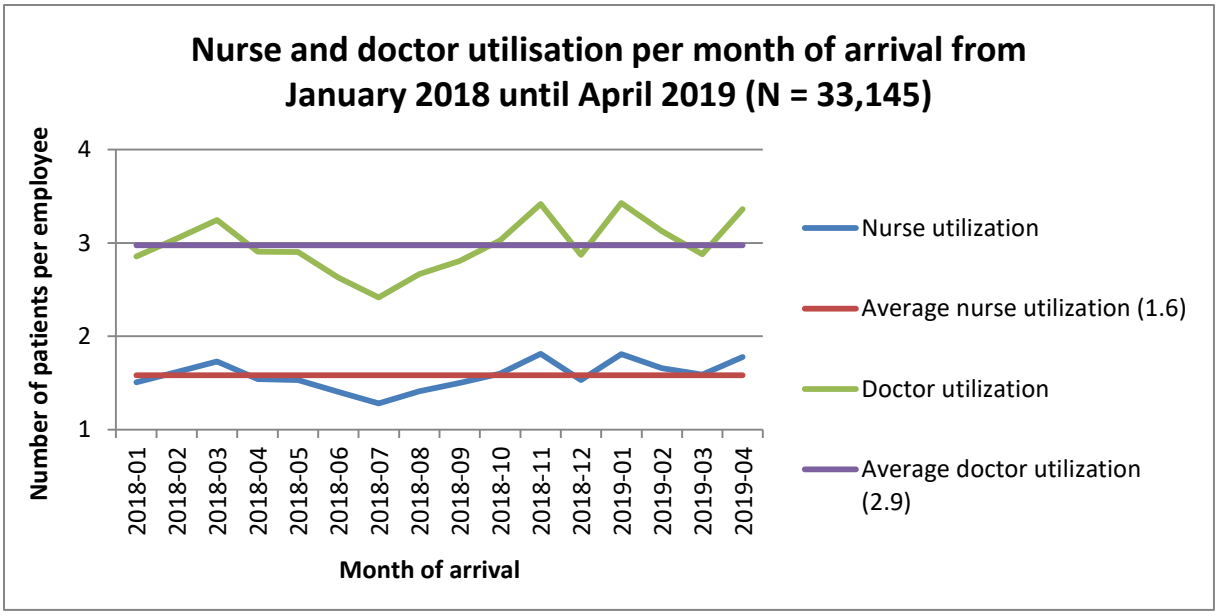

Figure B.25: Nurse and doctor utilisation per month of arrival from January 2018 until April 2019 (N = 33,145)

Table B.22: Nurse and doctor utilisation per month of arrival from January 2018 until April 2019 (N = 33,145)

Month	Nurse utilisation	Doctor utilisation
2018-01	1.5	2.9
2018-02	1.6	3.0
2018-03	1.7	3.2
2018-04	1.5	2.9
2018-05	1.5	2.9
2018-06	1.4	2.6
2018-07	1.3	2.4
2018-08	1.4	2.7
2018-09	1.5	2.8
2018-10	1.6	3.0
2018-11	1.8	3.4
2018-12	1.5	2.9
2019-01	1.8	3.4
2019-02	1.7	3.1
2019-03	1.6	2.9
2019-04	1.8	3.4
Average	1.6	2.9

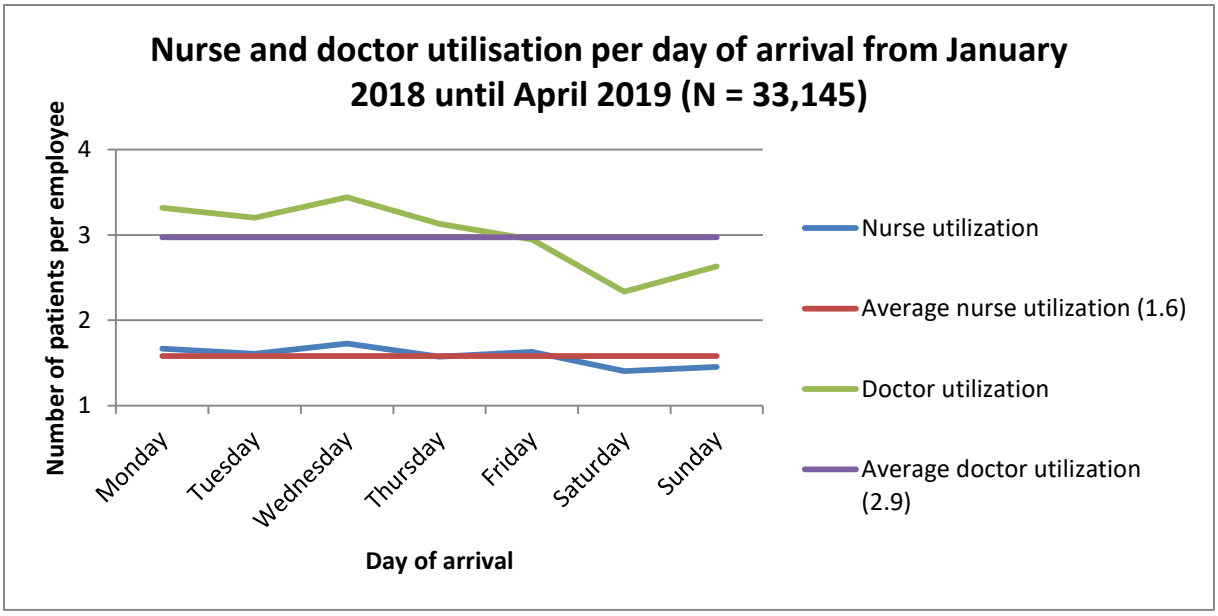

Figure B.26: Nurse and doctor utilisation per day of arrival from January 2018 until April 2019 (N = 33,145)

Table B.23: Nurse and doctor utilisation per day of arrival from January 2018 until April 2019 (N = 33,145)

Day	Nurse utilisation	Doctor utilisation
Monday	1.7	3.3
Tuesday	1.6	3.2
Wednesday	1.7	3.4
Thursday	1.6	3.1
Friday	1.6	2.9
Saturday	1.4	2.3
Sunday	1.5	2.6
Average	1.6	2.9

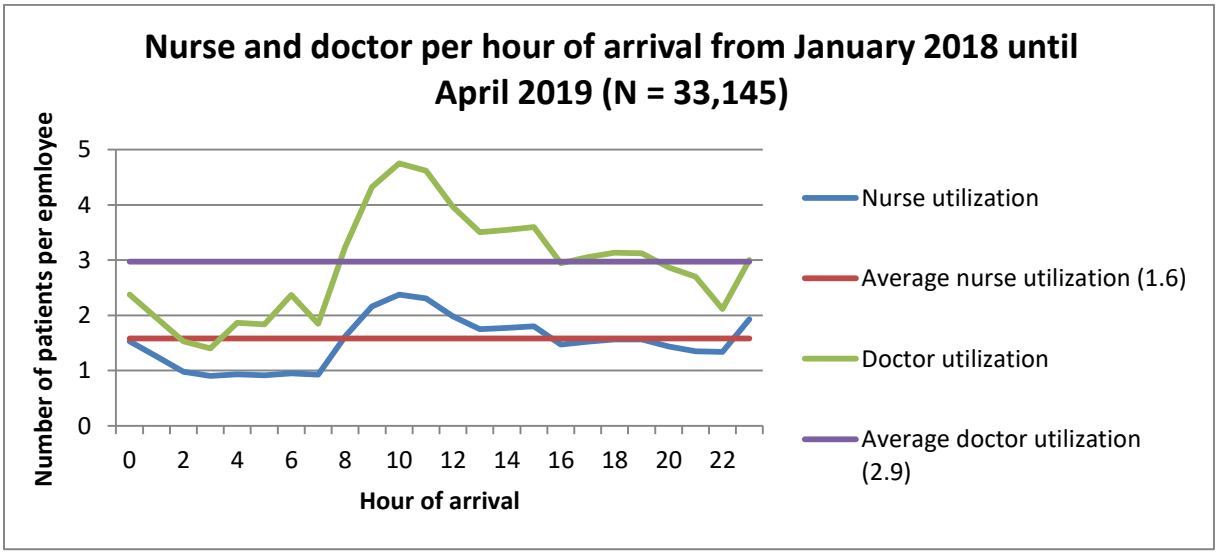

Figure B.27: Nurse and doctor utilisation per hour of arrival from January 2018 until April 2019 (N = 33,145)

Table B.24: Nurse and doctor utilisation per hour of arrival from January 2018 until April 2019 (N = 33,145)

Hour of arrival	Nurse utilisation	Doctor utilisation
0:00 – 0:59	1.5	2.4
1:00 – 1:59	1.3	2.0
2:00 – 2:59	1.0	1.5
3:00 – 3:59	0.9	1.4
4:00 – 4:59	0.9	1.9
5:00 – 5:59	0.9	1.8
6:00 – 6:59	0.9	2.4
7:00 – 7:59	0.9	1.8
8:00 – 8:59	1.6	3.2
9:00 – 9:59	2.2	4.3
10:00 – 10:59	2.4	4.8
11:00 – 11:59	2.3	4.6
12:00 – 12:59	2.0	4.0
13:00 – 13:59	1.8	3.5
14:00 – 14:59	1.8	3.5
15:00 – 15:59	1.8	3.6
16:00 – 16:59	1.5	2.9
17:00 – 17:59	1.5	3.1
18:00 – 18:59	1.6	3.1
19:00 – 19:59	1.6	3.1
20:00 – 20:59	1.4	2.9
21:00 – 21:59	1.3	2.7
22:00 – 22:59	1.3	2.1
23:00 – 23:59	1.9	3.0
Average	1.6	2.9

KPI 7: ED arrivals who can be treated by GP(S) care

The three tables and figures show the nurse and doctor utilisation per month, per day and per hour of arrival from January 2018 until April 2019 (N = 33,145). The ED nurse that triages is not included in this calculation.

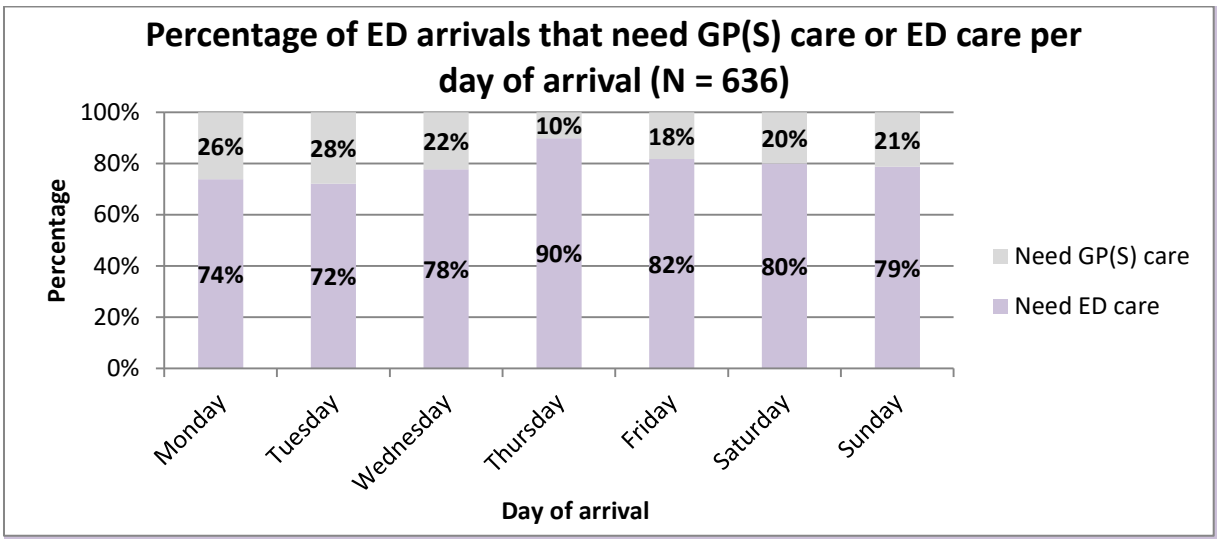

Figure B.28: ED arrivals who can be treated by GP(S) care per day of arrival from May, 6, 2019 7:00 to May, 13, 2019 7:00 (N = 636)

Table B.25: ED arrivals who can be treated by GP(S) care per day of arrival from May, 6, 2019 7:00 to May, 13, 2019 7:00 (N = 636)

Day of arrival	Need ED care	Need GP(S) care
Monday	74%	26%
Tuesday	72%	28%
Wednesday	78%	22%
Thursday	90%	10%
Friday	82%	18%
Saturday	80%	20%
Sunday	79%	21%
Average	78.9%	21.1%

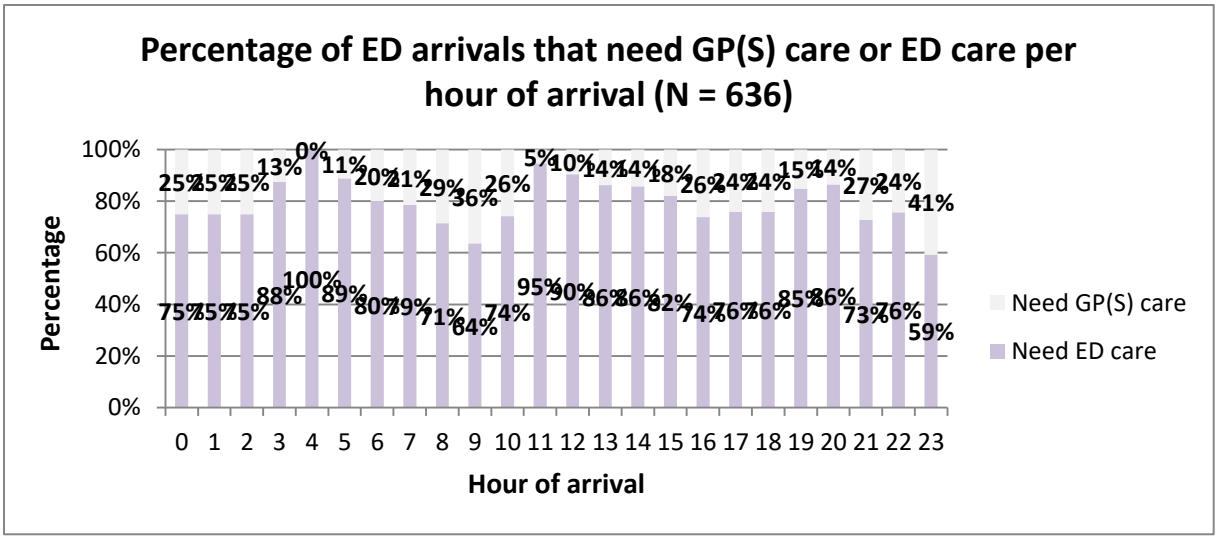

Figure B.29: ED arrivals who can be treated by GP(S) care per hour of arrival from May, 6, 2019 7:00 to May, 13, 2019 7:00 (N = 636)

Table B.26: ED arrivals who can be treated by GP(S) care per hour of arrival from May, 6, 2019 7:00 to May, 13, 2019 7:00 (N = 636)

Hour of arrival	**Need ED care**	**Need GP(S) care**
0:00 – 0:59	75%	25%
1:00 – 1:59	75%	25%
2:00 – 2:59	75%	25%
3:00 – 3:59	88%	13%
4:00 – 4:59	100%	0%
5:00 – 5:59	89%	11%
6:00 – 6:59	80%	20%
7:00 – 7:59	79%	21%
8:00 – 8:59	71%	29%
9:00 – 9:59	64%	36%
10:00 – 10:59	74%	26%
11:00 – 11:59	95%	5%
12:00 – 12:59	90%	10%
13:00 – 13:59	86%	14%
14:00 – 14:59	86%	14%
15:00 – 15:59	82%	18%
16:00 – 16:59	74%	26%
17:00 – 17:59	76%	24%
18:00 – 18:59	76%	24%
19:00 – 19:59	85%	15%
20:00 – 20:59	86%	14%
21:00 – 21:59	73%	27%
22:00 – 22:59	76%	24%
23:00 – 23:59	59%	41%
Average	78.9%	21.1%

KPI 8: ED arrivals being seen by an ED physician

The three tables and figures show the average percentage of ED arrivals being seen by an ED physician per month, per day and per hour of arrival from January 2018 until April 2019 (N = 45,541).

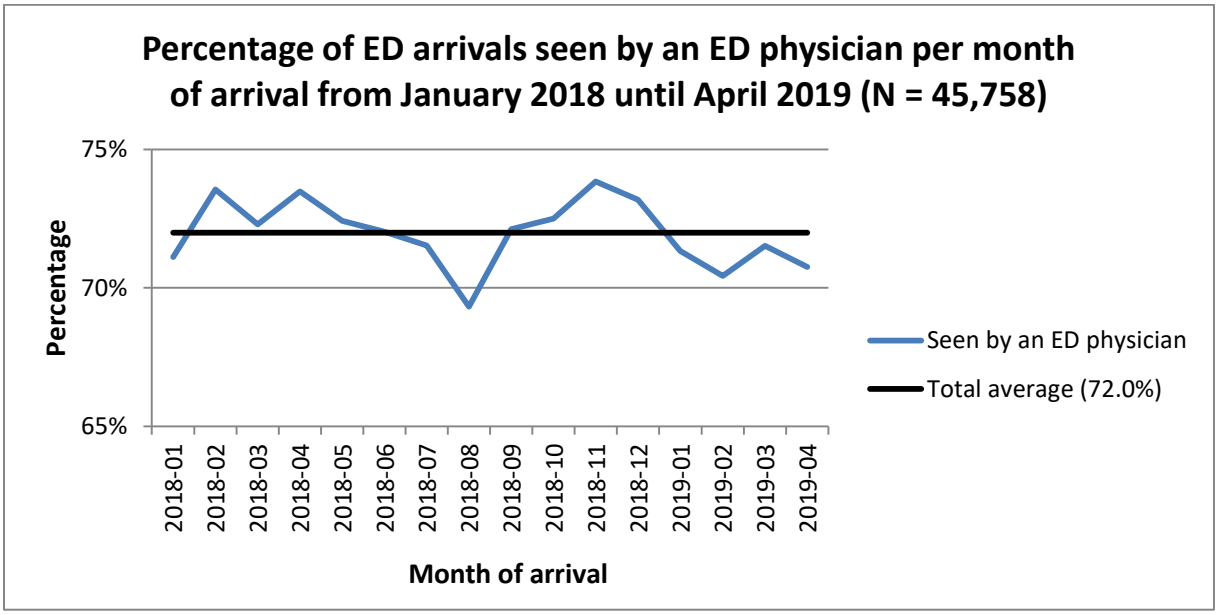

Figure B.30: Percentage of ED arrivals being seen by an ED physician per month of arrival from January 2018 until April 2019 (N = 45,578)

Table B.27: Percentage of ED arrivals being seen by an ED physician per month of arrival from January 2018 until April 2019 (N = 45,578)

Month of arrival	Seen by an ED physician
2018-01	71.1%
2018-02	73.6%
2018-03	72.3%
2018-04	73.5%
2018-05	72.4%
2018-06	72.0%
2018-07	71.5%
2018-08	69.3%
2018-09	72.1%
2018-10	72.5%
2018-11	73.9%
2018-12	73.2%
2019-01	71.3%
2019-02	70.4%
2019-03	71.5%
2019-04	70.8%
Average	72.0%

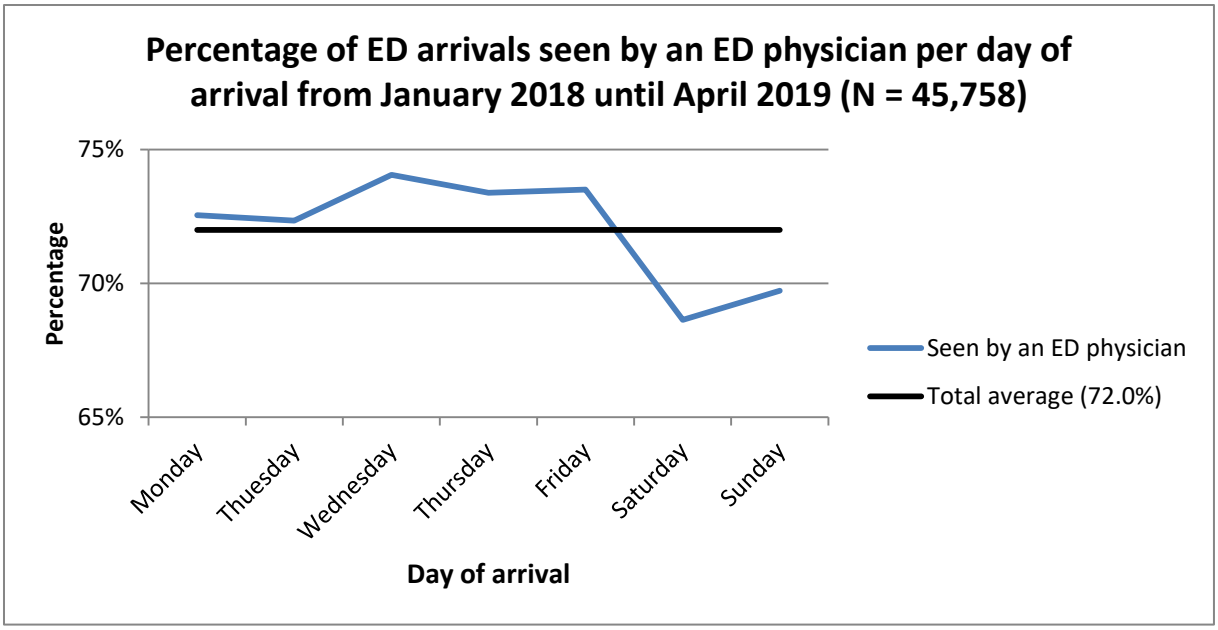

Figure B.31: Percentage of ED arrivals being seen by an ED physician per day of arrival from January 2018 until April 2019 (N = 45,578)

Table B.28: Percentage of ED arrivals being seen by an ED physician per day of arrival from January 2018 until April 2019 (N = 45,578)

Day of arrival	Seen by an ED physician
Monday	72.6%
Thuesday	72.3%
Wednesday	74.1%
Thursday	73.4%
Friday	73.5%
Saturday	68.6%
Sunday	69.7%
Average	72.0%

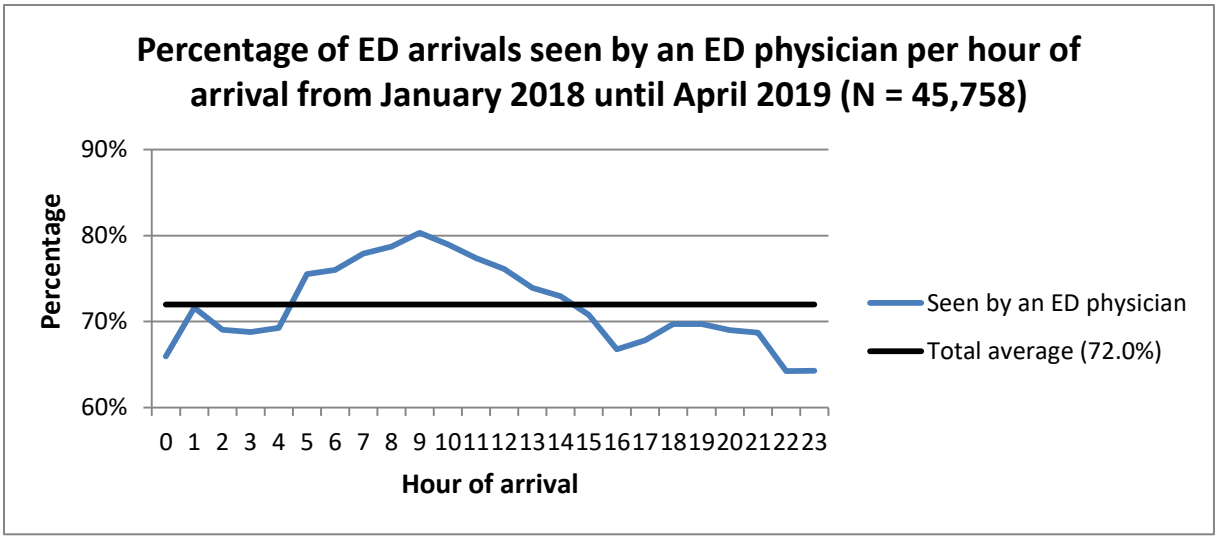

Figure B.32: Percentage of ED arrivals being seen by an ED physician per hour of arrival from January 2018 until April 2019 (N = 45,578)

Table B.29: Percentage of ED arrivals being seen by an ED physician per hour of arrival from January 2018 until April 2019 (N = 45,578)

Hour of arrival	Seen by an ED physician
0:00 – 0:59	65.9%
1:00 – 1:59	71.6%
2:00 – 2:59	69.0%
3:00 – 3:59	68.8%
4:00 – 4:59	69.3%
5:00 – 5:59	75.5%
6:00 – 6:59	76.0%
7:00 – 7:59	77.9%
8:00 – 8:59	78.7%
9:00 – 9:59	80.3%
10:00 – 10:59	79.0%
11:00 – 11:59	77.4%
12:00 – 12:59	76.1%
13:00 – 13:59	73.9%
14:00 – 14:59	73.0%
15:00 – 15:59	70.8%
16:00 – 16:59	66.8%
17:00 – 17:59	67.8%
18:00 – 18:59	69.7%
19:00 – 19:59	69.7%
20:00 – 20:59	69.0%
21:00 – 21:59	68.7%
22:00 – 22:59	64.2%
23:00 – 23:59	64.3%
Average	72.0%

Appendix C: Effects of most suitable interventions

This appendix shows the data that was used to measure the effects of the most suitable interventions in Section 5.2 mentioned by the stakeholders in Section 5.1.

Extending opening hours of the GPS

This table shows the effects of extending the opening hours of the GPS described in Section 5.2.1.

Table C.1: Effects of extending opening hours of the GPS.

Hours of arrival	Total treatment time (hours)	Total waiting time 3 (hours)	Treatment time + Waiting time 3 (hours)	Total available time (hours)	Room utilisation
16-17	5,188	630	5,818	12,610	46.1%
22-23	3,621	303	3,924	12,610	31.1%

More personnel and different shifts

These tables show the effects of different situations with more personnel and / or different shifts described in Section 5.2.3.

Table C.2: Effects of optimising the current situation with the same ED nurse- and doctor capacity.

Hour of arrival	Total treatment time (hours)	Total waiting time 3 (hours)	Total available time (hours)	Room utilisation	Average number of ED beds occupied	Average number of nurses present per hour	Average number of doctors present	Nurse utilisation	Doctor utilisation

							per hour		
0:00 – 0:59	1380	100	6305	23,5%	3,06	2	1,29	1,53	2,37
1:00 – 1:59	1120	98	6305	19,3%	2,51	2	1,29	1,26	1,95
2:00 – 2:59	856	96	6305	15,1%	1,96	2	1,29	0,98	1,52
3:00 – 3:59	765	110	6305	13,9%	1,81	2	1,29	0,90	1,40
4:00 – 4:59	811	92	6305	14,3%	1,86	2	1	0,93	1,86
5:00 – 5:59	805	85	6305	14,1%	1,84	2	1	0,92	1,84
6:00 – 6:59	1031	117	6305	18,2%	2,37	2,17	1	1,09	2,37
7:00 – 7:59	1624	169	6305	28,5%	3,70	4	2	0,92	1,85
8:00 – 8:59	2810	324	6305	49,7%	6,46	4	2	1,62	3,23
9:00 – 9:59	3743	449	6305	66,5%	8,64	5	2	1,73	4,32
10:00 – 10:59	4136	475	6305	73,1%	9,51	5	2	1,90	4,75
11:00 – 11:59	3968	510	6305	71,0%	9,24	5	2	1,85	4,62
12:00 – 12:59	3422	420	6305	61,0%	7,92	5	2	1,58	3,96
13:00 – 13:59	3009	390	6305	53,9%	7,01	4	2	1,75	3,50
14:00 – 14:59	3040	399	6305	54,6%	7,09	4	2	1,77	3,55
15:00 – 15:59	3131	359	6305	55,4%	7,20	4	2	1,80	3,60
16:00 – 16:59	2542	313	6305	45,3%	5,89	4	2	1,47	2,94
17:00 – 17:59	2645	316	6305	47,0%	6,11	4	2	1,53	3,05
18:00 – 18:59	2694	346	6305	48,2%	6,27	3	2	2,09	3,14
19:00 – 19:59	2690	340	6305	48,1%	6,25	3	2	2,08	3,12
20:00 – 20:59	2507	277	6305	44,2%	5,74	3	2	1,91	2,87
21:00 – 21:59	2404	213	6305	41,5%	5,40	3	2	1,80	2,70
22:00 – 22:59	1894	158	6305	32,6%	4,23	3,17	2	1,34	2,12
23:00 – 23:59	1725	145	6305	29,7%	3,86	2	1,29	1,93	2,99

Table C.3: Effects of the stakeholders' proposed situation with increased ED nurse- and doctor capacity recommended by HOH's management.

Hour of arrival	Total treatment time (hours)	Total waiting time 3 (hours)	Total available time (hours)	Room utilisation	Average number of ED beds occupied	Average number of nurses present per hour	Average number of doctors present per hour	Nurse utilisation	Doctor utilisation
0:00 – 0:59	1380	100	6305	23,5%	3,06	3	2	1,02	1,53
1:00 – 1:59	1120	98	6305	19,3%	2,51	3	2	0,84	1,26
2:00 – 2:59	856	96	6305	15,1%	1,96	3	2	0,65	0,98
3:00 – 3:59	765	110	6305	13,9%	1,81	3	2	0,60	0,90
4:00 – 4:59	811	92	6305	14,3%	1,86	3	2	0,62	0,93
5:00 – 5:59	805	85	6305	14,1%	1,84	3	2	0,61	0,92
6:00 – 6:59	1031	117	6305	18,2%	2,37	3,08	2	0,77	1,18
7:00 – 7:59	1624	169	6305	28,5%	3,70	4	2	0,92	1,85
8:00 – 8:59	2810	324	6305	49,7%	6,46	4	2	1,62	3,23
9:00 – 9:59	3743	449	6305	66,5%	8,64	4	2	2,16	4,32
10:00 – 10:59	4136	475	6305	73,1%	9,51	4	2	2,38	4,75
11:00 – 11:59	3968	510	6305	71,0%	9,24	4	2	2,31	4,62
12:00 – 12:59	3422	420	6305	61,0%	7,92	4	2	1,98	3,96
13:00 – 13:59	3009	390	6305	53,9%	7,01	4	2	1,75	3,50
14:00 – 14:59	3040	399	6305	54,6%	7,09	4,25	2	1,67	3,55
15:00 – 15:59	3131	359	6305	55,4%	7,20	5	3	1,44	2,40
16:00 – 16:59	2542	313	6305	45,3%	5,89	5	3	1,18	1,96
17:00 – 17:59	2645	316	6305	47,0%	6,11	5	3	1,22	2,04
18:00 – 18:59	2694	346	6305	48,2%	6,27	5	3	1,25	2,09
19:00 – 19:59	2690	340	6305	48,1%	6,25	5	3	1,25	2,08

20:00 – 20:59	2507	277	6305	44,2%	5,74	5	3	1,15	1,91
21:00 – 21:59	2404	213	6305	41,5%	5,40	5	3	1,08	1,80
22:00 – 22:59	1894	158	6305	32,6%	4,23	4,17	3	1,02	1,41
23:00 – 23:59	1725	145	6305	29,7%	3,86	3	2	1,29	1,93

Table C.4: Effects of the quantitative performance analysis' proposed situation with increased ED nurse- and doctor capacity recommended by HOH's management.

Hour of arrival	Total treatment time (hours)	Total waiting time 3 (hours)	Total available time (hours)	Room utilisation	Average number of ED beds occupied	Average nurses present per hour	Average number of doctors present per hour	Nurse utilisation	Doctor utilisation
0:00 – 0:59	1380	100	6305	23,5%	3,06	3	2	1,02	1,53
1:00 – 1:59	1120	98	6305	19,3%	2,51	3	2	0,84	1,26
2:00 – 2:59	856	96	6305	15,1%	1,96	3	2	0,65	0,98
3:00 – 3:59	765	110	6305	13,9%	1,81	3	2	0,60	0,90
4:00 – 4:59	811	92	6305	14,3%	1,86	3	2	0,62	0,93
5:00 – 5:59	805	85	6305	14,1%	1,84	3	2	0,61	0,92
6:00 – 6:59	1031	117	6305	18,2%	2,37	3,08	2	0,77	1,18
7:00 – 7:59	1624	169	6305	28,5%	3,70	4	2	0,92	1,85
8:00 – 8:59	2810	324	6305	49,7%	6,46	4	2	1,62	3,23
9:00 – 9:59	3743	449	6305	66,5%	8,64	5	3	1,73	2,88
10:00 – 10:59	4136	475	6305	73,1%	9,51	5	3	1,90	3,17
11:00 – 11:59	3968	510	6305	71,0%	9,24	5	3	1,85	3,08
12:00 – 12:59	3422	420	6305	61,0%	7,92	5	3	1,58	2,64
13:00 – 13:59	3009	390	6305	53,9%	7,01	5	3	1,40	2,34
14:00 – 14:59	3040	399	6305	54,6%	7,09	5	3	1,42	2,36

15:00 – 15:59	3131	359	6305	55,4%	7,20	5	3	1,44	2,40
16:00 – 16:59	2542	313	6305	45,3%	5,89	5	3	1,18	1,96
17:00 – 17:59	2645	316	6305	47,0%	6,11	4	2	1,53	3,05
18:00 – 18:59	2694	346	6305	48,2%	6,27	4	2	1,57	3,14
19:00 – 19:59	2690	340	6305	48,1%	6,25	4	2	1,56	3,12
20:00 – 20:59	2507	277	6305	44,2%	5,74	4	2	1,44	2,87
21:00 – 21:59	2404	213	6305	41,5%	5,40	4	2	1,35	2,70
22:00 – 22:59	1894	158	6305	32,6%	4,23	3,58	2	1,18	2,12
23:00 – 23:59	1725	145	6305	29,7%	3,86	3	2	1,29	1,93