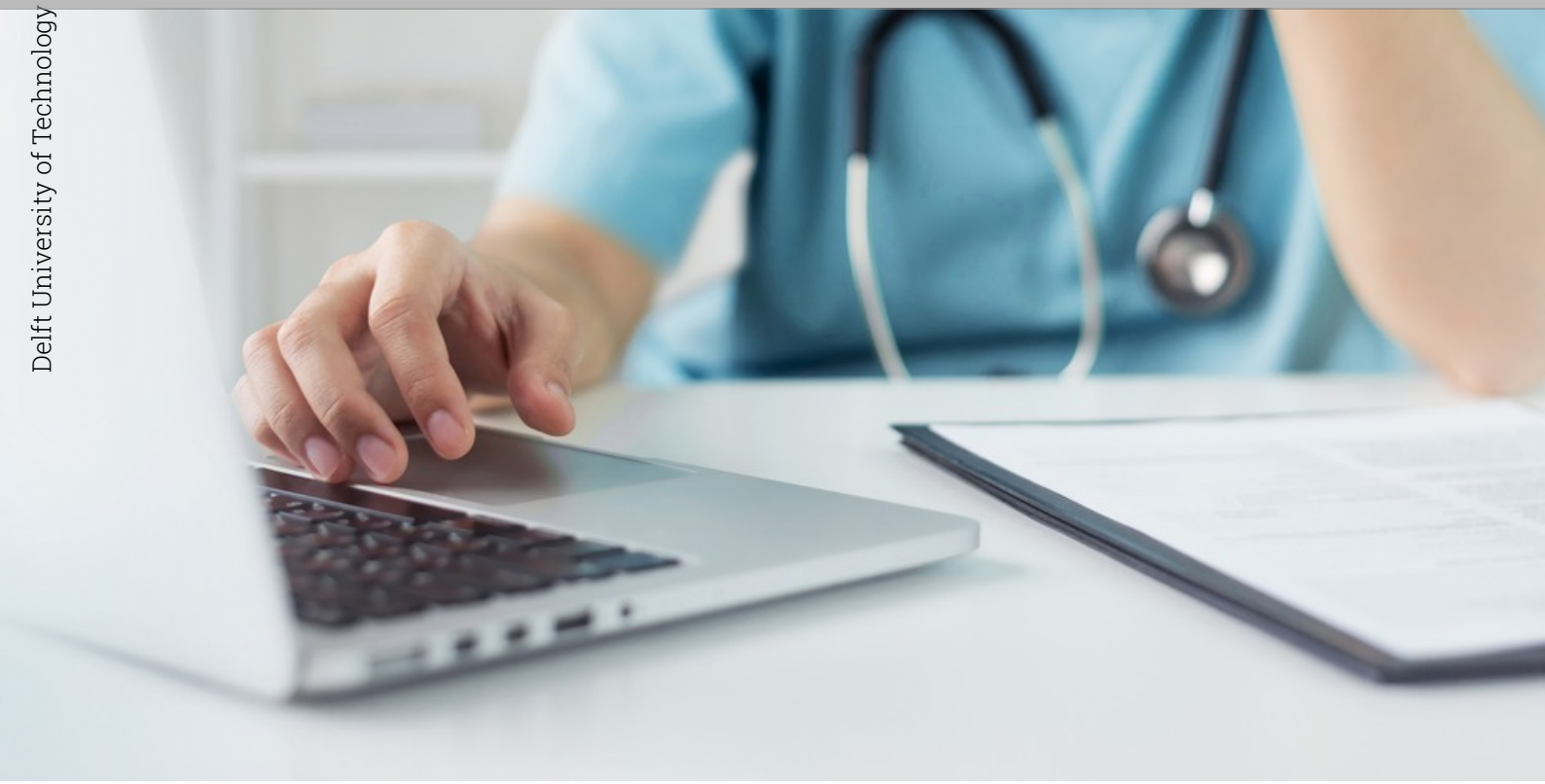
A Socio-Technical System approach to Healthcare Capacity at Deventer Hospital

An integrated research of Technical Workflows and Social Dynamics to enhance Efficiency in Acute Care

Master: Engineering Policy Analysis
S.S.E.S. Wielders



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An integrated research of Technical Workflows and Social Dynamics to enhance Efficiency in Acute Care

by

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Preface

This thesis marks the final step in completing my Master's degree in Engineering Policy Analysis at Delft University of Technology. The research presented here has been both a challenging and rewarding process, made possible through the support and guidance of many individuals and organizations, to whom I am thankful.

First, I would like to express my appreciation to my supervisors. Irene Grossmann, for her invaluable guidance throughout the research process and for making this study possible at Deventer Hospital. Naomi van der Linden for her expertise in quantitative analysis and Saba Hinrich Krapels for her critical insights and feedback. Their advice and encouragement have been essential in shaping this thesis, and I am grateful for their contributions.

I would also like to extend my gratitude to Deventer Hospital for facilitating this research and providing the necessary resources. Additionally, I am thankful to all the professionals who participated in the interviews, including emergency department physicians, ambulance personnel, general practitioners, and specialists, for sharing their time, experiences, and valuable insights. Their perspectives were instrumental in deepening my understanding of the complexities within acute care capacity management.

Beyond academic support, I want to thank my family and friends for their encouragement throughout this journey. Their patience, motivation, and willingness to listen have been invaluable. A special thank you to my roommates and to Luuk and Jasper, who were there during the final phase when the last stretch of writing became particularly stressful.

This thesis also marks the end of my time as a student, a period that has shaped me both academically and personally. Studying Engineering and Policy Analysis has given me a broad and analytical perspective on complex societal challenges, and I am grateful for the opportunities and experiences I have gained. Looking back, I appreciate the journey that brought me here, and I look forward to what comes next.

Abstract

The Netherlands faces significant capacity challenges in healthcare due to staff shortages. Many healthcare positions remain unfilled, despite rising demand for medical services. This also impacts the Emergency Department (ED), as higher patient volumes lead to longer wait times and increased responsibilities for emergency physicians. The combination of these variables leads to an increase in personnel turnover, putting additional strain on capacity. These capacity difficulties may also be seen in Deventer Hospital's ED, highlighting the significance of effectively organising patient flows and addressing system dynamics.

Although Deventer Hospital has conducted analyses to improve capacity management, current approaches, both locally and in the broader literature, primarily focus on technical aspects, such as staffing planning within the ED. However, by focusing solely on technical factors, such analyses may fail to account for social factors that influence system performance, such as human behaviour, communication patterns, decision-making processes, and institutional constraints. To bridge this gap, this study adopts a socio-technical systems approach that incorporates both technical and social factors of capacity management in the ED.

The main question is: **How can Emergency Department capacity challenges be improved using a social-technical approach?**

To answer this question, the current system at Deventer Hospital's ED was examined through a socio-technical systems framework. The IDEF0 model was used to map both the technical and social factors influencing capacity management. This model systematically represents workflow processes, resource dependencies, regulatory constraints, and the stakeholders involved. The system mapping was informed by multi-day observations, open interviews with ED physicians, document analysis, and a stakeholder analysis. The stakeholder analysis provided deeper insights into communication patterns, knowledge distribution, and power-interest relationships among the actors. Together, these methods resulted in a comprehensive and structured representation of the ED.

The system analysis revealed that ED capacity challenges involve both technical and social dynamics. These were categorized across three phases: inflow, throughput, and outflow. Specific issues included variability in triage processes, workforce shortages, delays in diagnostics, and asymmetric information exchange between departments. Furthermore, ED physicians noted that a proportion of patients could potentially have been treated elsewhere, affecting resource allocation and patient flow.

Based on these insights, potential interventions were developed to optimize patient redirection within the socio-technical landscape. A snapshot analysis estimated the proportion of patients who, according to ED physicians, could have been treated in alternative settings, such as by general practitioners or outpatient clinics. This analysis was complemented by interviews with ambulance personnel, GPs, and medical specialists, which provided deeper insight into barriers and opportunities for patient redistribution.

The findings indicate that while technical opportunities exist, particularly in redirecting patients to urgent outpatient clinics, success is dependent on effective capacity planning and accessibility in alternative care settings. Social factors play an equally critical role. Efficient patient diversion requires a robust communication framework among general practitioners, ambulance services, and specialists. In practice, however, such communication is not always optimal.

Additionally, a growing claims culture increasingly influences referral behavior. Concerns regarding legal liability and potential complaints compel healthcare providers to refer patients to the ED more frequently as a precaution, even when alternative care options could be more appropriate. This defensive referral behavior exacerbates ED workload and reflects a broader trend of risk aversion in healthcare decision-making.

To address these issues, both technical and social interventions are proposed. Technically, expand-

ing urgent outpatient clinic capacity could offer potential, provided that accessibility and appointment scheduling are carefully managed. Socially, interventions such as structured feedback systems between EDs and referring providers, enhanced real-time communication channels, and targeted legal literacy training for healthcare professionals could reduce unnecessary referrals.

In conclusion, the socio-technical system analysis provided a more comprehensive understanding of ED capacity management by considering both technical and social dimensions. This approach revealed important dynamics that a purely technical analysis might have overlooked, such as communication gaps, coordination barriers, and organizational constraints. It led to the development of potential interventions that not only address logistical aspects of patient redirection but also promote social structural improvements within the healthcare system. By targeting both technical workflows and social coordination mechanisms, this socio-technical approach offers a more realistic pathway to optimizing Emergency Department capacity.

Contents

Abbreviations

Abbreviation	Definition in english
AVG	General Data Protection Regulation
DH	Deventer Hospital
ED	Emergency Department
EPA	Engineering Policy Analysis
GP	General Practitioner
GP-Ooh	General Practitioner Out of Office Hours
KPI	Key Performance Indicators
LNAZ	National Network for Acute Care
NVSHA	Dutch Society of Emergency Physicians
NZA	Dutch Healthcare Authority
RIVM	National Institute for Public Health and the Environment
ROAZ	Regional Consultations for Acute Care
STS	Socio-Technical System
VWS	Health, Welfare and Sport

1

Introduction

1.1. Problem

1.1.1. Emergency Departments in the Netherlands

The healthcare sector worldwide is currently facing severe capacity issues [1]. These challenges are particularly evident in staff shortages. In many countries, such as the Netherlands, thousands of healthcare positions remain unfilled as the demand for care continues to rise. This growing demand places pressure on the quality and safety of care [2]. A significant factor driving this increased demand is the dual ageing of the population [3], leading to a substantial rise in the number of people needing care while the number of healthcare providers declines.

These staff shortages are evident in Emergency Departments (EDs), where acute care is provided. Acute care includes all medical assistance that requires immediate hospital-based treatment and cannot be postponed until regular care hours [4]. To optimize scarce resources and ensure that high-quality care remains accessible, centralizing care has been implemented. As a result, the number of EDs in the Netherlands has significantly declined in recent years, despite the growing demand for acute care [5]. Between 2016 and 2024, 13 EDs have closed, leaving a total of 77 departments currently offering 24/7 care for patients with urgent medical needs [6]. ED closures arise from problems with a lack of healthcare workers, and efforts to keep costs down [7]. Merging emergency departments is meant to improve care by focusing expertise in fewer, more specialized places [8], but this has also put more pressure on the EDs that are still open [9].

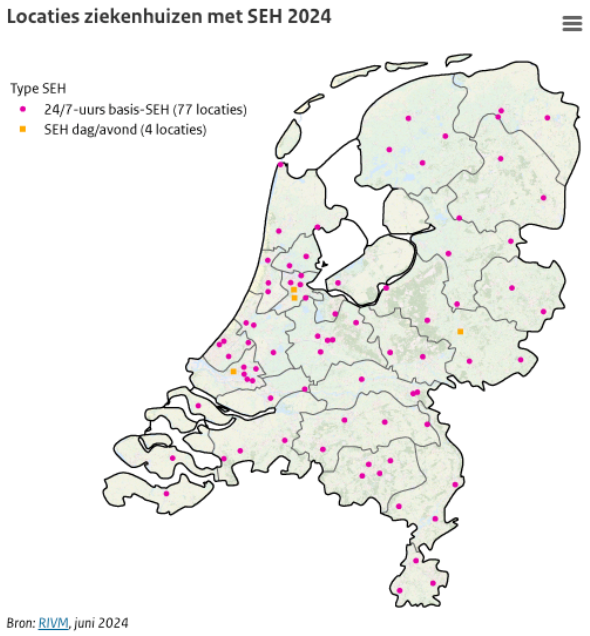

Figure 1.1: 77 Hospitals with Emergency Departments in the Netherlands [6]

The increasing pressure of a decreasing number of EDs has led to challenges, resulting in longer patient wait times. These problems are made worse by a lack of emergency department physicians and specialized nursing personnel [10], which is frequently brought on by heavy workloads and burnout symptoms [11]. Higher workloads and burnout among ED physicians result in higher attrition rates, which further strain the remaining staff and increase overall workload, thus escalating the capacity issues. This creates a self-reinforcing cycle. In addition to endangering acute care access, this vicious cycle has a direct effect on the quality and safety of patient care.

This highlights the urgency of the Dutch ED capacity issue, which needs to be addressed. Emergency Departments play a critical role within the healthcare system, as they provide essential care to patients with urgent and life-threatening conditions [12]. Acute care safety and quality will continue to deteriorate without effective interventions, negatively impacting patient care in general [9]. The shortage of ED physicians exacerbates this issue, potentially leading to burnout and creating a self-reinforcing problem.

As patient flow becomes more complex and resources remain limited, the pressure on hospital infrastructure increases. To manage these challenges while ensuring quality care, hospitals need to optimize and restructure the logistical patient flow through the ED. Optimizing these capacity problems will improve efficiency and enhance overall patient care, ensuring the healthcare system can continue to meet rising demand without relying solely on additional staffing [13].

1.1.2. Emergency Department Deventer Hospital

This research focuses on capacity issues within the Emergency Department of Deventer Hospital, a medium-sized hospital known for its high-quality, patient-centered care. The hospital employs 2410 staff members, including 204 medical specialists [14], and provides care to the residents of Salland and the surrounding areas, with a strong commitment to delivering optimal care to each patient [15]. As a member of the Association of Cooperating Top Clinical Hospitals (STZ), the hospital focuses on providing top-level clinical care, fostering innovation, developing talent, and advancing scientific research [16].

Deventer Hospital has been experiencing an ED physician shortage for the past ten years. Because of these shortages, maintaining acute care capacity continues to be a challenge. Furthermore, in 2023, the obstetrics and Emergency Departments in Zutphen were closed from 21:00 to 08:00, which increased pressure on the ED at Deventer Hospital, as more patients who would otherwise have been treated in Zutphen are now referred to Deventer and surrounding hospitals [17]. In response to this increased pressure, Deventer Hospital offers a suitable case study for analyzing ED capacity and investigating the underlying causes of capacity challenges.

Staff and Capacity

This study specifically focuses on the operational processes within the ED, with an emphasis on staffing capacity rather than broader issues related to physical resources such as beds (linens), medical supplies, or equipment. Capacity challenges related to these physical resources are outside the scope of this research, and neither is a problem, as Deventer Hospital is adequately equipped with the necessary infrastructure and support services to meet the current demand. Resource or supply chain shortages are not considered limiting factors in the hospital's capacity management.

Within the broader staffing framework, a distinction is made between doctors and nurses. While there are no reported shortages among nursing staff at Deventer Hospital, challenges persist within the group of ED physicians. Consequently, this research focuses exclusively on the role of ED physicians, as their shortages represent a key dynamic in the ED's ability to meet the growing demand for services. By excluding nursing staff from the scope of this study, the research allows for a more focused and in-depth analysis of the factors contributing to physician shortages and care capacity challenges within the ED. This approach ensures the study remains manageable and precise.

The research focuses on studying methods to increase capacity without expanding the current workforce, as increasing staff is not feasible due to the challenges outlined. This is particularly important for patients, as improved efficiency can lead to shorter wait times, better access to care, and overall enhanced care quality.

1.1.3. Current capacity Deventer Hospital

The current situation at Deventer Hospital is evaluated by examining previous studies that focused on capacity optimization at the hospital's Emergency Department in recent years. This analysis provided insight into the limitations of existing practices and the opportunities for enhancing capacity management within the hospital.

The first phase consisted of analyzing internal Deventer Hospital documents that address capacity challenges in the ED. One key strategy that is implemented in DH to reduce pressure on the ED is differentiating patient inflow by directing specific patient groups immediately to specialized departments. Patients with acute cardiac conditions are no longer treated in the ED but are transferred directly to the Cardiac Care Unit (CCU), where specialized cardiologists take over their care. This ensures that these patients receive appropriate medical attention more efficiently while simultaneously alleviating the burden on the ED. Similarly, pediatric emergency cases are referred directly to the Paediatrics Outpatient Clinic, where paediatricians take charge of treatment. Pregnant women with urgent conditions are also redirected to the obstetrics department instead of receiving initial care in the ED. Additionally, a special fracture clinic has been established, allowing patients with fractures to bypass the ED during weekday working hours. By implementing these targeted referral pathways, the ED workload is reduced, enabling staff to focus on patients who are most appropriately treated in the ED.

Beyond structural changes in patient intake, policies have been introduced by the ministry to limit self-referrals, significantly reducing the number of patients visiting the ED without a medical referral. Patients can only access the ED via a general practitioner's referral, ambulance transport, or after-hours referral from the out-of-hours general practice clinic (GP-Ooh), which is physically connected to the ED. This policy has reduced the proportion of self-referred patients to barely two percent of all ED visits at Deventer Hospital [18], contributing to a more efficient allocation of resources and preventing non-urgent cases from straining ED capacity.

In addition to regulating patient inflow, workflow analyses have been conducted to explore ways to improve patient throughput. These studies examined how the balance between incoming patients and available staff might be optimized. External experts, including the firm Doc2Doc, contributed to these analyses, providing insights into capacity planning strategies. The research considered not only patient arrival rates but also the length of stay within the ED, which varies significantly. While some patients are discharged within one hour after a short consultation, others remain for up to five hours, contributing to fluctuations in occupancy rates and pressure on available resources.

An analysis conducted by the hospital of patient occupancy patterns throughout the day provided insight into how patient numbers align with staffing levels. The data showed that while staffing levels generally followed patient demand, there were notable mismatches during peak hours. Specifically, between 12:00 and 18:00, the number of patients exceeded the available staff capacity at certain points, as indicated by the red-circled areas in the figure. These fluctuations suggest that, despite an overall alignment, temporary shortages occurred during high-demand periods, as shown in the red circles.

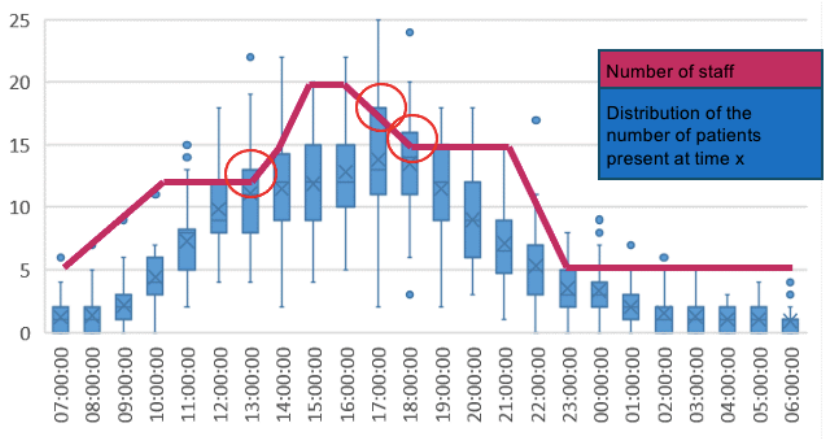

Figure 1.2: Staff planning on Monday based on patient flow [19]

While the implementation of specialized care pathways and improved staffing strategies has contributed to operational efficiency, several challenges remain. Discrepancies between available capacity and fluctuating patient demand persist, particularly during peak hours. Unpredictable factors, such as staff turnover and sudden surges in patient inflow, further complicate efforts to establish an efficient system.

The ED has a targeted staffing level of 7.43 Full-Time Equivalents (FTE), while the current staffing level is 4.40 FTE. This indicates a discrepancy between the planned and actual personnel capacity. FTE is a measure of the total workload of employees, where 1.0 FTE corresponds to a full-time position. A lower FTE than the target means that fewer working hours are available than planned [20]. To bridge this gap, the staffing is temporarily supplemented with more doctors in training than usual, allowing the personnel capacity to be approximated as closely as possible. Although night shifts are increasingly covered by less experienced staff, any potential slight delays in seeking assistance are uncommon in practice and are typically handled appropriately.

Although the goal is to maximize the efficiency of capacity planning, inherent uncertainty and variability mean that the limits of predictability have largely been reached. These ongoing challenges highlight the need for further refinement of existing analyses and interventions. A literature evaluation is necessary to understand how to improve capacity optimisation inside the ED. By comparing similar analyses, it becomes possible to explore potential improvements and alternative approaches.

1.2. Knowledge gap

Figure 1.3 summarises the process of identifying the knowledge gap. An exploratory review was conducted using PubMed, Google Scholar, and Elicit, complemented by the analysis of internal hospital documents. The aim was to investigate how capacity challenges in emergency care are currently addressed in both literature and practice, and to identify limitations in the literature that may hinder improvement efforts. The comparison revealed a strong emphasis on quantitative analyses, with limited attention to the interaction between social and technical factors. This highlighted a key shortcoming: the absence of a socio-technical perspective in existing approaches to capacity management [21, 22]. By adopting a socio-technical lens, this research seeks to provide deeper insights into system dynamics and to uncover pathways for more effective interventions. For a detailed description of the knowledge gap identification process, see Appendix A.

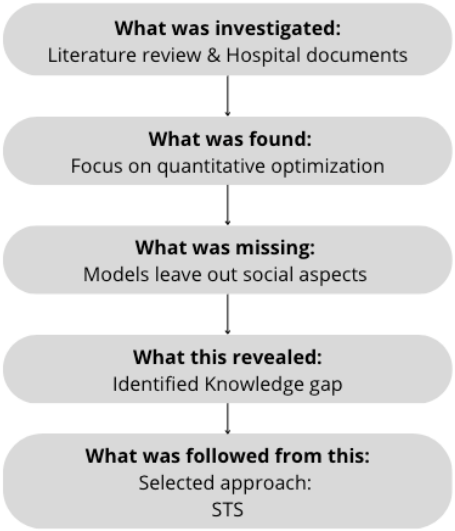

Figure 1.3: Identifying Knowledge Gap

A more detailed explanation of the knowledge gap is provided below.

1.2.1. Quantitative optimization of capacity

The challenges related to patient flow, waiting times, and efficiency in the ED of Deventer Hospital are not unique, as similar issues are widely studied in academic research. EDs serve as the primary entry point for acute and life-threatening cases. Their unpredictability is driven by the need to accommodate both scheduled and unscheduled patients, fluctuating demand patterns, and the urgency of care required [23]. To address these difficulties, several approaches for analysing and optimising emergency care systems have been created during the last several decades.

A commonly used approach in this context is the use of Discrete-Event Simulation (DES) and Queueing Theory, which have been utilised since the 1950s by researchers and healthcare managers to represent and analyse hospital systems [24, 25, 26, 27]. These analyses map patient flows, identify dynamics, and simulate interventions before their real-world implementation. Through quantitative analyses, these methods contribute to better resource allocation, reduced waiting times, and improved efficiency in ED operations [24, 28]. This emphasis on quantitative flow analysis and waiting time reduction is also reflected in internal documents and aligns with the findings presented in 'Current capacity at Deventer Hospital'. However, while these quantitative analyses offer valuable insights and efficiencies, they also have limitations. The following section explores these limitations.

1.2.2. Limitations of quantitative analyses

The commonly used analyses for addressing capacity issues in EDs only focus on one aspect only and these are the quantitative analyses and logistical aspects of operations [29]. They concentrate on the operational processes of planning, executing, and controlling the flow and storage of services and patients [30]. This includes aspects such as bed availability, staff schedules, and diagnostic throughput. Notably, around 30–40% of hospital expenditures are linked to such logistical operations, underlining their practical importance [23].

However, these analyses often rely on simplified system assumptions, such as linear workflows or fixed resource availability. As a result, they fall short in capturing the complex, dynamic, and interdependent nature of real-world ED environments [31]. For instance, they typically overlook how factors like interdepartmental communication, decision delays due to uncertainty, or role ambiguity between staff affect throughput in practice. Such aspects are part of the broader social and organisational dimensions of hospital work, including professional roles, behavioral patterns, informal routines, and cross-team dependencies [32].

Compared to sectors like finance or retail, where behavioral analytics and socio-organisational aspects are more integrated, healthcare remains behind in incorporating these elements into its decision-making systems [33]. A recent survey shows that 60% of healthcare organisations report difficulties in developing coherent strategies for implementing quantitative analyses that account for human behaviour and organisational complexity [34].

These constraints highlight the need for analyses that can better account for the inherent variation and uncertainty in hospital operations. The review of existing methodologies and literature identified a knowledge gap: while present approaches focus primarily on quantitative optimisation, they may fail to properly capture the importance of social and organisation factors in capacity management.

1.2.3. Socio-Technical approach

Capacity issues in Emergency Departments stem from both technical inefficiencies and social or organisational dynamics. Focusing on one perspective in isolation fails to fully capture the complexity of acute care environments [35]. While many existing analyses emphasise operational and logistical optimization, they often overlook how behavioural, cultural, and professional factors influence capacity management. At the same time, a purely social lens does not offer practical tools for resource allocation or patient flow design. This highlights the need for an integrated perspective that brings together both domains [22].

A socio-technical approach addresses the interactions between human behaviour, team collaboration, decision-making frameworks, and technological systems [21]. By combining these factors, it offers a more comprehensive understanding of capacity management in emergency care. This perspective is increasingly recognised as a suitable method for analysing and improving complex systems, including

healthcare [21, 22]. Unlike a purely technical approach that focuses on scheduling or operational flows, a socio-technical approach also considers human interactions, decision-making structures, and organisational culture that influence system performance. In the context of the ED, this means acknowledging how staffing analyses, communication routines, and clinical hierarchies interact with planning tools and IT systems to shape overall capacity and patient flow [36].

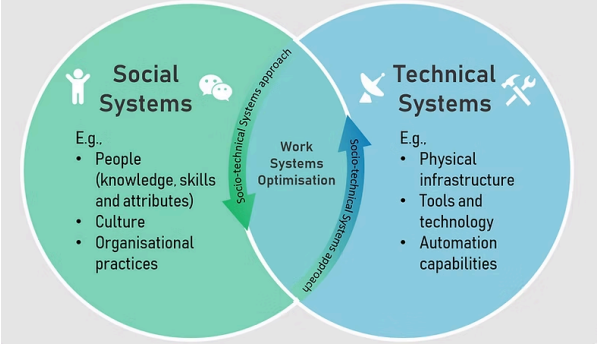

Figure 1.4: Socio-technical system approach [37]

Literature supports the relevance of this integrated view: several studies underline the importance of aligning technical capabilities with human behaviour to improve system functioning [38, 39]. For example, Borycki and Kushniruk demonstrate how socio-technical integration in health informatics leads to deeper insights into system use and design [40]. Although the socio-technical systems approach has been proposed in healthcare, it has not yet been applied to the specific case of capacity management in the ED of Deventer Hospital. This study, therefore, explores its potential in a new context.

1.3. Research objective

By considering both technical constraints and social dynamics within EDs, this research explores how a socio-technical approach could contribute to capacity optimization in Deventer Hospital. This perspective provides an alternative way to examine capacity challenges by integrating operational efficiencies with the role of human interactions in emergency care. Additionally, this study explores whether alternative strategies exist to reduce patient inflow in response to the increasing demand and pressure on the ED. The growing number of patients contributes to capacity challenges, making the management of inflow an area of focus.

1.4. Research questions

The research question is as follows: *How can Emergency Department capacity challenges be improved using a social-technical approach?*

The corresponding sub-questions are as follows:

1. How can the Emergency department be represented within a socio-technical system landscape?
2. What are the key social and technical dynamics that influence the actual care capacity?
3. How can partial redistribution of patient flow contribute to improving acute care capacity, viewed from a socio-technical perspective?

1.5. Methodology

IDEF0, complemented by a stakeholder analysis, was used to map both the technical and social components of the Emergency Department at Deventer Hospital. Data collection included direct observations, informal conversations, open interviews with care professionals, internal hospital documents, and hospital data. Key system dynamics were categorized into inflow, throughput, and outflow processes. A one-week snapshot analysis was conducted to assess the redirection potential of non-urgent patients. This was followed by logistic regression to explore patterns in patient characteristics. Finally, a second round of semi-structured interviews with healthcare professionals was used to understand barriers

and opportunities for patient redirection, resulting in technically and socially informed interventions to improve ED capacity.

1.6. EPA Relevance

This research addresses challenges within the complex socio-technical healthcare system, focusing on capacity management in EDs. By integrating operational data with systems-based analyses and stakeholder perspectives, the study contributes to improving the resilience and efficiency of acute care without expanding the workforce. The interdisciplinary approach reflects the core principles of Engineering Policy Analysis (EPA), using modeling, observational insights, and structured analysis to explore interventions.

By examining both technical processes and social factors, the research takes a holistic view of capacity management, balancing operational feasibility, patient safety, and sustainable working conditions for healthcare personnel. This perspective is particularly relevant for Dutch acute care, where structural limitations and fluctuating demand call for a systems-oriented response. The findings lead to recommendations that align technical improvements with organizational realities and provide actionable interventions for future-proofing acute care delivery.

Through this integrated approach, the research contributes to addressing broader societal challenges in healthcare, where complex problems require coordinated and adaptive solutions.

1.7. Structure report

The study begins by introducing the socio-technical systems perspective and developing a conceptual STS model for Deventer Hospital (Chapter 2). Chapter 3 outlines the research methodology. Chapters 4 and 5 focus on mapping the current STS: Chapter 4 examines the technical processes using IDEF0 modeling and hospital data, while Chapter 5 explores the social dimension through stakeholder and organizational analyses. Chapter 6 identifies system dynamics within the STS. Chapter 7 investigates the feasibility of redirecting patients using snapshot data and process modeling. Chapter 8 explores the conditions and focuses on social and technical factors affecting redirection based on semi-structured interviews with professionals. Chapter 9 presents potential technical and social interventions. Chapters 10 and 11 provide the study's conclusion and discussion.

2

Conceptual modelO

To answer the main question, a deeper understanding of the socio-technical system approach is needed. This chapter defines the variables relevant to the Emergency Department of Deventer Hospital and develops a conceptual model to map them. Appendix A outlines the literature selection method.

2.1. Socio-Technical System

A socio-technical System (STS) is a theoretical framework that examines the interconnectedness of social and technical factors within an organization or system. Achieving optimal performance requires an integrated approach that aligns social factors (people, relationships, and culture) with technical factors (technology, processes, and infrastructure). The STS framework addresses the limitations of technological determinism, as identified by Trist and Bamforth, and highlights the importance of social and organizational dynamics in influencing technological implementations [41].

The STS concept is integrated into a broad sociological environment. This perspective has led to an increased interest in the social and political implications of new technologies and has become a fundamental aspect of the sociology of technology. Modern applications of STS focus on understanding how complex systems such as those in healthcare not only require technical optimizations but also require a restructuring of social and organizational processes [42].

2.1.1. Key Characteristics of STS Principles

The essential aspects of this method include:

Mutual dependence of social and technical components
Social and technical factors do not operate in isolation but depend on one another. The overall success of the system is determined by how well these factors interact. For example, technology can only be used effectively if it aligns with the skills, behaviors, and needs of the individuals who interact with it. A key feature of socio-technical systems is the existence of multiple interconnected subsystems. These subsystems can range from technical components, such as machines and networks, to social structures, such as organizations and communities. The interactions among these subsystems are critical to the overall functioning of the system. A failure or inefficiency in one subsystem can disrupt others, highlighting the importance of recognizing and managing these interdependencies [43].

Complexity and non-linearity
Socio-technical systems are complex due to the non-linear and unpredictable interactions among their components. A change in social factors, such as team dynamics, can have significant consequences on technical processes and vice versa. This complexity requires a comprehensive approach to system analysis and management, as the interaction between components frequently defies a clear prediction or resolution [43, 32].

Emergent Behavior
The behavior of the socio-technical system as a whole cannot be fully predicted by analyzing its components. Emergent behavior arises from the dynamic interactions between social and technical subsystems and often appears in unexpected patterns or outcomes, such as the success or failure of a technological innovation within a specific social context. Socio-technical systems are not static, they evolve continuously under the influence of both external and internal factors. Changes in technology, policies, or social norms can significantly affect system performance. Understanding this dynamic de-

velopment and predicting possible changes are important for making sure that socio-technical systems are strong and work well [43].

2.1.2. STS Structure

The structure of socio-technical systems is characterized by the dynamic interaction between technical and social subsystems. These subsystems work together to ensure that the technological responsibilities work well with how people and organizations work. Within this framework, the technical system is formed by the integration of the task and physical components, while the social system encompasses people and structural factors. Together, these systems offer a clear view of how socio-technical systems function and adapt [44, 45].

The technical system

The operational basis of the socio-technical framework is defined by the technical system, which consists of the task and physical components. The task system is made up of the system's goals, acts, and steps for how it should work. Tasks can range from routine, procedural operations to highly complex, dynamic activities that require strategic decision-making and adaptability. The degree of coordination and technological assistance required for successful execution depends on the complexity of the task system [44].

Closely related to the task system is the physical component, which includes the tools, equipment, software, and infrastructure required to perform the tasks. This component provides the technical means to achieve the system's goals, enhancing precision, efficiency, and scalability [46]. Aside from its main purpose, the physical system needs to be flexible so that the socio-technical system can react to changing needs, problems from outside, and user wants. For example, scalable infrastructure or modular technologies can ensure resilience and flexibility in dynamic environments [44, 45].

The interaction between the task and physical systems is essential, tasks drive the requirements for technology, while technology enables the efficient and reliable execution of tasks. This relationship is not static but iterative, with feedback loops allowing continuous improvements [46]. When external demands, regulatory settings, or organisational goals change, the technology must also adapt to make sure it stays in line with new goals [44]. Additionally, the success of the technical system depends on user-centered design principles, which ensure that the tools and processes are insightful, accessible, and tailored to the capabilities and limitations of the users operating within the system [45].

Ultimately, the effectiveness of the technical system lies in its capacity to not only support current operational demands but also anticipate future needs, integrating innovation and flexibility to sustain long-term system performance.

The social system

The social system, which includes people and structural components, forms the human and organizational basis of the socio-technical framework. The people component refers to the individuals and teams who interact with the technical system to carry out tasks. This includes their roles, responsibilities, skills, knowledge, values, needs, and behaviors, which collectively shape the system's ability to function and adapt [32]. In addition to these attributes, the capacity for learning and knowledge sharing among individuals is essential, as it enables continuous improvement and adaptability in response to evolving system demands.

Communication, collaboration, and decision-making among people are critical for maintaining system coherence and addressing challenges as they arise [42]. Effective communication is not only a means of coordinating tasks but also a mechanism for establishing trust, sharing knowledge, and resolving conflicts. Collaborative dynamics, particularly in multidisciplinary teams, play a vital role in aligning diverse perspectives and expertise to achieve common goals.

The structural component provides the organizational framework within which the people and technical systems operate. This includes governance structures, policies, workflows, and cultural norms that regulate how tasks are performed and how resources are allocated. Importantly, the structural component also includes feedback mechanisms, which allow the organization to monitor performance, identify inefficiencies, and implement changes that align with strategic objectives. Such mechanisms are vital for creating a system that is both resilient and adaptable [44].

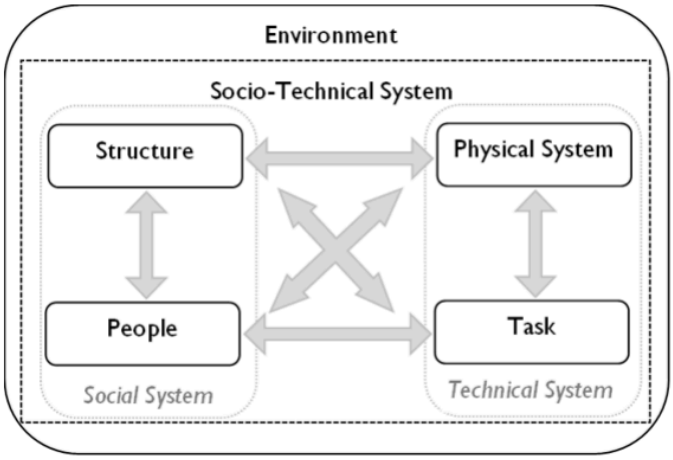

Figure 2.1: Socio-technical system [45]

2.2. STS for Emergency Departments

What does the STS framework look like within the Emergency Department of Deventer Hospital, and which key aspects should be included to effectively map the socio-technical system?

2.2.1. STS is suited for ED optimization

Socio-technical systems theory is particularly well-suited for addressing the challenges of EDs due to its holistic approach. The following aspects highlight the relevance of STS to ED optimization.

STS ensures that technical solutions are both functional and usable. This integration of social factors is important for improving patient flow and reducing dynamics in the ED. The principles of STS align with the need for flexibility in high-pressure environments. These environments are dynamic and high-pressure, where decisions must be made rapidly, often under conditions of uncertainty. This setting requires seamless integration of technical tools with social processes like teamwork and communication. Poor alignment between these components has been shown to increase errors and inefficiencies [31, 47]. By incorporating feedback loops and emergent behaviors, STS models can guide the development of resilient systems that adapt to fluctuations in demand. Effective communication and teamwork are central to STS, addressing the social challenges that often hinder technological adoption in healthcare settings. Studies by Janse (2022) and Hadi (2018) underscore the importance of fostering a culture of collaboration to improve outcomes [22, 42]. STS provides a framework for aligning policies and organizational structures with operational needs, ensuring that systemic changes are both feasible and sustainable. The RIVM report (2022) highlights the importance of such alignment in optimizing ED throughput [47].

2.2.2. Key Characteristics of EDs in Relation to STS Principles

Mutual dependence of social and technical components

Socio-technical systems theory explains that social and technical factors are interconnected, shaping overall system performance. In the ED, this interdependence is essential to daily operations.

An example is the integration of the CCU within the ED. The effectiveness of this separation is not solely dependent on technological infrastructure but also on precise alignment with clinical expertise and streamlined workflow requirements. Only when healthcare professionals correctly apply these systems and combine technical decision-making with medical expertise can patient flow be optimized [31].

Another example is the study by Tsai et al. (2020), which demonstrates that the success of medical informatics systems, such as electronic health records (EHRs), largely depends on organization-wide adoption and the adaptability of users to the technology [48]. This is true in DH as well. Similarly, van der Ham et al. (2020) emphasize that integration challenges arise when technical systems fail to align

with the workflows and perspectives of diverse healthcare professionals, leading to inefficiencies in patient flow [31].

Complexity and Non-Linearity
Emergency Departments are highly complex systems with nonlinear interactions. A change in one part of the system, such as staffing levels or bed availability, can have wide-reaching consequences that affect workflows and patient outcomes across the department. This complexity is reinforced by unpredictable patient inflow, rapidly shifting priorities, and strong interdependencies between staff, technology and resources [12, 47]. Traditional optimisation strategies are often based on the assumption that processes are predictable and linear [26]. While these methods may support planning and resource allocation, they frequently overlook the influence of social dynamics. Factors such as unclear responsibilities, limited communication or hesitation during high-pressure situations can significantly disrupt performance. These aspects are often not visible in technical models but play a critical role in how systems operate under stress. The socio-technical approach helps to identify and understand these hidden dynamics.

Kemp et al. emphasize that research on healthcare logistics often neglects social and behavioural factors [45]. During the COVID-19 pandemic, many technical models failed to respond effectively to shifting demands. Evaluations carried out after the crisis showed that the absence of insights into the social context severely limited the ability to manage patient flows and resource shortages [49]. By incorporating social and organisational dynamics into capacity analyses, the socio-technical systems approach enables a more accurate interpretation of system behaviour. It helps explain why some interventions do not deliver the expected results, even when they meet technical goals, and highlights the conditions that support resilient and adaptive emergency care.

Emergent Behavior
Emergent behavior in STS arises from the dynamic interactions between social and technical factors, producing outcomes that cannot be fully predicted by analyzing individual factors alone [50]. In EDs, emergent behaviors are frequently observed during the implementation of new protocols or technologies. Process mining techniques can uncover unexpected patterns in workflow adaptation, which may lead to either improved collaboration or unintended bottlenecks [51]. Dhirasasna and Sahin (2019) showed that causal loop diagrams help map these interactions, highlighting how trust affects the adoption of new technologies [52].

2.2.3. Socio-technical systems in the context of the Emergency Department

To address the complexity of capacity issues within the ED of Deventer Hospital, the existing conceptual model of the STS framework is applied and linked to Deventer's ED. This framework integrates the technical and social variables of the ED into a comprehensive model for analysis and optimization. The four fundamental components of the STS framework task, physical environment, people, and structure, are applied as follows.

Task

The task component of the STS framework focuses on the operational processes and objectives within the ED. In this research, the primary task is defined as the efficient management of patient flow through the ED, encompassing triage, diagnosis, treatment, and discharge or admission. These activities require seamless coordination among various medical and administrative processes to ensure timely and high-quality patient care.

Patient flow is inherently dynamic, influenced by variability in patient arrival rates, acuity levels, and resource availability [53]. In this context, triage plays a critical role in prioritizing patients based on the urgency of their medical needs. Efficient patient flow not only reduces waiting times but also prevents overcrowding, which is a common challenge in EDs [53]. By examining the workflow and its interdependencies, this research aims to identify dynamics and areas for improvement.

The importance of patient flow as a task in the STS framework stems from its direct impact on both patient outcomes and operational efficiency. Streamlining patient flow requires integrating advanced technologies, effective teamwork, and adaptive policies to handle fluctuations in demand and resource constraints.

Physical: Tools

The physical component of the STS framework comprises the infrastructure, tools, and equipment that support the ED's operations. While this research does not delve deeply into physical resources due to the absence of significant shortages at the ED, their role is acknowledged in the conceptual model. Infrastructure elements such as medical devices, access to diagnostic tools and the physical layout of the ED are crucial for enabling efficient workflows.

People: Behavior, Knowledge, and Communication

The people component of the STS framework addresses the human dynamics within the ED, focusing on behavior, knowledge, and communication among healthcare professionals. These social factors are critical for ensuring effective collaboration and decision-making in a high-pressure environment like the ED [54].

Behavior encompasses actors' actions, attitudes, and adaptability in responding to patient needs and operational challenges. It reflects how individuals interact with one another and with technology, influencing the efficiency and quality of care.

Knowledge pertains to the expertise and skills of healthcare professionals, which are crucial for accurate diagnosis, treatment, and patient management. Knowledge-sharing practices, such as team briefings and case discussions, enhance collective decision-making and ensure that staff are equipped to handle complex cases.

Communication is the backbone of effective teamwork in the ED. Clear and timely communication among doctors, nurses, technicians, and administrative staff reduces errors and ensures that workflows proceed smoothly. This research emphasizes organizational communication, as breakdowns in information flow can lead to delays, inefficiencies, and compromised patient care.

Structure: policies, regulations, and organizational framework

The structural component of the STS framework provides the organizational context within which the ED operates. It encompasses policies, regulations and organizational structures that govern decision-making and resource allocation. By aligning policies and organizational framework strategies with operational needs, the ED can optimize its capacity and adapt to changing demands [55].

Policies and regulations define the procedural standards for triage, treatment, and patient redirection, ensuring compliance with healthcare laws and quality benchmarks. For example, national guidelines on emergency care delivery and local hospital protocols dictate how resources are allocated and tasks are prioritized.

Organizational structure refers to the hierarchy and roles within the ED. The clarity of roles and responsibilities among doctors, nurses, and support staff is vital for minimizing redundancies and improving coordination. A well-defined structure ensures that staff can focus on their core tasks while adhering to established workflows.

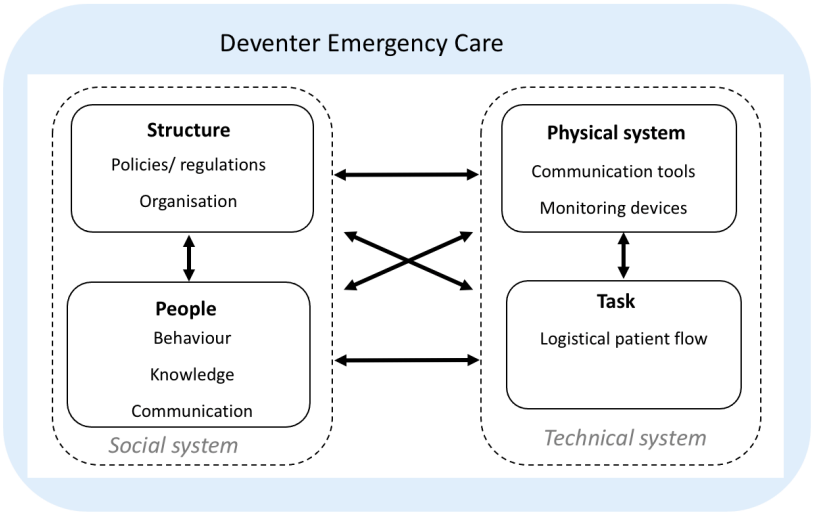

Figure 2.2: Conceptual model Deventer Hospital

To effectively map the socio-technical system of the Emergency Department, it is essential to include these elements. These components provide a comprehensive understanding of the system. The following paragraph outlines how each of these elements is examined in this study.

3

Research methodology

This chapter outlines the methodological approach used to answer the sub-questions of this study. Figure 3.1 provides an overview of the research design. Ethical approval was obtained from the Human Research Ethics Committee (HREC), ensuring compliance with standards for consent, confidentiality, and data security.

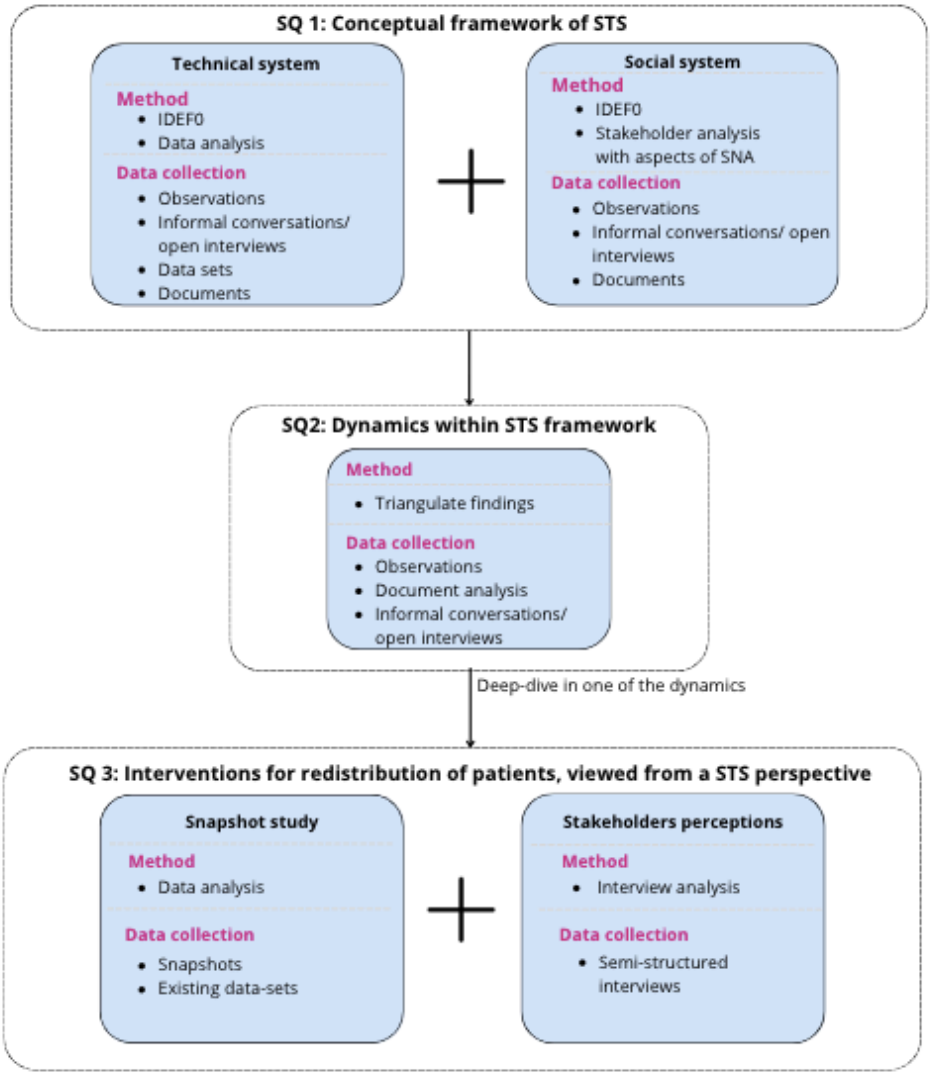

Figure 3.1: Research design

3.1. Sub-question 1: Conceptual framework of current STS

To map the current social-technical system, different methods were reviewed based on their ability to reflect both technical and social components of the system.

3.1.1. Method selection

To analyse the current system, a method is required that can represent both technical processes and social dynamics, as defined in the conceptual model Figure 2.2. Many existing methods in healthcare focus either on efficiency and workflows or on social behaviour, but rarely combine both perspectives [35]. Table 3.1 presents several examples of methods which could be used.

Table 3.1: Comparison of methods and their suitability for a socio-technical systems approach

Method	Explanation	Fit for this research
Discrete-Event Simulation (DES) [56, 57, 58, 59]	Simulates discrete events in a system, typically used for queuing and resource allocation. Good for simulating and optimizing resource use over time, particularly for operations management.	While DES provides detailed insights into operational dynamics, it primarily focuses on technical operations and offers a limited understanding of human and organizational aspects.
Queueing Theory [60, 61, 27]	Utilizes mathematical methods to analyze queuing systems and throughput times.	Primarily focused on mathematical modeling of waiting times, which is not the central focus of this research.
Markov Models [59, 62]	Uses probabilistic methods to model transitions between states, such as different phases of patient care.	Suitable for statistical analysis of technical systems, but not for modeling social or organisational aspects.
Flow Chart [63, 64, 65]	Visual tool that represents sequential steps and decisions in a process. Also often used before other technical models.	Suitable for simple process representations, but limited in representing dynamic interactions or social components like regulations.
Social Network Analysis (SNA) [23]	Examines relationships and information-sharing patterns between individuals or groups, such as how healthcare providers collaborate.	Provides valuable insight into the social relationship between actors of a system, but does not capture technical workflows or operational dynamics.
Agent-Based Modeling (ABM) [56, 57, 66]	Models interactions of agents (people, things, places, and time) in a system, useful for detailed agent behavior modeling. It can simulate agent interactions and adaptability, which is valuable for systems with decentralized control.	While ABM captures adaptive interactions between individual agents, it requires extensive data on agents and their behaviors, and may not capture system-wide processes effectively. Additionally, the development and validation of ABM models are resource-intensive.

Method	Explanation	Fit for this research
IDEF0 [66, 67, 68]	Describes and maps complex processes, identifying interdependencies between components, and focusing on system workflows and roles. Provides clear, structured models for processes, identifies system inputs and outputs, and allows detailed visualization of operations.	IDEF0 primarily focuses on processes and technical components and does not naturally capture dynamic social behavior over time. However, by incorporating regulations and actors at each process step, it becomes well-suited to systematically integrate social aspects into the system without altering the model's core structure.
Business Process Model and Notation (BPMN) [69, 70, 71]	Models and optimizes business processes by defining workflows, roles, and interactions.	Lacks a system-wide perspective on capacity management and resource dependencies in acute care. Not widely established for modeling resource dynamics or constraints in emergency departments.
System Dynamics (SD) [58, 72, 73]	Captures feedback mechanisms within systems to analyze long-term dynamics and strategic developments. Especially useful for insights into system-wide trends in complex or large-scale environments.	However, SD is primarily focused on strategic-level modeling and policy evaluation rather than detailed, operational-level processes. It does not adequately capture the day-to-day workflows, real-time decision-making, or social interactions between healthcare professionals that are critical in understanding and improving ED capacity.

Table 3.1 provides an analysis of methods in healthcare, with a specific emphasis on their ability to integrate both social and technical components.

In this study, no advanced technical methods such as queueing theory, Markov models, or Discrete-Event Simulation were used to represent patient flows. While these methods are powerful tools for analyzing technical system dynamics, such as waiting times, transition probabilities, and resource utilization, they are also highly detailed, technically intensive, and time-consuming to develop and validate [57, 60, 62]. Given the focus of this research on the socio-technical dimensions of capacity management, a simplified yet structured representation of patient flows was considered sufficient. The primary aim was not to optimize technical efficiency alone, but to understand how social dynamics and system coordination interact with patient flow.

Therefore, a flowchart was initially considered due to its clear visualization of sequential tasks. However, its inability to capture resource dependencies and social aspects made it less suitable for a socio-technical analysis. Alternative methods were also evaluated. System Dynamics (SD) is effective for analyzing high-level interdependencies and long-term policy impacts but lacks the operational detail needed for Emergency Department workflows [72, 73]. Agent-Based Modeling (ABM) captures decentralized decision-making and adaptive behavior but demands significant computational resources and does not naturally structure patient flows and system constraints [74, 75]. Business Process Model and Notation (BPMN) supports workflow visualization and procedural efficiency, but insufficiently represents system interdependencies and organizational structures for a socio-technical perspective [70].

Consequently, a more structured method like IDEF0 was selected. IDEF0 systematically integrates tasks, actors, resources, and regulations at each process step, making it particularly suited for capturing the combined technical and social aspects found in Figure 2.2. While methods such as ABM could offer deeper insights into adaptive behaviors, or BPMN could offer detailed workflow optimization, these approaches typically involve more extensive modeling efforts and computational demands.

Moreover, while IDEF0 effectively captures the structural and process-driven aspects of the Emergency Department, it offers limited insight into the underlying social dynamics, such as collaboration patterns

and communication flows. To address this, a stakeholder analysis is conducted, incorporating elements of Social Network Analysis (SNA) to further explore these relational aspects. By adding this layer, the socio-technical perspective is strengthened, allowing for a deeper understanding of how social interactions influence system behavior.

3.1.2. IDEF0 structure

The IDEF0 modeling is a structured and hierarchical approach to process mapping, designed to provide a comprehensive and detailed understanding of complex systems. It organizes processes into interconnected subsystems, represented visually to facilitate analysis and communication [76].

At the highest level, the IDEF0 at the A-0 level offers an overview of the system, outlining key activities and their interactions. It identifies essential inputs, outputs, constraints, and mechanisms, forming the basis for further detailed analysis.

- Inputs: Elements that transform within the process.
- Outputs: Results or deliverables produced by the process.
- Mechanisms: Tools, equipment, resources used to execute the process and people who are involved in the process step
- Control: Policies, regulations, or limitations guiding the process.

In Figure 3.2, arrows entering the top of a process box indicate constraints or controls, while arrows entering the bottom represent mechanisms. This structured representation enables a detailed examination of how individual components interact within the broader system, highlighting dependencies, dynamics, and opportunities for optimization [76].

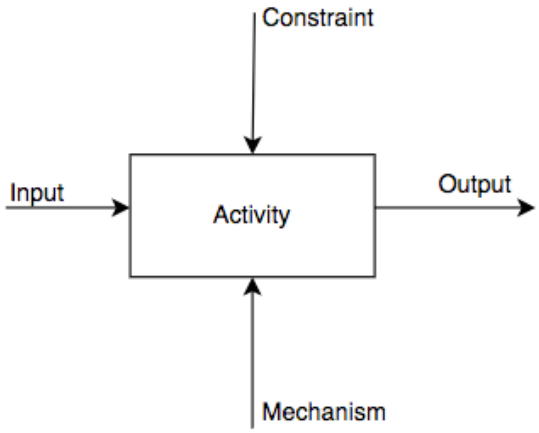

Figure 3.2: IDEF0 model structure

The A-1 model further specifies the ED process by breaking down overarching activities into smaller sub-processes, each described using the IDEF0 components of input, output, control, and mechanism [77]. This layered structure allows the model to reflect both the general process flow and more detailed operational steps, making it possible to zoom in on specific aspects when needed.

3.1.3. IDEF0 Deventer Hospital

In the case study of Deventer Hospital, the IDEF0 model was used to represent the current socio-technical system by mapping its core components and interactions in a structured way.

Figure 3.3 shows how each element of the conceptual model is incorporated into the IDEF0 framework for Deventer Hospital. This mapping structures the integration of technical processes and social interactions.

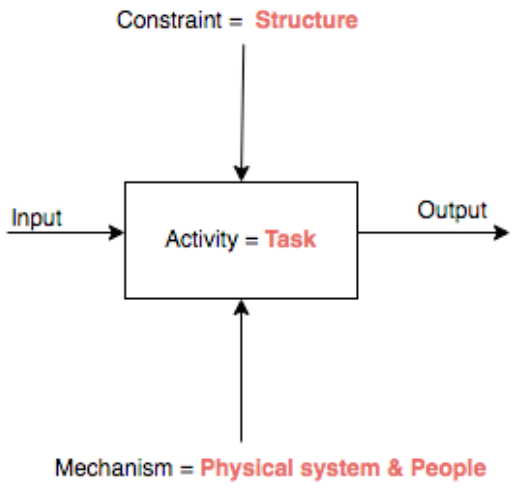

Figure 3.3: IDEF0 in combination with conceptual model terms

3.1.4. Data collection

To develop the IDEF0 model for Deventer Hospital, data was gathered through direct observations over three days, open interviews with three ED physicians and the hospital's capacity advisor, as well as analysis of internal hospital documents and national policy frameworks. Multiple data collection methods were used to support a structured and reliable analysis [78].

The interviews were primarily open in nature and aimed at gathering contextual information about the Emergency Department. Additionally, informal conversations with other ED physicians and the capacity advisor for nursing were held during observations to further deepen the understanding of day-to-day operations.

Table 3.2: First round interviews: open interviews % informal conversations

Reference name	Person
Open interview 1	ED specialist
Open interview 2	ED specialist
Open interview 3	ED specialist
Open interview 4	Capacity advisor
Informal conversation 1	ED specialist
Informal conversation 2	ED specialist
Informal conversation 3	department manager of the ED

The IDEF0 model was developed in several stages, starting with the technical system, mapping the core process flow and physical elements, followed by the identification and inclusion of social factors, including the structural context and key actors. The steps are described below.

Technical system: Task/ process

Observations were conducted to document workflows and patient movement. To supplement these findings, open interviews and informal conversations were held to clarify specific process steps not visible through observation alone [79, 66].

A document analysis was conducted to provide additional context, focusing on internal hospital documents related to capacity planning and daily operations. To further understand logistical procedures and

internal coordination, an open interview was held with the hospital's capacity advisor, complemented by an informal conversation with the department manager.

Data analysis for ED process

A data analysis was conducted to gain insight into patient flow and capacity management at the ED. The focus was on key aspects of patient throughput, such as length of stay, admission rates, staff planning and referrals to specialist care. This provided a clearer understanding of how the system operates and how patients move through the ED from arrival to discharge.

The analysis was based on anonymized patient data from Deventer Hospital collected in 2024. Although the dataset did not contain personally identifiable information such as names, birthdates, or addresses, anonymisation was used to guarantee that individual records could not be indirectly linked to specific patients.

The data were processed and analyzed using Python and the Pandas library, which supported the cleaning, structuring, and interpretation of patient flow data in a systematic manner [80].

Technical system: Physical resources

The analysis is followed by assessing the relevant resources per process step. Since resources do not present significant challenges, the analysis focuses specifically on those that play a role in communication within the ED. Observations, informal conversations and open interviews with healthcare professionals were used to assess the utilization, functionality, and necessity of these resources.

Social system: Structure

Chapter 2 introduced the organizational structure as the foundation encompassing governance, policies, and workflow regulations [44]. In this study, the concept is further specified to include the national framework, the hospital organization, and the associated legal and procedural context.

To map the organizational structure of the ED in Deventer, a document analysis was conducted. This began with the review of national-level public documents, including guidelines and policy frameworks relevant to acute care.

Next, the hospital-level structure was examined. This included publicly available materials such as annual reports, as well as internal documents outlining the organization of care, responsibilities, and coordination mechanisms within Deventer Hospital.

Finally, the analysis focused on internal protocols, regulations, and interdepartmental agreements that apply specifically to ED operations. These are directly linked to the process steps to clarify how activities are shaped within the organizational framework.

Social system: People

The people component was analyzed by identifying actors involved in each process step within the IDEF0 model, based on field observations, open interviews, informal conversations and document analysis. These actors were integrated under the mechanism category, aligning them with their roles in ED processes. Patients are intentionally excluded from this analysis, as they do not have a direct influence on capacity management in acute care.

Stakeholder analysis

To gain a deeper understanding of the social dimension of the ED system and to examine how different actors interact, a stakeholder analysis was conducted. This analysis aimed to explore how key stakeholders influence decision-making and logistical processes. By mapping roles, communication structures, and collaboration, the analysis provided insights into stakeholder interactions affecting capacity management [81, 82].

The stakeholder analysis focused on:

- Communication links: This analysis specifically maps how stakeholders communicate across departments and roles to reveal the structure and strength of their interactions. To achieve this, we will perform a concise Social Network Analysis (see Table 3.1), which will:
  - Systematically chart all communication links between actors

  - Quantify each actor's centrality and influence within the network by counting their direct communication links.

  By doing so, we can see which individuals or groups drive information flow and where coordination gaps may occur.
- Knowledge Sharing: This analysis explores how knowledge is shared among stakeholders and assesses their level of expertise about capacity management within the Emergency Department.
- Behavior: This analysis looks at the degree of influence and interest that stakeholders have in capacity management choices.

By integrating these methods, the current socio-technical system within the Emergency Department can be accurately represented.

3.2. Sub-question 2: Dynamics within STS framework

This sub-question explores the dynamics that influence the functioning of the ED at Deventer Hospital.

3.2.1. Data collection

Based on the socio-technical system mapping from Sub-question 1, recurring patterns were identified across different parts of the system. These dynamics were examined during field observations, informal conversations, open interviews and analysis of hospital data. The open interviews allowed respondents to reflect on how workflows, coordination, and resource use unfold in daily practice [66, 83]. Observations offered additional insights into operational dynamics that were not captured through documentation or the open interviews alone [79, 84]. By combining these methods, the analysis provides a more comprehensive understanding of the factors that shape processes within the ED [84, 66].

3.2.2. Data presentation

To systematically address the identified challenges, the dynamics have been categorized into three main areas of the patient journey: inflow, throughput, and outflow. This categorization reflects the sequential stages of the ED process and for an exploration of inefficiencies within each stage.

- Inflow: Processes related to the admission of patients into the ED, encompassing all activities and systems involved in managing incoming patient flow.
- Throughput: Processes that influence the duration of a patient's stay within the ED, including factors that may delay or hinder patient progression.
- Outflow: Processes concerning the discharge of patients from the ED, whether to their homes, specialist care, or other departments within the hospital.

Each subsection presents the observed dynamics and discusses their implications for the socio-technical system of emergency care.

3.2.3. Data analysis

To gain a clearer understanding of the dynamics identified in the system, each dynamic was examined in terms of its underlying nature. Specifically, the analysis assessed whether the origin of a dynamic was primarily social (communication patterns, cultural dynamics, roles, responsibilities, behaviours) or technical (logistical flows, physical infrastructure), or a combination of both. This classification supports a more structured interpretation of the findings and helps to distinguish between different types of contributing factors within the socio-technical system.

3.3. Sub-question 3: Interventions for redistribution of patients

This sub-question explores, through a deep dive into one of the system dynamics, how it could contribute to care capacity. It examines potential interventions for patient redistribution and how these might enhance acute care capacity from an STS perspective. The underlying hypothesis is that a proportion of patients currently presenting to the ED could be effectively treated in alternative care settings, thereby reducing pressure on ED capacity. Following the socio-technical approach, the analysis

focuses on technical feasibility, followed by an examination of relevant social factors. Based on these findings, potential interventions are outlined to support improvements in care capacity.

3.3.1. Snapshot study

The technical exploration of patient redistribution consists of three components:

1. Snapshot analysis: Identifying non-urgent patients within patient inflow patterns
2. Process mapping: Modeling the redistribution process within a socio-technical framework, using IDEF0.
3. Characteristics analysis: Investigating whether patient characteristics can predict which patients are more likely to be redirected.

Snapshot analysis

To explore patient redirection, a one-week snapshot analysis was conducted in the ED of Deventer Hospital. The selected week was chosen based on ED physician input. Each day, the coordinating ED physician completed a standardized form developed for this study to assess whether patients presenting at the ED required emergency care or could have been redirected to an alternative care setting.

The form captured whether the patient required emergency care, using three classification categories:

- Emergency care required: The patient needed to be treated in the ED.
- Alternative care pathway possible: The patient could potentially have been treated in a different healthcare setting.
- Uncertainty about ED suitability: There may have been other options for patients, but there remains doubt

For patients in the latter two categories, a potentially more suitable alternative care option was recorded. These classifications formed the basis for further analysis of redirection opportunities and their potential effect on ED capacity. Completed forms were kept on-site in a secure cabinet in the ED in accordance with privacy regulations. .

After data collection, the analysis examined how many patients could potentially be referred and to which alternative care sites. Using Python, the data were processed to quantify the proportion of patients in each classification group and identify the proposed alternative care sites.

Modeling the redistribution process

Based on the snapshot data, the possible alternative care options for redirectable patients are added to the IDEF0 process to represent the redirection pathways. The existing model is expanded to include these pathways, ensuring that the updated process reflects how non-urgent patients could be redirected within the ED workflow at Deventer Hospital.

Analysis patient characteristics

After identifying which patients could potentially be redirected, a further analysis was conducted to examine their characteristics. The goal was to explore whether specific characteristics were associated with redirection potential.

In collaboration with an ED physician familiar with hospital data systems, relevant variables from the hospital database were selected for exploration. The analysis consisted of two steps. First, Python was used to examine the basic characteristics of patients within each redirection category. This included exploring the dataset using the pandas library [80]. Next, a logistic regression model was applied in SPSS to determine whether these characteristics could predict which patients were more likely to be classified as non-urgent. Logistic regression is appropriate for this analysis as it evaluates the probability of a binary outcome [85]. In this case, whether a patient is classified as needing ED care or not. SPSS was used due to its built-in statistical tools for regression analysis and hypothesis testing.

All categorical variables were converted into dummy variables for inclusion in the model. The time of arrival was divided into four time blocks: morning (06:00–12:00), afternoon (12:00–17:00), evening (17:00–00:00), and night (00:00–06:00). The triage category was excluded due to inconsistent documentation.

To increase robustness, an additional analysis was conducted in which patients marked as 'uncertain' were combined with those classified as 'not suitable for ED care. ' A backwards elimination method was applied, in which non-significant variables were stepwise removed from the model until only those with the lowest p-values remained. In the equation, p-values represent the probability that a certain outcome is 1, meaning that a patient is classified as urgent [85].

The aim of this analysis is not to develop a predictive model but rather to investigate whether identifiable patterns exist that support or nuance earlier findings. A more extensive analysis in which alternative dummy codings of variables is included in Appendix E. These additional tests were performed to check the robustness of the findings and explore different ways of structuring the data.

3.3.2. Stakeholder perspectives on patient redirection

This chapter explores, through semi-structured interviews with healthcare professionals, why patients continue to use the ED even when their care needs could be addressed elsewhere. The focus lies on both the technical and social dimensions that hinder patient redirection.

Semi-structured interview setup

To investigate the perceptions of patient redistribution, seven semi-structured interviews were conducted with professionals involved in acute care. The selection of participants was guided by the IDEF0 process model, which identified the key actors in patient redirection. Interviewees included a general practitioner, an ambulance nurse, and five medical specialists.

Table 3.3: Data collection second round interviews: semi-structured interviews

Reference name	Person
(Semi-structured) interview 1	Medical Specialist
(Semi-structured) interview 2	Medical Specialist
(Semi-structured) interview 3	Medical Specialist
(Semi-structured) interview 4	Ambulance personal
(Semi-structured) interview 5	Medical Specialist
(Semi-structured) interview 6	General Practitioner
(Semi-structured) interview 7	Medical Specialist

The interviews were structured around four main themes, allowing for consistent data collection and easier comparison across responses, while still offering flexibility for deeper insights. The themes are shown in Figure 3.4

Figure 3.4: Themes of interviews

Awareness of patient flows

This theme focuses on the degree of awareness among healthcare professionals regarding current patient flows and their perceptions of whether specific patients could have received treatment elsewhere. This theme clarifies professionals' perceptions regarding the allocation of patients among available healthcare services.

Reasons for current care choices

This theme examines the reasons why some patients go to the ED. It focuses on the healthcare professional's views and experiences rather than the patient's perceptions. It considers factors like referral procedures, access to alternative care, and professional opinions on care continuity and workload.

Benefits of patient redirection

This theme focuses on the prospective benefits of patient redirection for individual patients and the healthcare system at large, including reducing the congestion in the ED and optimizing the healthcare capacity.

Challenges of patient redirection

This theme examines the structural, logistical, and social obstacles to the implementation of alternative care pathways. Besides systemic factors, it underscores possible adverse effects for healthcare providers and patients. This analysis clarifies the requirements for a successful and efficient patient redirection strategy.

Structuring the analysis around these four themes facilitates a clearer understanding of the feasibility of patient redirection.

Interview analysis

The interviews were audio-recorded and transcribed. The analysis was conducted using the qualitative analysis tool Insight7. Based on the four predefined themes, the interviews were analyzed per theme. Within each theme, relevant subthemes were identified using the tool's categorization functions. These subthemes were further substantiated by manually selecting and adding quotes from the transcripts to illustrate and support the analysis.

3.3.3. Potential interventions to improve care capacity

As a final step, potential interventions were developed to explore how patient redistribution could help address challenges in care capacity. Based on the findings, potential interventions were first formulated with a focus on the technical aspects of the analysis. Subsequently, it was assessed whether social adjustments would be necessary alongside technical measures.

4

Technical system

This chapter examines the technical system of Deventer Hospital, providing a detailed analysis of patient volumes, process flows, and the physical components required for operational efficiency.

4.1. Logistical patient flow

In 2023, a total of 20.320 visits were recorded at the Emergency Department of Deventer Hospital [19]. Patients accessed the ED through various pathways, with the primary routes being ambulance arrivals and referrals by general practitioners (GPs) or out-of-hours GP services (GP-ooh). Additionally, 2.13% of patients presented directly without a referral [19].

Patients in need of acute care at Deventer Hospital (DH) can be treated at three different locations: the Cardiac Care Unit (CCU), which handled 3,261 patients, the Children ED, which saw 1,346 patients, and the General ED, which treated 15,713 patients. For this study, the focus is solely on the General ED, excluding the CCU and children ED. As a result, the analysis covers 77.3% of the total incoming patients at the hospital's emergency facilities [19].

Once patients have been treated in the ED, their destinations vary. They are either discharged home, admitted to a hospital ward, or, in unfortunate cases, the patient passes away. Figure 4.1 provides a summarized overview of the ED process, detailing the flow from patient intake to treatment and eventual discharge or transfer in 2023.

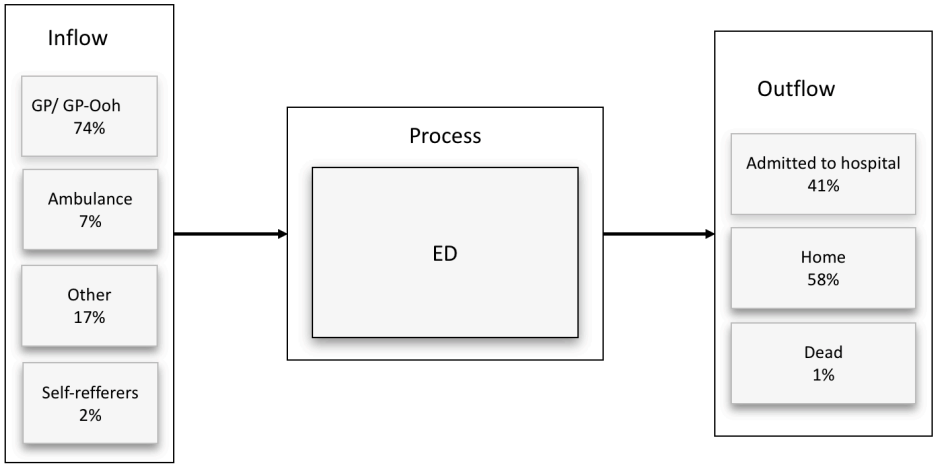

Figure 4.1: Patient In/out-flow Deventer Hospital

Abbreviations: ED = Emergency Department

4.2. How is the ED structured and background information

At the ED of Deventer Hospital, a central hub referred to as the ”Vissenkom” (Fishbowl) serves as the operational nerve centre. This nickname comes from its design as a centrally placed operational space surrounded by glass. This space is occupied by both the ED physicians and nursing staff, facilitating real-time coordination of patient flow and care delivery.

One of the nurses is designated as the ZOCO (Zorgcoördinator), who is responsible for managing all patient assignments and overseeing the allocation of tasks among nurses. The ZOCO also acts as the primary point of contact for incoming communications from ambulance services, determining where patients should be directed upon arrival. It is important to note that the ZOCO does not provide direct patient care, focusing instead on the logistical and operational aspects of the ED.

A designated ED physician takes charge of coordinating interactions with external healthcare providers, such as general practitioners (GPs) and GP out-of-hours services (GP-OoHs). This physician coordinates patient referrals and supervises the intake process for patients referred by GPs and GP-OoHs. This includes analysing referral information, determining the appropriate level of urgency, and managing patient distribution throughout the ED. Furthermore, the physician assigns ED physicians to specific patients based on their triage priority and availability. Depending on the workload and current patient volume, this physician may give direct patient care to assist the team.

ED staff, including both physicians and nurses, have access to a shared digital system displayed on monitors in the central operation space with the Hospital Information System (HIS). This system provides a comprehensive view of all patient admissions, including their location in the ED, urgency levels and any additional information needed for assignment (see Appendix B). From this central point, decisions are made about which team member will treat a specific patient and what the required urgency level is.

4.2.1. GP/ GP-Ooh

The GP out-of-hours service plays a pivotal role in regulating access to the ED during evenings, nights, and weekends when regular general practitioner practices are closed. As outlined in the introduction, one GP-OoH is located within the hospital building, while others operate in the surrounding area, providing key points of contact for patients seeking medical care after regular office hours. However, it operates independently from the hospital, as the space is rented by general practitioners rather than being an integral part of the hospital organization. Upon arrival, patients are evaluated by GPs and healthcare providers at the GP-OoH. If the GP or GP-OoH determines that a patient’s condition requires specialized acute care, the referral to the ED is made in consultation with the ED staff. An exception to this process applies to patients with fractures, who are directly referred to the radiology department during working hours. This regulatory arrangement ensures that patients cannot directly access the ED during out-of-hours periods without an initial assessment by the GP-OoH, allowing for controlled referrals.

4.3. Process

The following sections describe the processes within the ED. First, the A0 model is presented, providing a high-level overview, followed by a more detailed breakdown of subsystems in the A1 model.

4.3.1. A0 IDEF0 model

The A0 IDEF0 model provides a high-level overview of patient flow through the ED. It illustrates how patients enter the ED with symptoms, undergo referral processes, and leave with a defined destination. The model highlights key controlling factors, such as regulations and the systems and personnel involved in facilitating the process.

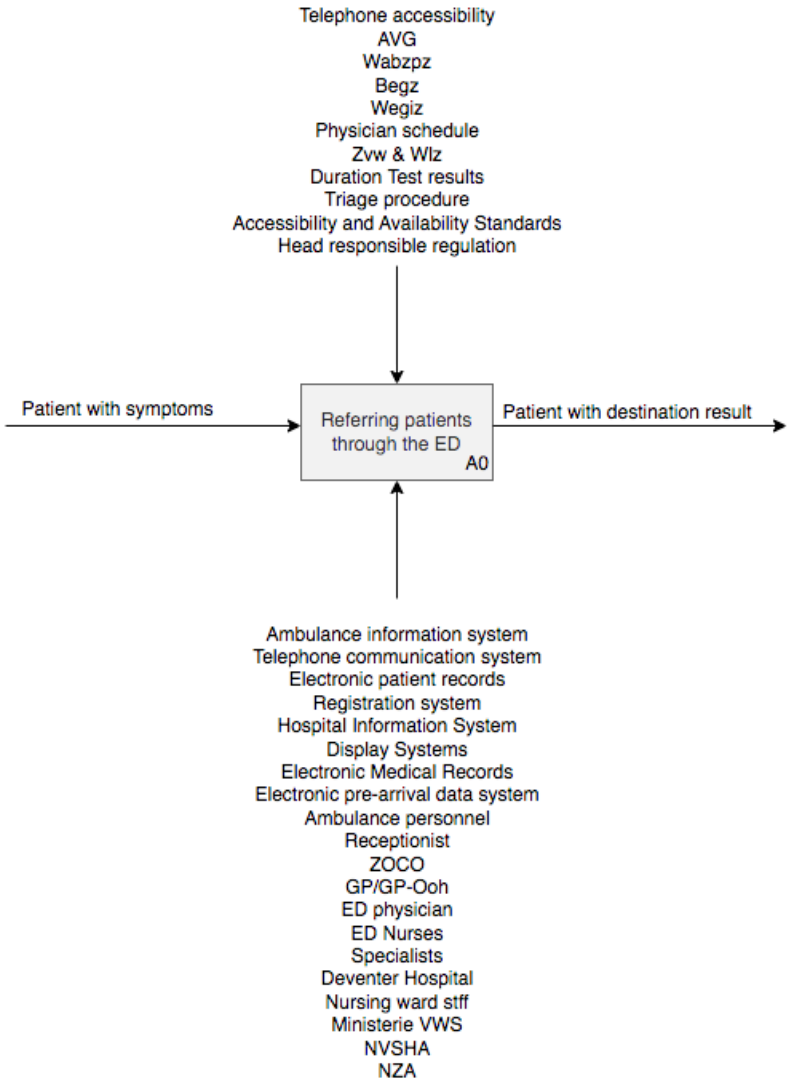

Figure 4.2: A0 IDEF0 model

Abbreviations: AVG = General Data Protection Regulation, Wabzpz= Act on Additional Provisions for the Processing of Personal Data in Healthcare, Begz = Decree on Electronic Data Processing by Healthcare Providers, Wegiz = Electronic Data Exchange in Healthcare Act, Zvw = Health Insurance Act, ED = Emergency Department, GP = General Practitioner, Wlz = Long-Term Care Act, NVSHA = Dutch Society of Emergency Physicians, VWS = Ministry of Health, Welfare and Sport, NZa = Dutch Healthcare Authority.

4.3.2. A-1 IDEF0 model

The A-1 IDEF0 model breaks down the ED process into detailed sub-processes. The following sections outline the key steps patients go through, from registration to treatment, discharge, or admission.

Patient referral by ambulance(A1)

Patients transported by ambulance to the ED usually require urgent or critical care. The process begins with an emergency call to 112, the national emergency number, or a request made through the non-emergency ambulance line. Calls can be made by the patient, a relative, or a bystander on the scene of an incident. The dispatch centre evaluates the circumstances to determine whether an ambulance deployment is required. When paramedics arrive, they give pre-hospital care to stabilise the patient before transferring them to the ED.

In certain situations, ambulance personnel may contact the patient's primary care physician to assess whether transport to the ED is necessary. This usually occurs when the urgency of the patient's condition is unclear. Unlike ambulances, the GP has access to the patient's medical history and can provide crucial information on whether treatment is necessary. Following this conversation, the GP may urge transportation to the ED, offer an alternative care pathway, or determine that emergency assistance is not required.

Patient referral by GP/ GP-Ooh (A2)
Parallel to the patient's arrival by ambulance runs the process of patient arrival by GP or GP-Ooh. A significant proportion of patients presenting at the ED are referred by their GP or GP-OoH. Both the regular GP and the GP-OoH follow similar procedures for referring patients to the ED.

When a patient contacts their GP with a medical concern, the GP assesses whether a referral to the ED is necessary based on symptoms and medical history. For more complex or urgent cases, the GP may directly consult with an ED physician or specialist to discuss the patient's condition and the need for emergency care. Appendix B shows a flow chart indicating whether or not a patient is referred. If a referral is warranted, the patient typically travels to the ED independently. In cases of severe urgency, the GP may arrange for ambulance transport. Such cases, even when transported by ambulance, are still recorded as referrals initiated by the GP.

Registration patient (A3)
For patients arriving by ambulance, the registration process begins during transport. Key medical information, such as vital signs, administered treatments, and an initial assessment of urgency, is digitally transmitted to the ED via the ambulance system. In addition to this digital data, the ZOCO receives a telephone call from the paramedics. During this call, supplementary details are provided, including details on the patient's condition, estimated time of arrival (ETA), and any specific preparations required in the ED.

Using this information, the ZOCO organizes the necessary steps, such as preparing the required equipment and allocating appropriate healthcare personnel. Immediately following the call with the ambulance crew, the ZOCO contacts the admissions desk to register the patient in the HIS. Once registration is complete, the patient's details appear on the large display in the central coordination area. This display allows both the ZOCO and the ED physician to monitor incoming patients and coordinate subsequent actions.

For patients referred by a GP or through the GP-OoH, the registration process follows a distinct procedure. When a GP contacts the ED by phone to refer a patient, the medical issue is discussed, and the ED physician determines whether the referral warrants admission to the ED. If the patient is accepted, the ED physician completes an admission form outlining necessary actions, such as laboratory tests or imaging studies (e.g., ultrasound). This form is then handed over to the ZOCO (See Appendix B for this registration form). The ZOCO subsequently informs the hospital's admissions desk, which uses this information to register the patient in the HIS. Once the registration is complete, the patient's details are displayed in the central coordination room on the large display. At this stage, the ED physician and nursing staff decide on the next steps, including the urgency of assessment and whether the patient requires immediate attention

For patients referred via the GP-OoH, the procedure is largely identical, with the primary distinction being the proximity of the GP-OoH to the ED. After being evaluated by the attending GP at the GP-OoH, patients deemed in need of ED services are referred directly. The admissions desk registers the patient in the HIS, after which their details become visible on the fishbowl display. Patients then proceed to the ED for further care.

During this phase, the focus is on documenting the medical and administrative details of the patient as accurately and comprehensively as possible. Thorough registration supports the coordination of care and helps reduce the risk of errors in the later stages of treatment.

Enrolling and allocating patient (A4)
The process of "enrolling and allocating patients" begins once the patient's registration is completed in the HIS. Upon completion of the registration, the patient's details are displayed on the centralized coordination screen.

Once a patient is registered, their details are listed in the ”enrolled” section of the screen. The display includes key information such as the patient’s name, time of arrival, and urgency level as assessed by the referring GP or ambulance personnel. When the patient’s information appears on the screen, the ZOCO assumes responsibility for coordinating the next steps. The ZOCO plays a pivotal role in allocating patients to treatment rooms and assembling the appropriate treatment team. This allocation process is guided by three primary factors:

- Urgency of Complaints: Patients with higher urgency levels are prioritized for room allocation.
- Availability of Treatment Rooms: The ZOCO continuously monitors which rooms are available or occupied.
- Staff Workload: Patient assignments are evenly distributed among the nursing team to prevent overburdening any individual staff member.

By carefully balancing these factors, the ZOCO assigns patients to appropriate treatment rooms and mobilizes the necessary treatment team. The initial care is typically provided by a nurse, who is responsible for conducting preliminary assessments and administering immediate care. At Deventer Hospital, patients are usually escorted directly to an available treatment room, significantly reducing wait times in the reception area and facilitating a quicker start to medical treatment.

As shown in Appendix B, patients are moved from the ”enrolled” list to a specific treatment room on the coordination screen. The screen also displays the urgency category of each patient, using a color-coded system to indicate priority levels. This color-coded system enables quick identification of patients requiring immediate attention. Additionally, the screen tracks which nurse and, subsequently, which physician has attended to the patient. This systematic approach ensures that the process is closely monitored, minimizing the risk of any patient being overlooked.

In rare cases, such as when no treatment rooms are temporarily available, patients remain under observation in the waiting area until a room becomes free. During this observation period, the nursing staff regularly monitors the patient’s vital signs to ensure their safety while awaiting transfer to a treatment room.

Getting additional information and conducting preliminary investigations(A5)
During this process, the nurse gathers additional information about the patient’s symptoms and conducts preliminary investigations. These may include collecting blood and urine samples for laboratory analysis, as well as measuring vital signs such as body temperature, blood pressure, and heart rate. In some cases, additional diagnostic procedures, such as radiological imaging, may be initiated. All results and procedures are noted in the patient’s medical record, making them easily available to medical professionals. Based on these observations and findings, the patient’s condition is reviewed to determine the urgency and timeliness of additional medical assessment by a physician.

In some situations, a patient may be discharged without seeing an ED physician if their condition is no longer critical or has been effectively handled by the nurse’s actions. This simplifies the care procedure while ensuring that appropriate treatment is given. The patient goes directly to A8. In addition, it is possible that the patient is examined directly by an ED physician and progresses from A4 to A6. This happens when a patient’s condition is severe enough that they need emergency surgical intervention. In these cases, the patient is treated promptly rather than following regular methods. Surgeons and ED physicians are ready to intervene as soon as the patient arrives, making initial nursing assessments unnecessary. These accelerated protocols are intended for essential crises to enable prompt treatment and the best possible patient outcomes.

Diagnose treat, care for the patient (A6)
Following triage and early assessments by the nurse, the patient is assessed by an ED physician or an ANIOS (Arts Niet in Opleiding, physician in training). The coordinating ED physician assigns a physician to the patient and updates the centralised monitoring system at the coordination centre. As a result, the system delivers real-time information about all present patients and their treatment status.

The assigned physician conducts an evaluation to provide a preliminary diagnosis and identify the best treatment approach. ED physicians are experts in a variety of medical areas, allowing them to meet a wide range of patient demands. If the ED physician needs additional information or is unsure about the

treatment plan, he or she will discuss it with specialists from suitable departments. This consultation can take place over the phone, but in some situations, the specialist may visit the ED after the call to assess the patient in person.

During this phase, the physician also decides whether medicine is necessary as part of the patient's treatment. Medication can be administered directly by the ED nurse for treatment or by the pharmacist following discharge with a doctor's prescription. Once all diagnostic results, such as laboratory testing and radiology investigations, are obtained, the physician, maybe in collaboration with experts, finalises the care plan. Depending on the severity of the condition, the patient will be discharged with or without referrals for follow-up care or admitted to the hospital for additional treatment.

For patients who do not require immediate admission or referral to a specialized department, discharge from the hospital is arranged. They receive instructions regarding their follow-up care, which may include scheduling an appointment with the relevant outpatient clinic for further diagnostic evaluation or treatment if necessary. The patient goes from A6 to A8 directly.

Referring patient to specialist(A7)

When a patient requires further medical care, they will be referred to a specialized department within the hospital. This referral process depends on the urgency of the situation. Non-urgent patients are sent home and scheduled for a follow-up consultation with the specialist. For critically ill patients, immediate transfer to the appropriate specialized department is arranged. In these cases, the patient is admitted to a hospital ward, with the admission process coordinated by the Admissions Department. Once a suitable bed is available on the ward, staff from the designated department retrieve the patient. The handover is conducted by an ED nurse.

Discharge of patient (A8)

When a patient has been treated in the ED and no further medical care is required, they are discharged and allowed to return home. Upon discharge, the patient is provided with any necessary aftercare instructions and, if applicable, a referral to a care home, a GP or a specialist for follow-up care.

In rare instances, a patient may pass away while in the ED. In such cases, decisions regarding subsequent procedures are made in consultation with the forensic physician. This can occur at any stage of the process. For the purposes of simplifying the model, it is assumed that if a patient passes away, they are also categorized as being discharged.

4.4. Data analyses

Data from Deventer Hospital was analysed to gain a better understanding of the process overall. The study begins with an evaluation of patient numbers, then moves on to an investigation of staffing allocation, and lastly, an examination of patient time spent in the ED. Appendix B also outlines where the patients are admitted.

4.4.1. Average number of patients in ED

First, the average number of patients visiting the ED per day of the week is presented. Figure 4.3 shows that the average number of ED visits per day in 2024 is approximately 51 patients.

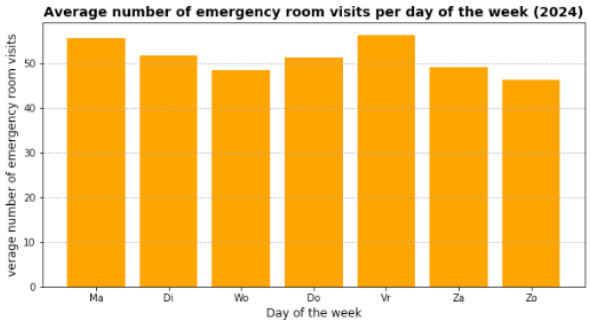

Figure 4.3: Bar plot average number of patients in Emergency Department 2024

The bar chart illustrates a relatively stable patient inflow during weekdays, with the highest numbers observed on Friday. Wednesday shows a slight decrease compared to other weekdays. There is a noticeable decline in ED visits during the weekend, particularly on Sundays. However, although the averages suggest stability, the actual situation in the ED can vary significantly from day to day due to external factors, sudden surges in demand can still occur and challenge capacity.

Based on analysis and visualisation by the hospital, patient arrivals at the ED are unevenly distributed across the day, with notable peaks during certain periods. Figure 4.4 illustrates the average number of ED arrivals per hour, categorized by day of the week.

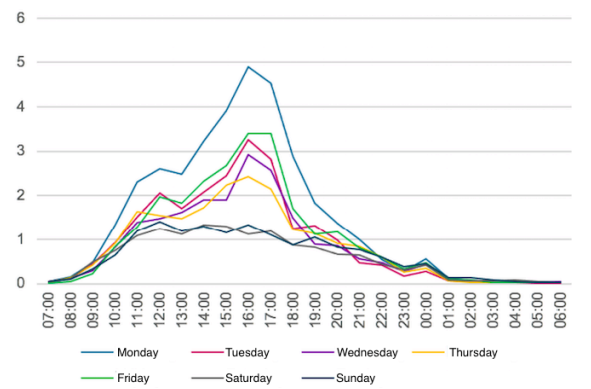

Figure 4.4: Average number of patients in Emergency Department during weekdays [86]

A significant peak in patient arrivals occurs between 14:00 and 17:00, with a gradual increase starting late in the morning. This trend may be influenced by general practitioner availability. During midday and early afternoon, many GPs take breaks or conduct home visits, limiting the number of available consultations. As a result, patients who might otherwise visit their GP may seek care at the ED instead.

Physicians schedule

Based on the patient patterns, staffing levels are adjusted to align with peak hours in the ED. Figure 4.5 below illustrates the staff scheduling patterns analysed by Door2Doc, showing a structured distribution of personnel over time, with the number of FTEs represented on the y-axis. Peaks in staffing correspond to expected increases in patient arrivals, suggesting that scheduling adjustments account for fluctuations in demand, as mentioned in the introduction.

Figure 4.5: Staff scheduling based on number of patients in ED[86]

Intermediate shifts are used to give additional coverage during peak hours, distributing physician availability more equally throughout the day. This staffing schedule reflects only the ED physicians, excluding physicians in training. As mentioned in the introduction, current shortages are being mitigated by deploying physicians in training to ensure the ED remains operational without severe understaffing. Typically, a 2:1 ratio of physicians in training per ED specialist is maintained, but due to the more acute shortages at Deventer Hospital, this ratio is currently exceeded to keep the department running.

4.4.2. Average time in Emergency Department

In addition to analyzing the number of patients in the ED, the average time patients spend in the process was also examined. These analyses are further detailed in Appendix B.

The average length of stay in the ED is approximately 151 minutes per patient, with most data points clustering around 175 minutes and occasional peaks above 275 minutes. In addition to the average length of stay, the time until a patient is seen by an ED physician has also been plotted. The data indicate that the average waiting time before being seen by a physician is approximately 50 minutes. The times have been incorporated into the IDEF0 process, as shown in Figure 4.6.

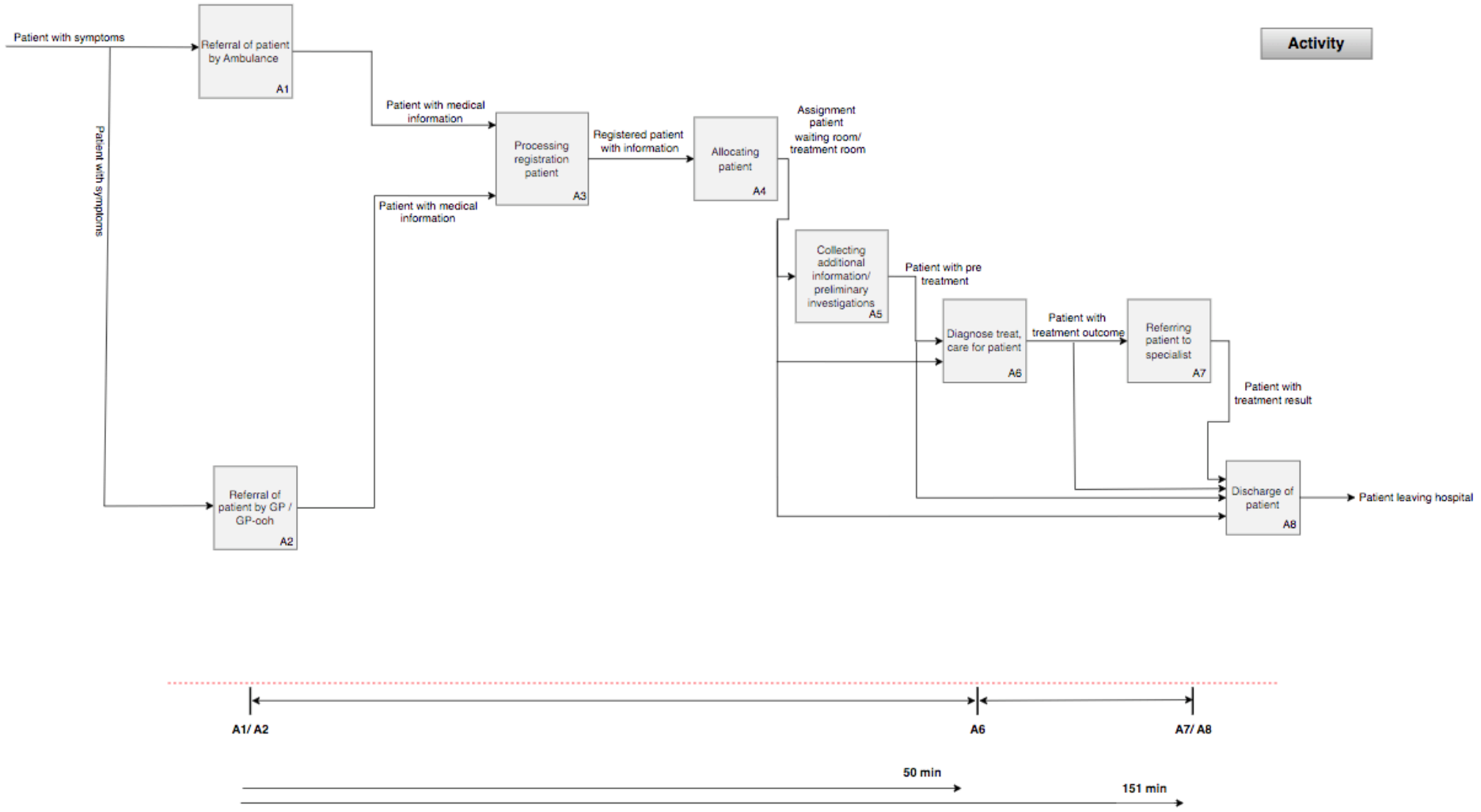

Figure 4.6: IDEF0 A-1 level process

Abbreviations: GP(Ooh) = General Practitioner (Out of Office Hours)

4.5. Physical system

After outlining the process flow in the ED, this section looks at the physical resources used for each activity in the IDEF0 model. Figure 4.7 illustrates the mechanisms required for each process step.

4.5.1. A1 physical mechanism

Digital communication tools, such as telephone systems and the ambulance information system, are used for consultations between ambulance personnel, the ZOCO, and general practitioners. Patient data is recorded in electronic patient records (EPRs) within HIS systems.

4.5.2. A2 physical mechanism

Digital communication tools are used to transmit patient information, such as vital signs and administered treatments, from general practitioners to the ED. Telephone systems allow direct communication between ED physicians and GPs. Patient data is recorded in electronic patient records within HIS.

4.5.3. A3 physical mechanism

Ambulance

Ambulance staff send a verbal report to the ZOCO by phone. Receptionists enter the patient's information into the HIS, making the patient visible on the HIS system's display in the operating room, which shows registered patients.

GP/GP-OoH

General practitioners and ED physicians communicate by telephone to discuss patient cases and determine the necessity of ED admission. ED physicians complete referral documentation outlining the required medical actions, which the ZOCO then processes. The registration desk enters patient data into the system, making the patient visible on the display in the operating room.

4.5.4. A4 physical mechanism

The HIS is used for patient registration, status display in the operation room and assignment of treatment rooms. Internal communication systems, such as telephones and digital messaging, are used by the ZOCO to coordinate with the registration desk and nursing staff for patient allocation. Electronic patient records document patient medical history, urgency status, and required treatments.

4.5.5. A5 physical mechanism

Electronic Medical Records (EMRs) are used to document and update findings, observations, and test results during nursing treatments, as well as to access the patient's medical history. Internal telephone communication tools are used for coordination between nurses, lab technicians, and radiology staff during the process.

4.5.6. A6 physical mechanism

EMRs allow physicians to access information collected in earlier steps of patient care, including triage results, vital signs, and medical history. Telephone communication systems are used for contacting specialists, allowing ED physicians to request advice on complex medical cases.

4.5.7. A7 physical mechanism

Communication between the ED, the registration desk and specialized departments takes place through internal communication systems, including direct phone lines and hospital messaging platforms. For non-urgent cases, an appointment scheduling system is used to arrange follow-up visits with specialists or outpatient clinics before the patient leaves the hospital.

4.5.8. A8 physical mechanism

The Electronic Medical Record system is used to document discharge details, including the patient's diagnosis, treatments provided, and follow-up instructions. Discharge summaries are recorded for access by the patient and relevant healthcare providers.

Additionally, the attending physician or nurse provides verbal explanations regarding the patient's con-

dition, treatment, and aftercare requirements. These instructions are also given in writing to support the patient in following their care plan.

4.6. Key findings

Mapping the technological system gave insight into the EDs process structure, which included patient referral, registration, room assignment, diagnostics, treatment, and referral or release. Structured communication methods, including telephone systems and electronic patient records, are used in the ED to help with coordination and medical decisions.

A review of patient flows reveals that the ED sees 51 patients per day on average, with a peak between 14:00 and 17:00, particularly on Mondays, Thursdays, and Fridays. The average wait time until the first physician interaction is 50 minutes, with an average length of stay of 152 minutes. Internal Medicine, Pulmonology, and Neurology account for the vast majority of admissions following an ED visit. Physician staffing is consistent with these trends, with the highest coverage between 12:00 and 20:00, which corresponds to peak patient volume. Additionally, it becomes evident that the capacity limits of the available physicians have already been reached, leading to an increased reliance on physicians in training to fill the gaps and maintain operational continuity.

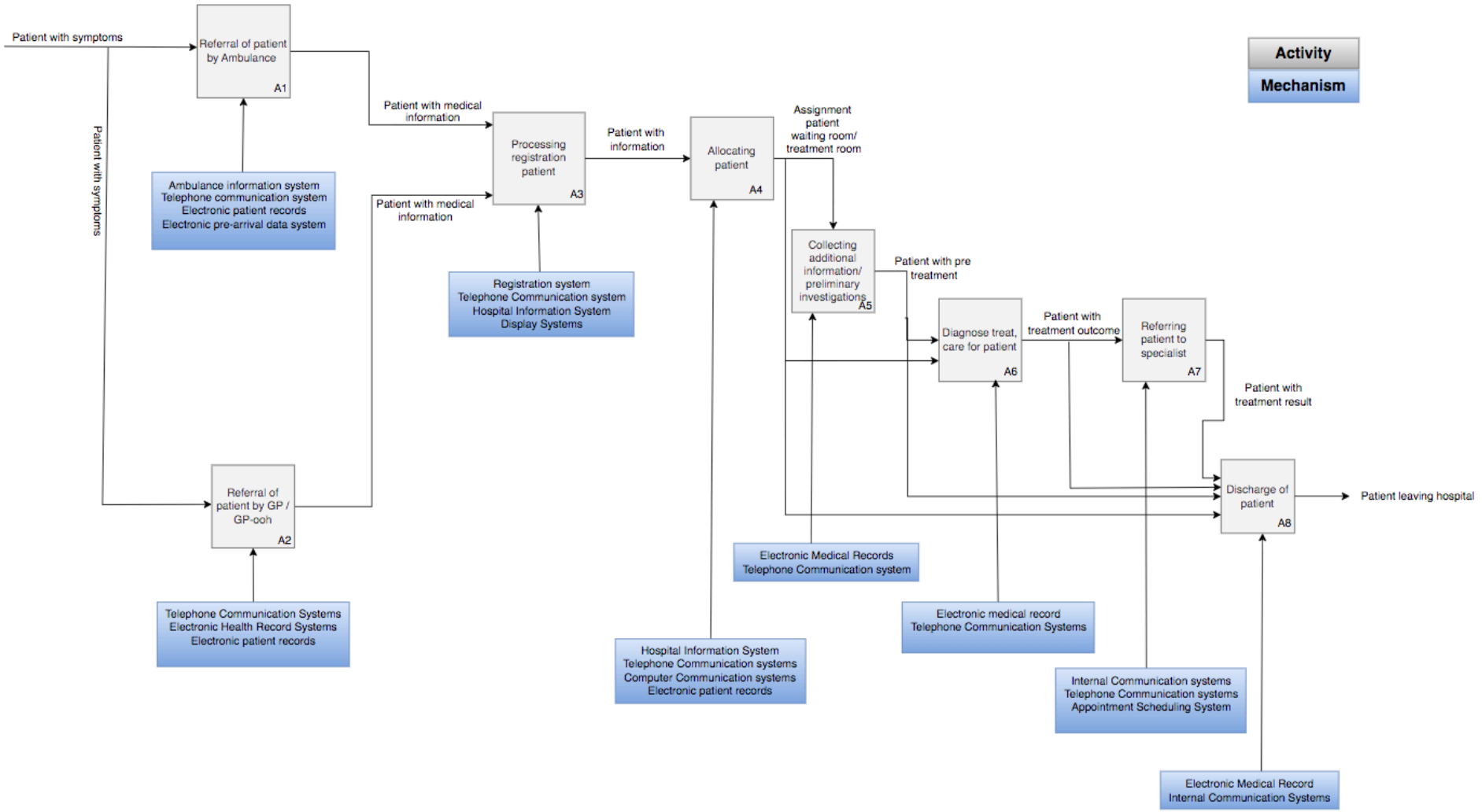

Figure 4.7: IDEF0 A-1 Level process & physical factors

Abbreviations: GP(Ooh) = General Practitioner (Out of Office Hours)

5

Social system

This chapter addresses the social dimension. First, the structural component is examined, followed by an analysis of the human component using a stakeholder analysis.

5.1. Structure

The structure is specified as consisting of the national framework, the hospital organization, and the associated laws and regulations that shape how the ED functions.

5.1.1. National organizational structure

This section outlines the national framework and the key organisations involved in acute care in the Netherlands, along with their respective responsibilities.

The Ministry of Health, Welfare, and Sport (VWS)

The Ministry of Health, Welfare, and Sport (VWS) is responsible for formulating national healthcare policies in the Netherlands, including the frameworks governing acute care. The primary role of the ministry is to ensure the accessibility, quality, and affordability of healthcare services. In this capacity, VWS develops a comprehensive legal framework to guarantee the quality and safety of healthcare delivery [87].

In addition to its involvement in developing legal frameworks, the ministry has made significant contributions to the 2022 Integral Care Agreement (IZA). Unlike structural legislation, the IZA is a project-based policy agreement created in partnership with healthcare providers, insurers, and patient organisations. It establishes strategic goals for sustainable, accessible, and high-quality healthcare by encouraging efficient collaboration among care chain partners, with a focus on the acute care chain [88].

Policy and supervision

Within the policy framework, the Ministry of VWS oversees various supervisory and executive bodies to ensure compliance with laws and regulations

The Health and Youth Care Inspectorate (IGJ) monitors the quality, safety, and accessibility of healthcare in the Netherlands [89]. The IGJ assesses whether healthcare institutions, including emergency departments, adhere to statutory standards and professional guidelines. In cases of non-compliance, the IGJ can impose corrective measures, such as issuing warnings or, in severe cases, closing a department. Additionally, the IGJ emphasizes fostering a culture of learning within healthcare organizations to promote continuous improvement [89].

The Dutch Healthcare Authority (NZa) is in charge of regulating the Netherlands' healthcare industry, with a focus on cost and accessibility. The NZa collaborates with VWS to establish price structures and monitor service availability for acute care [90].

The Health Institute Netherland (ZiNL) plays a role in safeguarding the quality of care and developing quality frameworks. Specifically for acute care, ZiNL has established the Acute Care Quality Framework, which outlines standards for the organization and delivery of emergency medical services [91]. This framework provides healthcare providers with guidelines to meet accessibility and quality requirements within the acute care chain. ZiNL collaborates closely with healthcare providers and regional networks to support the implementation of these standards.

The National Institute for Public Health and the Environment (RIVM) is responsible for monitoring public health and managing crises within public healthcare. In the context of acute care, the RIVM plays a role in coordinating responses to large-scale health incidents, such as pandemics and disasters [92].

Organization and cooperation

In addition to regulatory agencies, the Ministry of VWS facilitates collaboration among healthcare providers and institutions.

The National Acute Care Network (Landelijk Netwerk Acute Zorg, LNAZ) plays a central role in promoting nationwide coordination of acute care. The LNAZ develops guidelines and protocols aimed at enhancing the uniformity and quality of acute care across the Netherlands. During crises, the LNAZ coordinates the distribution of patients and resources between regions to maintain continuity of care [93].

The Netherlands is divided into several acute care regions where hospitals, GP(-OoHs), ambulance services, and other healthcare providers collaborate within the framework of Regional Acute Care Consultations (Regionale Overleggen Acute Zorg, ROAZ) [94]. These regional partnerships aim to ensure the coordinated and timely delivery of acute care. The ROAZ plays a pivotal role in aligning capacity and resources among different care providers within a region, supported by the LNAZ.

Deventer is part of the Acute Care Network Zwolle, which operates in the Salland region and surrounding areas. This network facilitates collaboration between healthcare providers and hospitals in the region to ensure the efficient and effective delivery of acute care, particularly during peak demand or crises [94]. The Acute Care Network Zwolle works closely with the ROAZ to establish regional protocols, allocate capacity, and improve the overall quality of care.

Figure 5.1: Region acute care network Zwolle

5.1.2. Deventer organisation structure

Besides the national organisation, there is also the organisation within the Deventer Hospital. The Deventer Hospital is organized and regulated through a combination of internal governance structures and partnerships at both national and regional levels, enabling the organization to fulfil its mission of providing high-quality acute care to the residents of Salland and its surroundings. The hospital is a member of the Dutch Association of Collaborating Top Clinical Hospitals (STZ), a network of top clinical hospitals focused on delivering specialized care, fostering innovation, and conducting scientific research [16]. Through knowledge sharing, the promotion of research and education, and policy advocacy, the STZ supports its affiliated hospitals in their pursuit of quality and efficiency [16].

The Deventer Hospital has a clear vision for its ED, aiming to provide high-quality and accessible acute

care for residents of Salland and the surrounding region. This objective aligns with government measures designed to restructure acute care, focusing on enhancing its availability and affordability. To meet the stringent requirements for a fully equipped ED, the hospital actively fosters collaboration between acute care units, such as the ED, Intensive Care Unit (ICU) and the Cardio Care Unit (CCU). A key strategy involves cross-training nurses to enable flexible deployment across various departments. This approach enhances efficiency within the hospital, ensuring optimal utilization of available resources and staff while maintaining high-quality care standards. Additionally, workflow processes have been optimized to deliver faster and more efficient care, playing a pivotal role in the overall capacity and responsiveness of acute care services [18].

The hospital's governance is led by a two-member Executive Board, which holds ultimate responsibility for the organisation and ensuring the quality of care, with a particular focus on critical departments such as the ED [18]. The Executive Board is accountable to the Supervisory Board, which oversees operations and provides strategic advice. The roles, responsibilities, and authorities of these governing bodies are outlined in regulations that comply with the Ministry of VWS guidelines [95]. The Supervisory Board comprises five members with diverse expertise in areas such as healthcare, health law, finance, and quality and safety management. Measures are in place to ensure the independence of these members during their appointment and throughout their tenure. The Dutch Governance and Supervision Act provides additional safeguards by limiting the number of supervisory roles an individual may hold, further supporting their independence. The Supervisory Board conducts an annual self-evaluation to assess its effectiveness and implement necessary improvements. This process ensures continuous monitoring and enhancement of its oversight functions [18].

Within the Supervisory Board, three committees are actively engaged: the Audit Committee, the Remuneration Committee, and the Quality and Safety Committee. The Audit Committee oversees the procedures and guidelines for the preparation of financial reporting. This responsibility is carried out in collaboration with the hospital's financial management and an external auditor, while the ultimate accountability for financial reporting lies with the Supervisory Board itself. The Remuneration Committee monitors the compensation structure for the Executive Board, which is determined by the Dutch Senior Officials in the Public and Semi-Public Sector (Standards for Remuneration) Act (WNT). The Quality and Safety Committee evaluates the hospital's quality policy and provides advisory input to the Executive Board regarding quality assurance and safety in healthcare delivery. This committee also acts as a sounding board, offering guidance on all matters relevant to ensuring safe and high-quality care [18].

The Deventer Hospital collaborates with several key advisory bodies that provide guidance and feedback to the hospital's leadership. The Integrated Board of Medical Staff (GBMS) represents both internally and externally appointed medical staff and serves as a strategic discussion partner for the Executive Board. Strategic themes of significance are discussed bi-weekly during meetings with the GBMS. The Works Council (OR) represents the hospital's employees and, by the Dutch Works Councils Act (WOR), holds formal monthly meetings with the Executive Board. Additionally, informal contact moments between OR representatives and the Executive Board foster an open dialogue. The Nursing Advisory Council (VAR) advocates for the interests of the nursing profession within the hospital. The VAR discusses policy issues relevant to nursing staff and provides advisory input to the Executive Board. The hospital prioritises strengthening nursing leadership, including the appointment of a Chief Nursing Officer (CNO) and further professionalisation of the VAR board. The Patient Council, established under the Dutch Client Participation in Care Institutions Act, acts as a key advisory partner to the Executive Board. The Patient Council addresses topics that are both legally mandated and initiated independently, offering recommendations on various policy issues related to patient care and safety [18].

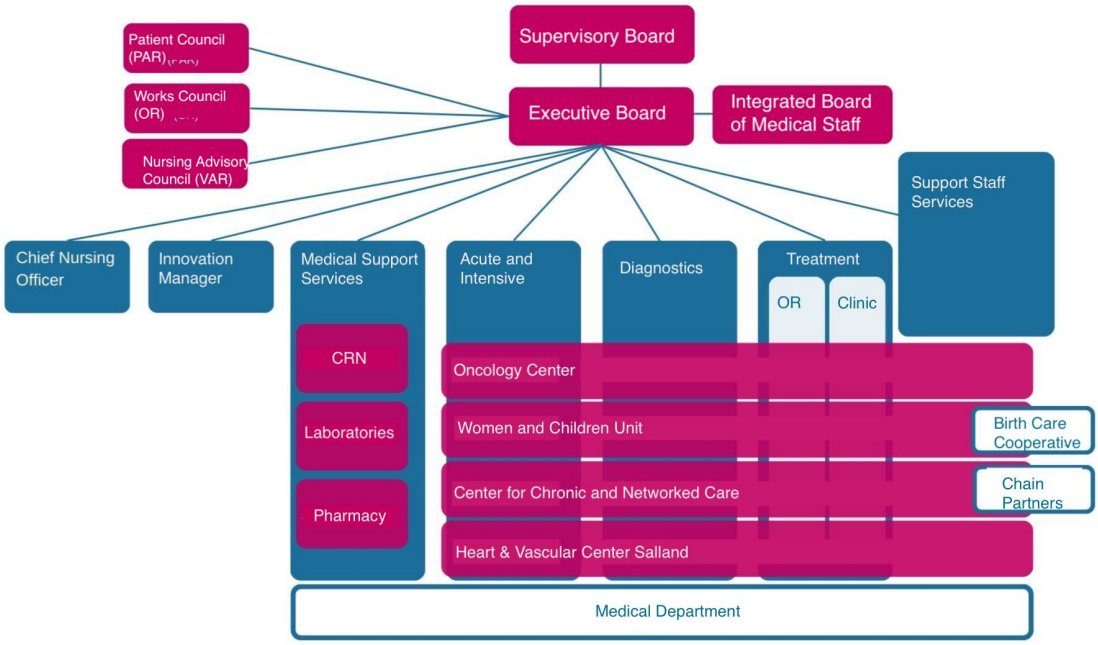

Figure 5.2: Organization Deventer Hospital [18]

Abbreviations: OR = Operation Room

Deventer Hospital places significant emphasis on transparent and effective governance. By the established Information Protocol, the Executive Board ensures that the Supervisory Board is provided with all necessary information on time to enable the effective execution of its supervisory role. In 2023, the Supervisory Board held five regular meetings with the Executive Board, focusing on various thematic and strategic issues. The hospital actively aligns itself with the formulation of new strategies in line with the priorities outlined in the Integrated Care Agreement [96].

Deventer Hospital's organisational structure outlines decision-making, resource management, and collaboration across the acute care chain, which includes the ED, ICU, and CCU. Workforce regulations, such as cross-training for nurses. Advisory boards help to formulate and oversee policies, and involvement in national agreements like the IZA has an impact on acute care strategic planning [18].

5.1.3. Laws and regulations

Within this structure, various laws and regulations have been established. The laws apply at the national level, while the regulations may be set at both the national level and specifically within Deventer Hospital. This section provides an overview of the relevant policies and regulations, first summarizing the national laws and regulations applicable to hospital processes in Table 5.1.

Table 5.1: National laws

Law	Content and application

AVG (General Data Protection Regulation) [97]	The AVG is a European regulation that governs how healthcare providers collect and process personal data. The processing of such data must comply with specific conditions outlined in the regulation. The AVG prohibits the processing of special categories of personal data, such as medical information, unless certain exceptions and a legal basis for processing are applicable. The regulation establishes requirements for obtaining consent, ensuring transparency, and implementing robust data security measures.
Wabvpz (Act on Additional Provisions for the Processing of Personal Data in Healthcare) [97]	Regulates the use of the Citizen Service Number (BSN) and the digital exchange of medical data. Healthcare providers are permitted to use the BSN to prevent identity errors and for billing purposes with health insurers. The legislation establishes specific patient rights, including: • Free digital access to and copies of medical records. • Free access to logging records that document who has accessed the medical file. • The right to add information to the medical record.
BIG (Individual Healthcare Professions Act) [97]	The Individual Healthcare Professions Act establishes regulations for the professional practice of healthcare providers to protect patients from unskilled or negligent practices. It governs the following key aspects: • Education requirements and qualifications for medical professions. • The medical duty of confidentiality. • Reserved procedures that may only be performed by authorized healthcare professionals. Additionally, the act includes disciplinary measures for healthcare providers through professional tuchtrecht (disciplinary law), with potential sanctions such as warnings, fines, or suspensions.
Begz (Decree on Electronic Data Processing by Healthcare Providers) [97]	A General Administrative Order (AMvB) detailing regulations on data processing by healthcare providers. This directive mandates the following: • Systems must comply with NEN 7510 standards (information security), NEN 7512 standards (secure communication), and NEN 7513 standards (logbook registrations). • Healthcare providers are required to maintain a register of data processing activities. • Compliance with applicable data retention periods is mandatory. This decision serves as a detailed elaboration of the Additional Provisions for the Processing of Personal Data in Healthcare Act (Wabvpz).
WGBO (Medical Treatment Agreement Act), [98]	The WGBO governs the rights and obligations of the patient. This law states that patients have a right to information and must give consent to treatment.

Wegiz (Electronic Data Exchange in Healthcare Act), [97]	Regulates the digital and secure exchange of health data between healthcare providers and patients. It establishes standards for data security (aligned with NEN standards) and ensures the standardization of data exchange processes. The law provides a framework for the minister to safeguard patients' rights and aligns with existing privacy legislation, including the WGBO and Wabvpz.
Zvw (Health Insurance Act) [99]	Access to medical care is regulated through the Zvw. This law requires everyone in the Netherlands to have basic insurance with a health insurer.
Wlz (Long-Term Care Act) [100]	Is a Dutch law that provides for the financing and organization of long-term, intensive care for people who need permanent supervision or 24-hour care in close proximity. The Wlz is intended for frail elderly people, people with physical or mental disabilities and persons with mental illnesses who cannot function independently without continuous support.

Furthermore, Table 5.2 presents the regulations relevant to the ED process, distinguishing between national regulations and those established within Deventer Hospital. Appendix C provides a more detailed explanation of these regulations.

Table 5.2: Regulations

Regulation	Agreement	Content and application
Physician workload [101]	National	This guideline outlines duty roster guidelines for the acute care sector, with particular emphasis on physicians in training., with a focus on rotation, maximum working hours, rest periods, predictability, and participation to ensure workload and patient safety.
Triage [102, 103]	National	This regulation describes responsibilities in emergency care triage at the GP-Ooh, ambulance care coordination by the Ambulance Dispatch Centre, and physical triage at the ED, with qualified staff acting in accordance with established guidelines.
Accessibility and Availability Standards [102]	National	This regulation ensures continuous accessibility and availability of EDs. It also encourages collaboration and communication with other healthcare providers, such as GPs and ambulance services.

Duration test results [104]	Deventer Hospital	This regulation outlines the procedures and turnaround times for radiological examinations for ED patients, including X-rays, ultrasounds, and CT scans, with specific time limits for both office and after-hours. The emergency physician or nurse submits requests and coordinates with the specialist, with maximum turnaround times ranging from 30 to 70 minutes, depending on the type of examination and staff availability.
Head of treatment [105, 106, 98, 97]	National/ Deventer Hospital	The KNMG guideline Division of Responsibility in Collaborative Healthcare states that each healthcare professional is responsible for their part of the treatment. In cases of simple, single-provider care, responsibility lies with the individual practitioner. However, when care becomes complex or multiple providers are involved, a coordinating practitioner (regiebehandelaar) must be appointed. This role does not necessarily have to be fulfilled by one of the treating professionals; another qualified healthcare provider registered under the BIG Act may also assume this responsibility. The coordinating practitioner ensures the coherence and coordination of care, facilitates information exchange, and designates a clear point of contact for the patient. Deventer Hospital has formalized this in a local protocol: Upon arrival at the ED, the emergency physician is responsible for diagnosis, treatment, and referral. If the patient is admitted, the coordinating role may be transferred to another healthcare provider.
Communication with specialist [105]	Deventer Hospital	The specialists promise each other that if the ED physician requires the assistance of a specialist, he will respond within 20 minutes. Unless it is an emergency, the quickest response is necessary.

5.1.4. Regulations/laws applicable throughout the entire process

Several laws and regulations are applicable throughout the ED process, from A1 to A8. **The AVG** regulates the handling of patient data at all stages, from registration to discharge, ensuring privacy, security, and controlled access to sensitive medical information. It mandates that patient data is processed lawfully and transparently while protecting it from unauthorized access [97].

Similarly, **the Begz** oversees the storage and exchange of electronic patient records, ensuring compliance with strict security standards and guaranteeing accessibility to authorized personnel while maintaining confidentiality. Throughout the ED process, patient records are continuously updated and accessed, making this law applicable at every stage [97].

Additionally, **the BIG Act** establishes professional standards and responsibilities for healthcare providers, ensuring that only qualified and authorized professionals perform medical procedures. This law governs competency requirements, medical confidentiality, and reserved procedures, safeguarding the quality and accountability of medical care. As healthcare providers are involved at every stage of the

ED process, the BIG Act ensures that medical tasks are carried out safely and in accordance with professional guidelines [97].

Furthermore, **physician workload regulations** affect the availability of physicians throughout the entire process. These regulations set limits on working hours, rest periods, and shift rotations to prevent excessive workload and fatigue, ensuring that physicians remain effective and available to provide high-quality emergency care [101].

Last, ED physicians must be available 24/7, making the **Accessibility and Availability Agreement** applicable throughout the entire process. Physicians must be accessible at all times for consultations with GPs and GP-OoH services, providing guidance on patient referrals and ensuring communication between primary and emergency care [102].

In addition, there are laws and regulations that apply to specific process steps. These are outlined below for each step.

A1 Constraints

The **Wabvpz** governs the standardized exchange of patient information between healthcare providers. During ambulance transport, this regulation ensures that essential patient details are pre-registered at the ED reception desk, facilitating accurate integration into the HIS. This process allows the ED staff to receive updated patient information and prepare accordingly [97].

The **Zvw** determines that patients arriving via ambulance receive insured medical care under the mandatory basic health insurance. This law ensures that emergency treatment is covered according to the regulations governing healthcare access [99].

The **Head of Treatment** regulation establishes the transition of responsibility for patient care. While the patient is under the responsibility of the ambulance personnel during transport, this responsibility shifts to the ED physicians upon arrival. This regulation outlines the responsibility of the ED physicians [105].

The **triage** guidelines for ambulance personnel specify their role in the intake process. They are in charge of assessing the patient, determining the appropriate level of care, and coordinating the transfer to the ED. This includes determining the urgency of the patient's condition and ensuring proper allocation within the hospital. Upon a patient's arrival, an ED staff member initiates the triage process within five minutes, followed by the nurse assessing and registering the urgency classification within ten minutes [102].

The **Wegiz** ensures that essential patient information from ambulances is electronically shared with the ED.

A2 Constraints

The **Accessibility and Availability** Standards are also relevant at this stage as they include provisions regarding the time (45 minutes) within which patients must reach the ED [102].

The **Head of Treatment regulation** establishes the transfer of responsibility when a patient is referred by a GP or GP-OoH, making the emergency physician the primary care provider upon arrival [105].

The **Zvw** ensures that patients referred by a GP or GP-OoH receive insured medical care under the basic health insurance system, covering their treatment upon arrival at the ED [99].

The **Wabvpz** facilitates the exchange of medical data between primary care providers and the ED. GPs and GP-OoH services share critical patient information, including urgency assessments and preliminary diagnoses, ensuring that relevant data is securely transmitted and integrated into the hospital system [97].

The **triage** guidelines for GP and GP-OoH define their role in the intake process, requiring a minimum qualification level for conducting triage, with the triage assessment being communicated to the ED physician. In the same manner, the triage process is initiated by an ED staff member within five minutes, and the nurse evaluates and records the urgency classification within ten minutes [102].

The **Wegiz** ensures that essential patient information from GP/ GP-Ooh is electronically shared with the ED.

A3 Constraints
Aside from the laws and regulations that apply throughout the process, there are no additional laws or regulations that apply specifically to this process step.

A4 Constraints
Aside from the laws and regulations that apply throughout the process, there are no additional laws or regulations that apply specifically to this process step.

A5 Constraints
The **triage** process in the ED must meet established requirements, ensuring reliability, validity, and applicability within the Dutch healthcare system. To maintain quality, mandatory training and certification are required for triage personnel [102]. If a patient's condition changes or waiting times exceed set thresholds, re-triage may be conducted based on the triage system or local agreements. These standards apply 24/7 to ensure consistent and efficient patient assessment across all operational EDs [102].

Before treatment begins, the **WGBO** requires that nurses inform patients about their health status and available treatment options. Patients are expected to provide accurate information about their condition and retain the right to refuse or discontinue treatment. Medical staff must ensure that informed consent is obtained and that patients fully understand the proposed interventions before proceeding [98].

At this stage, diagnostic tests may already be requested and performed by nursing staff. Regulations define the **duration test results** allowed for obtaining test results, ensuring timely access to diagnostic information needed for clinical decision-making [104].

A6 Constraints
In order to help patients make educated decisions about their care, ED physicians must also tell patients about their health status and the available treatment options, as stated in **WGBO**. In addition to having the freedom to decline or stop treatment, patients are expected to disclose accurate information about their conditions. Before acting, physicians must get patients' informed consent and make sure they comprehend the suggested interventions [98].

ED physicians can order diagnostic tests in addition to the tests requested in the previous step of the process. The rules that specify the maximum **duration test results** also apply here [104].

A7 Constraints
The **Wabvpz** regulates the exchange of patient data between specialists and ED physicians, ensuring that all data transfers comply with legal standards for secure and confidential handling. This regulation emphasizes data integrity and security throughout the communication and information-sharing process, supporting lawful and efficient collaboration among healthcare providers [97].

When a patient is referred to a specialist for more targeted care, responsibility for the patient is transferred to the respective specialist, who then becomes the **head of treatment**. If multiple specialists are involved in the patient's care, one specialist is designated as the primary responsible physician. This decision is made in consultation among the specialists [105].

If a patient requires long-term care, this is recorded under the **Zlw**, allowing for admission into an extended care facility or continued specialized treatment [100].

The **Wegiz** ensures that essential patient information from ED is electronically shared with the specialist.

A8 Constraints
Aside from the laws and regulations that apply throughout the process, there are no additional laws or regulations that apply specifically to this process step.

The table below provides a concise overview of the laws and regulations relevant to the process. It categorizes the laws and regulations based on the responsible monitoring authorities. Additionally, the table specifies the corresponding IDEF0 levels where each law applies within the ED.

Table 5.3: Regulations and laws linked to process step

Regulation/Law	Monitoring & Control	IDEF0 Level
AVG	Ministry of VWS	A1 up to 8
Wabvpz	Ministry of VWS	A1, A2, A7
Wet BIG	Ministry of VWS	A1 up to 8
Begz	Ministry of VWS	A1 up to 8
Wegiz	Ministry of VWS	A1, A2, A7
WGBO	Ministry of VWS	A5, A6
Zvw	NZA	A1, A2
Wlz	NZA	A7
Triage Procedure	NZA	A1, A2, A5
Accessibility and Availability Standards	Ministry of VWS	A1 up to 8
Physician schedule	NVSHA	A1 t/m 8
Head of treatment	Deventer Hospital	A1,A2, A7
Duration Test results	Deventer Hospital	A5, A6
Communication with specialist	Deventer Hospital	A7

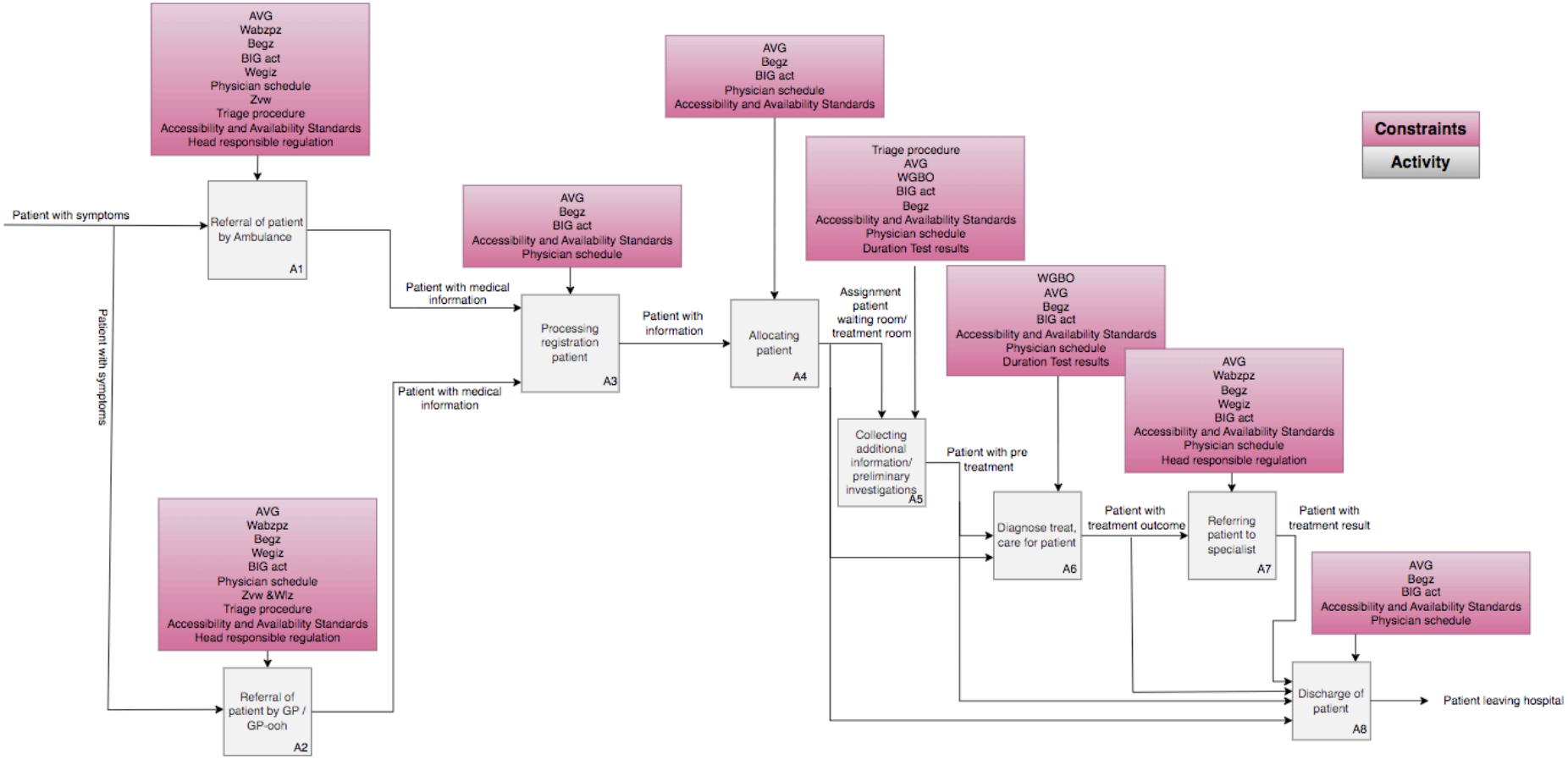

Figure 5.3: IDEF0 A-1 level with constraints

Abbreviations: AVG = General Data Protection Regulation, Wabzpz= Act on Additional Provi- sions for the Processing of Personal Data in Healthcare, Begz = Decree on Electronic Data Pro- cessing by Healthcare Providers, Wegiz = Electronic Data Exchange in Healthcare Act, Zvw = Health Insurance Act, ED = Emergency Department, GP = General Practitioner, Wlz = Long-Term Care Act

5.2. People

Figure 5.4, provides a comprehensive view of the socio-technical system by identifying all actors involved in the delivery of acute care. It distinguishes between institutional actors such as regulatory bodies and administrative entities, and individuals directly involved in the execution of care processes. The placement of institutional actors across the model illustrates which organizations influence specific stages of the ED process, offering insight into the underlying structure of responsibilities and governance.

In addition to these organizational roles, the model outlines the involvement of professionals who are actively engaged in the different phases of the patient pathway. Table 5.4 summarizes their core responsibilities, while Appendix D provides a detailed overview of how these roles are distributed across the functional process steps.

Table 5.4: Actors and their roles within the Emergency Department processes

Actor	Responsibilities
Ambulance Personnel	Stabilizes the patient, collects initial medical data, and hands over information to the ED.
General Practitioner/ General Practitioner out of office hours	Assesses patient complaints, provides referral details, and communicates with ED or specialists if needed.
Receptionist	Registers patient data, inputs information into hospital systems, and communicates with the ED Coordinator (ZOCO).
Emergency Department Nurse Coordinator (ZOCO)	Assigns rooms and nurses, assesses urgency, and oversees capacity management. Coordinates bed allocation and ensures smooth logistical planning for patient admission.
Emergency Department Nurse	Performs triage, collects patient data, initiates diagnostics, and assists with patient transfers and discharges.
Emergency Department Physician	Conducts physical examinations, prescribes treatment, consults specialists, and decides on patient discharge, referral, or admission.
Emergency Department Physicians in Training (Falls under ED doctor in stakeholder analysis)	In the Dutch context, this group includes both ANIOS (physicians not yet in specialist training) and AIOS (residents in training to become specialists). Under the supervision of senior ED physicians, they conduct physical examinations, prescribe treatments, consult with specialists, and make decisions regarding patient discharge, referral, or admission.
Emergency Department Physician Coordinator (Falls under ED doctor in stakeholder analysis)	Coordinates medical assessments and treatment planning, supervises junior ED staff, and oversees complex case management.
Medical Specialists	Offer consultations and contribute specialist expertise in complex cases. Assume responsibility when patients are admitted to their department.
Nursing Ward Staff	Transfers patients from the ED, performs initial assessments, and continues treatment on the ward.

Once the actors have been added, the IDEF0 model is complete and provides a comprehensive representation of the socio-technical system of the ED at Deventer Hospital, as illustrated in the figure 5.4 below.

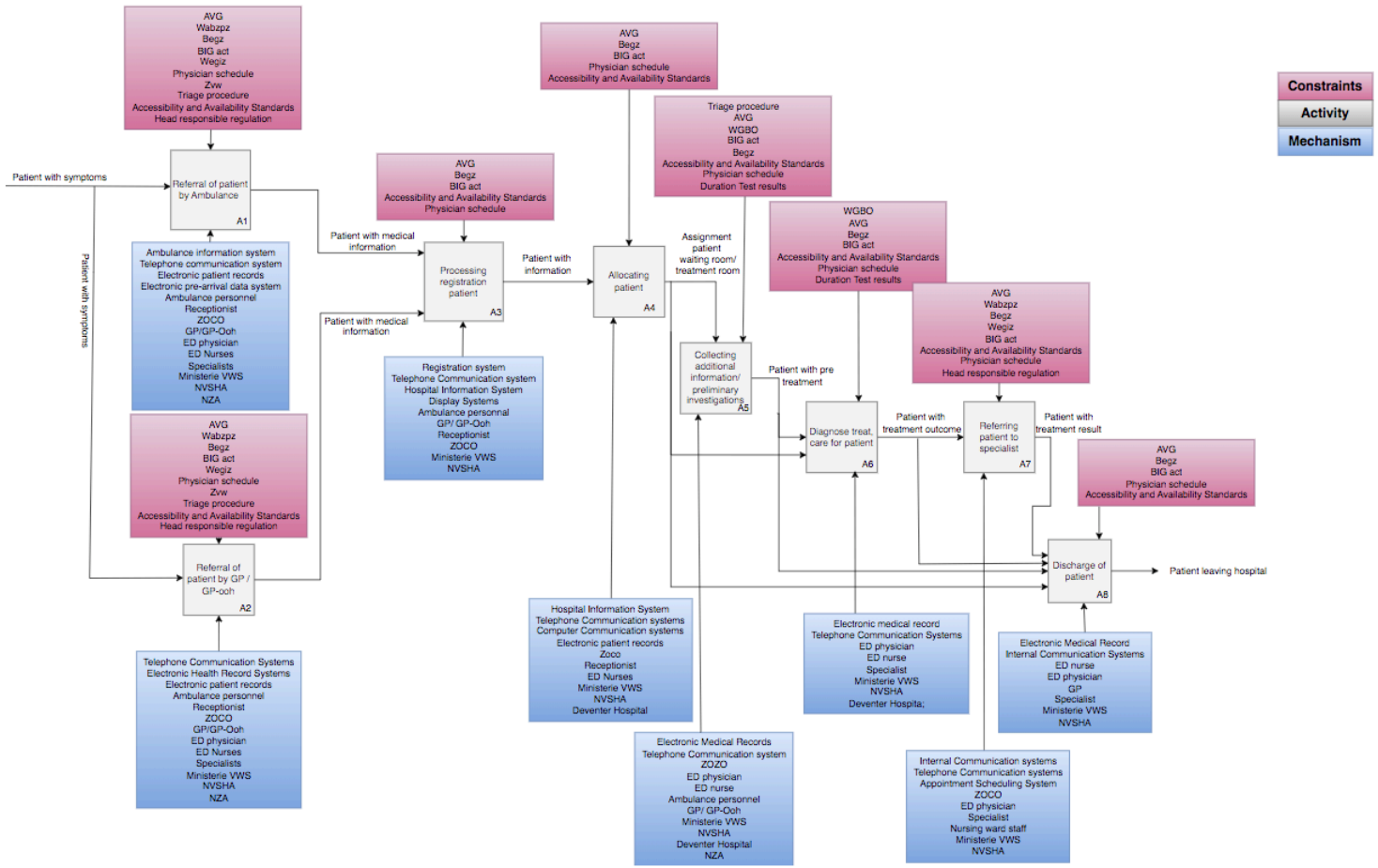

Figure 5.4: IDEF0 A-1 level complete

Abbreviations: AVG = General Data Protection Regulation, Wabzpz= Act on Additional Provisions for the Processing of Personal Data in Healthcare, Begz = Decree on Electronic Data Processing by Healthcare Providers, Wegiz = Electronic Data Exchange in Healthcare Act, Zvw = Health Insurance Act, ED = Emergency Department, GP = General Practitioner, Wlz = Long-Term Care Act, NVSHA = Dutch Society of Emergency Physicians, VWS = Ministry of Health, Welfare and Sport, NZa = Dutch Healthcare Authority.

5.3. Stakeholder analyses

The stakeholder analysis provides insight into how the actors involved within the ED process relate to one another. Their positions in the system are considered from three perspectives: patterns of communication, the distribution of relevant knowledge, and their role in capacity-related decision-making.

5.3.1. Communication flow within the process

The communication links between the involved actors are briefly described below. A detailed explanation is provided in Appendix C.

Ambulance staff and GPs (or GP-OoH) consult to determine the need for ED referral. In complex cases, a specialist or ED physician may be contacted. Upon referral, essential patient information is shared with the ED to support coordination. Registration and nursing staff are informed to ensure readiness upon arrival.

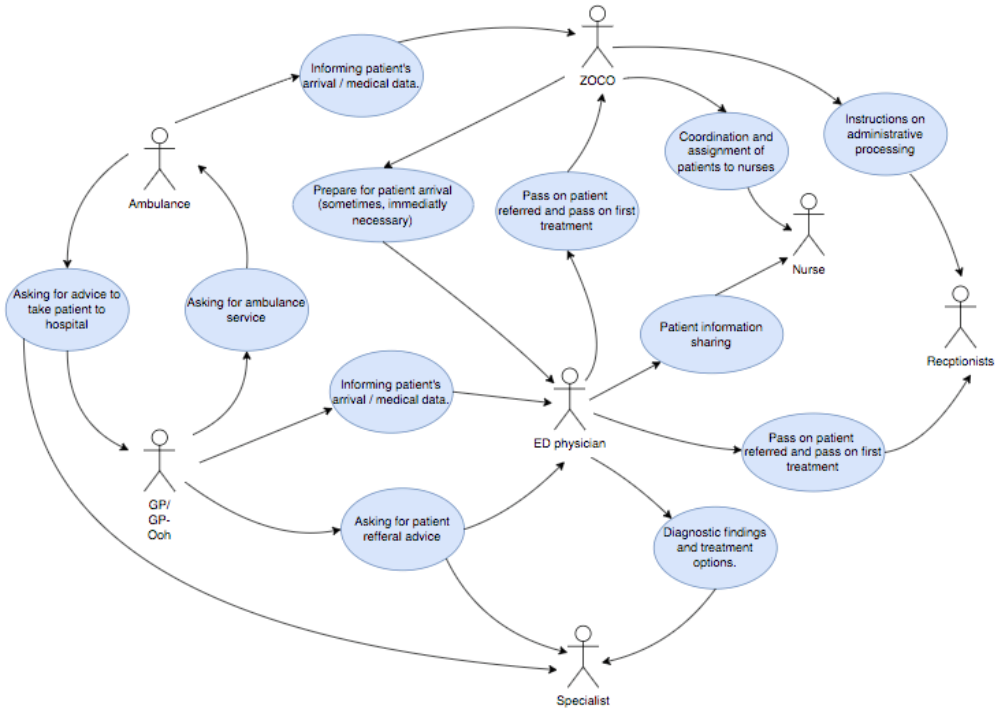

Figure 5.5: Communication between actors

Centrality

The communication within the ED can be analyzed using three key metrics: degree centrality, closeness centrality, and betweenness centrality. These metrics provide insights into the role and influence of each actor in the network and help to understand how information and decision-making flow through the system.

Degree centrality measures the number of direct connections an actor has with others in the network. In the current ED communication network, the ED physician exhibits the highest degree of centrality with five direct connections. This role involves direct communication with the ZOCO (care coordinator), the GP/GP-OoH (General Practitioner/Out-of-Hours Service), specialists, nurses, and receptionists. This position allows the ED physician to exchange information directly with multiple actors without intermediaries.

The ZOCO has a degree centrality of four, with direct connections to ambulance personnel, nurses, receptionists, and the ED physician. Although the ZOCO has fewer direct connections, it plays a coordinating role within the network. In contrast, the GP/GP-OoH and specialists have a lower degree

of centrality, indicating that their communication with other actors often occurs through intermediaries such as the ZOCO or the ED physician.

Closeness centrality measures how quickly an actor can access or disseminate information within the network. In the ED communication network, the ED physician has the highest closeness centrality, as they are directly connected to both operational actors (ZOCO and receptionists) and medical actors (such as specialists and GP/GP-OoH). This position allows the ED physician to interact with multiple actors without relying on intermediaries.

Betweenness centrality indicates how often an actor is positioned on the shortest communication paths between other actors in the network. The ED physician has the highest betweenness centrality due to direct connections with both the ZOCO and specialists. This position allows the ED physician to facilitate communication between operational and medical actors. Additionally, the ED physician's direct and indirect connections contribute to their role in the network.

Based on degree centrality and closeness centrality, the ED physician is the most central actor in the network, with multiple direct connections and the ability to quickly access information. The ZOCO functions as an intermediary, ensuring coordination between operational and medical actors. The ED physician primarily handles direct interactions and medical decisions, while the ZOCO is responsible for overall coordination and patient allocation within the system.

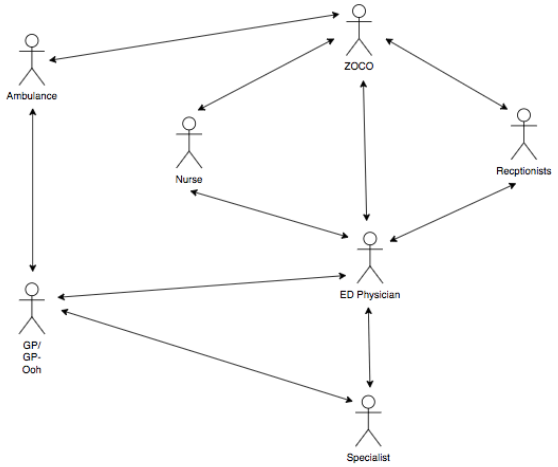

Figure 5.6: Communication links

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours)

5.3.2. Knowledge

Medical knowledge consists of the expertise required to assess, diagnose, and treat patients. This knowledge is primarily held by medical professionals directly involved in patient care. Process knowledge pertains to the operational understanding necessary for managing patient flow, administrative systems, and logistical processes within the ED, ensuring that the department functions efficiently.

Distinguishing between these types of knowledge provides insight into the expertise each actor contributes to capacity management within the ED. For this analysis, actors involved in the organizational aspects of the process have been excluded, as they fall under process knowledge and do not require further categorisation. Figure 5.7 below categorizes the actors involved in the process based on the type of knowledge they contribute.

Knowledge		
Kind	**Who**	**About**
Medical knowledge	**GP / GP-Ooh**	The GP or GP-Ooh services have a crucial role in assessing patients' medical complaints and making triage decisions.
	Ambulance	Have expertise in acute care, stabilization procedures, and assessing the urgency of a patient's condition during transport.
	ED nurse	Emergency room nurses have extensive knowledge of acute care and work in a multidisciplinary manner with physicians and specialists.
	ED Doctor	The emergency physician specializes in emergency medicine and is responsible for making rapid and accurate diagnoses. They decide on treatment options and possible referrals to other departments or specialists.
	Specialist	Provide in-depth expertise in their field. They support the ED in complex medical cases that require specialized knowledge.
Process knowledge	**Zoco**	Has a comprehensive understanding of capacity management, triage protocols, and patient allocation within the ED.
	Receptionist	Demonstrate operational knowledge required for preparing and performing medical procedures
	GP/ GP-Ooh	Decisions on referrals and activation of ambulances.
	Ambulance	Transfer of medical records and communication with ED.
	ED Nurse	Triage and coordinate medical procedures and documentation.
	ED doctor	Diagnostics, treatment and patient referrals.
	Specialist	Consultations and referrals within specialized processes.

Figure 5.7: Knowledge of actors

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours)

5.3.3. Power Interest grid

Figure 5.8 provides an overview of each actor's level of interest in improving capacity within the ED. Additionally, it examines the extent of each actor's influence on the process. This analysis also considers the knowledge each actor possesses regarding ED capacity, as outlined in the figure 5.7 above.

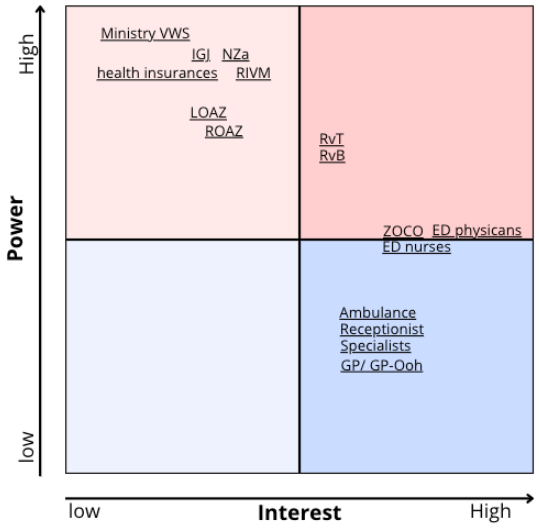

Figure 5.8: PI-grid actors

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours), RvT = Supervisory Board, RvB = The Board of Directors, VWS = Health, Welfare, and Sport, IGJ= The Health and Youth Care Inspectorate, NZA = Dutch Healthcare Authority, RIVM = National Institute for Public Health and the Environment, LOAZ = The National Acute Care Network, ROAZ = Regional Acute Care Consultations

High Power, Low Interest

Stakeholders in this quadrant, such as the Ministry of VWS, the IGJ, the RIVM, the NZa, LOAZ, ROAZ and health insurers, have significant influence over the regulatory framework and policies that determine the operation of the ED. Within this group, the Ministry of VWS holds the most direct authority. The NZa and IGJ are independent public bodies, but their frameworks and mandates are set by the ministry. Health insurers are private entities, yet their role is shaped by government regulation. ROAZ, on the other hand, has the least power, as it is a regional coordination body. The LOAZ has slightly more influence than the ROAZ, as it operates on a national level.

These stakeholders set national guidelines, quality standards and funding structures, indirectly influencing the capacity of the ED. Despite their high power, their interest in the day-to-day operations of the ED is limited. They are often not aware of the impact of capacity management in the ED because they are not directly involved in day-to-day practice.

High Power, High Interest

Key decision makers in this quadrant include the Rvt, RvB and the ED physicians. They have both great power and a direct interest in the capacity management of the ED. The RvB and RvT have a strong interest in a well-functioning ED because they are responsible for it and accountable to external parties. However, their interest is slightly lower than that of the ED physicians because they are not directly involved in the logistical processes surrounding patient care.

ED physicians have less power than the RvB and RvT because they cannot make or implement rules without the approval of actors with more power. They must adhere to established guidelines and laws, which affect their autonomy and decision-making freedom.

Low Power, High Interest

Stakeholders in this quadrant include ambulance services, nurses, receptionists, specialists, and the ZOCO. The ZOCO and ED nurses have a similar level of influence, as they, like ED physicians, are directly involved in the daily operations of the department. However, they do not have the authority to establish laws or regulations. Their interest in capacity management is slightly lower than that of ED physicians, as there are currently no nursing staff shortages in the ED at Deventer Hospital. As a result, they experience less pressure and urgency to implement improvements in capacity management.

Additionally, specialists, ambulance personnel, receptionists, and general practitioners (GP/GP-OoH) play a crucial role in the ED despite their relatively limited power. While ED physicians have a direct role in patient care, these stakeholders contribute indirectly to the functioning of the ED and remain essential to the process. Although they are not continuously present in the ED, they have a vested interest in ensuring its efficient operation.

5.4. Key findings

The social structure of the ED is shaped by a structured healthcare landscape that includes national, regional, and hospital-specific guidelines. Deventer Hospital is a member of the Regional Acute Care Consultation Zwolle, which oversees coordination among hospitals, general practitioner out-of-hours services and ambulance services.

The Board of Directors (RvB) and Supervisory Board (RvT) are responsible for strategic decisions, while ED physicians are in charge of operational decisions. The communication structure is centralised, with the ED physicians making medical decisions and coordinating with specialists and GPs.

The Power-Interest grid demonstrates that significant policy actors, such as the RvB, RvT, and ministries, prioritise strategic frameworks, while medical and coordination professionals on the ED floor make daily capacity decisions. This division highlights a dependency between policy-level decisions and their practical implementation. While operational actors experience the direct consequences of capacity constraints, their ability to influence structural change is limited. As a result, effective capacity management relies not only on clinical coordination but also on alignment with higher-level institutional priorities.

6

Dynamics within the STS landscape

This section provides the identified technical and social dynamics, exploring their impact on the functioning of the Emergency Department.

6.1. Dynamics

The dynamics are discussed below in terms of inflow, throughput, and outflow.

6.1.1. Inflow

Patient inflow with alternative care options

The ED experiences an influx of patients who, according to ED physicians, could have received care elsewhere or did not require urgent medical care. Open interviews with the ED physicians revealed that some patients may have waited until after the weekend to see their general practitioner, been treated by a different healthcare provider within the hospital, or, in some cases, not needed medical care.

The presence of these possible 'non-urgent' patients has an impact on resource availability in the ED. Beds designated for acute and critical cases may be occupied by patients with less urgent needs, reducing capacity for those who require immediate care. Furthermore, healthcare providers, including physicians and nurses, devote time to treating non-urgent cases, which could influence workload distribution.

Furthermore, a higher patient inflow leads to longer wait times for all patients. When resources are allocated to non-urgent care, critically ill patients may face delays. This can have an impact on patient flow in the ED, as well as overall patient experience and satisfaction.

6.1.2. Flow through

Formation shortage ED physicians

The ED's target staffing level is 7.43 FTE, while the current capacity is 4.40 FTE, revealing a notable discrepancy. Open interviews indicate that this shortage affects the availability of experienced physicians, particularly during busy periods and night shifts.

In the Dutch healthcare setting, there is a clear distinction between physicians in training (ANIOS/AIOS) and fully qualified ED specialists. Although staffing FTE generally reflects only the qualified ED specialists, many frontline tasks are carried out by junior doctors (ANIOS/ AIOS). These physicians in training are certified physicians and may take autonomous decisions when deemed competent, but final responsibility always lies with the supervising medical specialist. When supervision is limited, delays in clinical decision-making and the management of complex cases can occur. Interviewees also highlighted that high workloads for less experienced staff, especially without continuous guidance, contribute to stress and turnover, further exacerbating workforce shortages.

Delays in obtaining test results

A frequently observed dynamic is the delay in obtaining diagnostic results, such as blood tests and imaging. Although procedures and protocols are in place to ensure timely processing, these demands are not always met in practice. This may be due to capacity limitations within supporting services, resulting in unnecessary delays in accessing critical medical information. Observations confirmed this

issue, with instances where diagnostic results were pending significantly longer than the expected processing time.

Delayed access to diagnostic information affects physician's ability to make timely and well-informed decisions regarding patient diagnosis and treatment. This results in prolonged patient stays in the ED, impacting capacity by limiting bed availability and reducing throughput. Additionally, the extended processing time increases the workload for healthcare providers, as they must repeatedly check on patients and provide continued care beyond what would otherwise be required. The delay also influences patient experience by contributing to uncertainty and prolonged waiting periods.

Asymmetric information between departments

Asymmetric information between hospital departments can contribute to delays and inefficiencies, particularly in the ED. This dynamic became apparent during both open interviews and through direct observations and informal conversations, in which healthcare professionals described situations where a lack of mutual understanding of departmental workloads and priorities negatively impacted collaboration. As a result, coordination and communication may be less effective, impacting the speed of decision-making and overall patient flow.

One example is when both the ED and a specialist department are experiencing peak workloads at the same time. In such cases, ED physicians may request specialist support, but if the specialist department is also operating at full capacity, response times can be delayed. Limited awareness of each other's operational status hampers collaboration and creates friction between departments. This issue was also reflected in observations.

Even well-intentioned consultation requests may be delayed due to timing mismatches and limited coordination. As a result, patients may remain in the ED longer than necessary, contributing to bottlenecks and inefficient use of staff and resources. Notably, mutual understanding between departments was not always evident. When staff briefly visit another department, there is a risk of misjudging the workload. For example, comments such as "seems quiet here" may be casually made but can lead to frustration when they do not reflect the actual intensity of work. This highlights the importance of transparent communication and greater awareness of each other's working conditions.

Figure 6.1 illustrates the communication link between ED physicians and specialists, emphasizing its critical role in coordinating interdepartmental care.

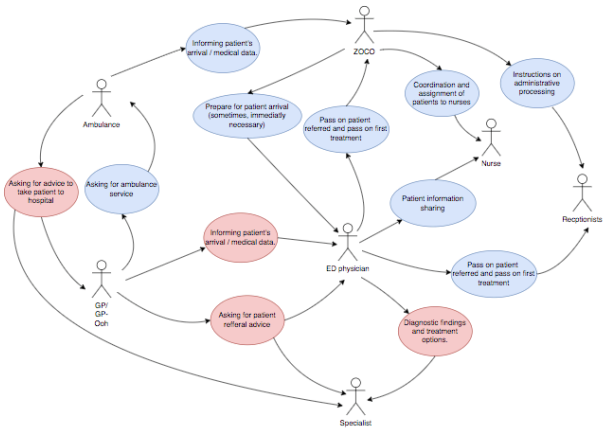

Figure 6.1: Dynamics in communication links

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours)

Triage insufficiency

Differences in triage processes between GPs and the ED can contribute to variations in patient flow and care efficiency. This was highlighted in open interviews with two ED physicians. Patients referred

by a GP are triaged using a different system from the one used within the ED. As a result, urgency assessments may not always align, potentially affecting patient flow and care allocation. However, ED physicians typically discuss cases with GPs over the phone, allowing them to independently assess urgency. While this prevents major issues, it still requires additional time.

Furthermore, document analysis revealed that triage levels are not always systematically recorded in the ED. In high-demand situations, triage information is often communicated verbally rather than documented, increasing the risk of miscommunication or incomplete information transfer. In smaller hospitals, such as Deventer Hospital, where communication lines are short and collaboration is close, this process generally functions well. However, in busier situations, reliance on verbal communication may lead to greater inefficiencies, as incomplete or unclear triage information can slow down decision-making.

These findings were also evident in the data analysis presented in Chapter 4, where a high number of missing values (NaN) in the dataset indicated incomplete or inconsistent triage registrations. In some cases, triage times were missing or incorrectly recorded (see Appendix A).

These findings align with broader observations in acute care, where variations in triage models and triage systems are identified as factors that can hinder collaboration and integration between healthcare providers. Additionally, triage for external referrals requires additional time and coordination, which may further impact the efficiency of the acute care process [90].

Cultural dynamics

Although ED physicians have been officially recognized as medical specialists under the BIG Act since January 1, 2024, the integration of this recognition into hospital structures and professional interactions is still ongoing [107]. The informal conversation with an ED physician and open interviews indicated that cultural dynamics continue to play a role in these processes. This may be attributed to the relatively recent formal recognition of emergency medicine as a medical specialty in the Netherlands, which has only been established for approximately 15 years.

Before this formal recognition, ED physicians were often not perceived as equal medical counterparts by other specialists. This created ambiguity in interdepartmental collaboration, particularly when it came to initiating consultations or making shared decisions. Without a clear specialist status, ED physicians sometimes encountered resistance or hesitation from other departments when requesting input, which contributed to delays in diagnostics, treatment decisions, or patient transfers.

Observations and open interviews suggested that these dynamics can sometimes make it more challenging to request input from other specialists, potentially leading to longer response times and delays in decision-making, which may contribute to extended patient stays in the ED. Even now that formal recognition has been achieved, cultural perceptions and historical patterns of interaction may persist, and some colleagues may not yet fully adjust their working assumptions or communication habits.

While the formal recognition of ED physicians as specialists represents a structural change, the extent to which this transition has been implemented in hospital practice is still developing. Findings indicate that professional recognition and organizational culture may influence operational processes within the ED.

Additionally, the open interviews and informal conversations with ED physicians indicated that these dynamics could influence patient outflow. Some ED physicians reported being cautious when asserting their authority in patient referrals, which may lead to longer patient stays and impact overall capacity. In the context of the PI grid, it appears that specialists have more power in patient flow decision-making, see figure 6.2.

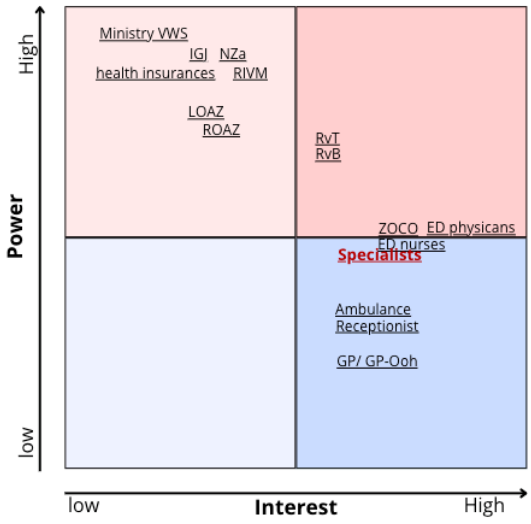

Figure 6.2: PI-grid change, involving cultural dynamics

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours), RvT = Supervisory Board, RvB = The Board of Directors, VWS = Health, Welfare, and Sport, IGJ= The Health and Youth Care Inspectorate, NZA = Dutch Healthcare Authority, RIVM = National Institute for Public Health and the Environment, LOAZ = The National Acute Care Network, ROAZ = Regional Acute Care Consultations

6.1.3. Outflow

Ultimately responsible physician

Although the term coordinating physician (regiebehandelaar) was introduced in 2022 as a replacement for the traditional “head of treatment,” there is still no formal legal framework for this role within hospital care. The KNMG guideline provides professional guidance, but it carries no legal authority [108]. Articles in the Dutch Journal of Medicine (NTvG) have advocated for this shift, citing the increasing complexity of care involving multiple specialties [108]. However, both disciplinary case law and practical experience show that the responsibilities associated with this role remain poorly defined in many institutions [20]. This ambiguity not only leads to avoidance of the role by healthcare professionals but also results in delays in diagnostics, repeated consultations, postponed admission decisions, and fragmented coordination across departments.

This dynamic is also evident in Deventer Hospital. Upon arrival, the ED physician is responsible for initial diagnostics, treatment, and referral decisions [105]. However, the coordinating physician role is not automatically assigned in complex or unclear situations. Contributing to this ambiguity is the fact that EDs are not formally recognized as admitting specialties (poortspecialismen), which means that ED physicians are typically not designated as the ultimately responsible physician, despite being the first to assess and stabilize the patient. Although a local protocol outlines the distribution of responsibilities, interviewees reported that it is often unclear who should assume the coordinating role, particularly for patients who do not fall under a single specialty or whose condition involves overlapping domains.

In such cases, ED physicians often find themselves maintaining an overview of the patient’s trajectory, repeatedly contacting various specialties in an attempt to reach a decision. This process can be time-consuming and frustrating, especially when no single specialty is willing or able to assume responsibility. Despite their central role in the acute phase, ED physicians have limited structural authority over the continuation of care, partly because of the cultural dynamics. The open interviews further revealed that hospital specialists frequently avoid taking on the coordinating physician role. This is often due to the absence of a clear legal mandate, which places significant responsibility on the individual physician. Since only the responsible physician is held accountable in disciplinary proceedings, this may discourage specialists from assuming the role, complicate interdepartmental coordination, and make practical implementation more difficult. In some situations, departments may even wait for each other to step

forward, resulting in delayed decision-making and stagnation in patient flow.

Until a national legal framework or sector-wide agreements are established, the coordinating physician role in emergency and multidisciplinary settings remains fragile, inconsistently applied, and vulnerable to interpretation at the expense of efficient collaboration and continuity of care.

Inefficiencies in ED outflow

Observations indicate that ED staff occasionally transport patients to nursing units themselves due to the limited availability of transfer support. This process requires time from ED nurses that would otherwise be allocated to direct patient care, potentially affecting overall patient throughput. Staff shortages in other nursing departments can contribute to prolonged bed occupancy in the ED, limiting the capacity to admit new patients. Additionally, the need for ED staff to assist with transfers increases their workload, requiring adjustments in task distribution and resource allocation within the department.

Registration inefficiencies

During the open interviews and informal conversations, several healthcare professionals expressed concerns that patients often remain in the ED longer than agreed upon, for instance, before being transferred to the ward where they are to be admitted. These experiences suggest potential bottlenecks in the patient flow process. However, to investigate and validate such concerns, reliable data is essential.

It became evident that this type of information is often poorly documented. Key process steps such as the time between the admission decision and the actual transfer to the ward or the duration between triage and initial medical evaluation, are not consistently recorded. In some cases, this data is entirely missing.

Without consistent and accurate data registration, it is impossible to objectively determine whether the perceived issues raised by clinicians reflect actual inefficiencies. This lack of data hampers research efforts, delays potential improvement initiatives, and limits the hospital's ability to optimize processes through data-driven insights. Therefore, systematic documentation of patient flow metrics is crucial to identifying, analyzing, and addressing operational challenges within acute care.

Table 6.1: Dynamics summarized

Dynamic	Category	Impact and Effect
Patient inflow with alternative care options	Inflow	• Non-urgent patients occupy valuable beds, reducing capacity for critical cases. • Increased workload for healthcare professionals, leading to uneven distribution of attention and effort. • Reduced ability to handle emergencies effectively due to resource strain. • Longer wait times for all patients due to resources being used for non-urgent care.
Formation shortage ED physicians	Flow through	• Increased reliance on junior staff without continuous supervision. • Delays in decision-making for complex cases due to a lack of senior ED physicians. • Longer processing times and variability in care delivery. • Higher workload contributes to stress and the risk of staff turnover.

Dynamic	Category	Impact and Effect
Delays in obtaining test results	Flow through	• Frustration and uncertainty among patients and ED physicians due to delays in results. • Longer ED stays, reducing capacity and increasing wait times. • Increased workload for staff due to repeated follow-ups for results. • Delayed availability of diagnostic results due to non-adherence to protocols.
Asymmetric information between departments	Flow through	• Miscommunication leading to incorrect, incomplete, or delayed treatment orders. • Frustration and conflict between departments, reducing morale and cooperation.
Triage insufficiency	Flow through	• Increased risk of miscommunication or errors, especially during busy periods. • Reliance on verbal communication can hinder decision-making speed. • Negative impact on operational efficiency and care quality during peak times.
Cultural dynamics	Flow through & Outflow	• Longer ED stays, reducing capacity and increasing wait times. • Hesitation from other departments to promptly respond to ED input or referral requests. • Delays in consultations caused by hierarchical ambiguity or unclear responsibilities
Registration inefficiencies	Flow through	• Missing timestamps (e.g., admission decision to transfer) hinder analysis. • Lack of accurate data impedes evaluation of care processes. • Delays in improvement initiatives due to limited insight into flow dynamics. • Hinders accountability and performance monitoring.
Ultimately responsible physician	Outflow	• Increased bed occupancy in the ED due to delayed patient transfers. • Reduced capacity to accommodate new patients. • Increased overcrowding and delays in care delivery. • Increased coordination burden for ED physicians in unclear cases.
Inefficiencies in ED outflow	Outflow	• ED staff are diverted from direct patient care. • Increased bed occupancy in the ED due to delayed patient transfers. • Reduced capacity to accommodate new patients. • Increased overcrowding and delays in care delivery.

6.2. Key findings

The analysis shows that capacity challenges in the ED are caused by a mix of social and technical factors. Some became visible when looking at processes, resources, and data use, while others were more related to coordination, role clarity, and communication between professionals.

A few dynamics involve both social and technical aspects. For example, differences in how triage is done are linked to professional judgment and communication, but also to how the process is structured. The same applies to inflow decisions, which depend on agreements between care providers and the way resources are organized.

The dynamics are grouped based on what mainly contributes to them: social, technical, or a combination of both. Table 6.2 gives an overview of these dynamics.

Table 6.2: Categorization of social and technical dynamics

Category	Factor type	Description
Asymmetric Information between Departments	Social	Limited insight into other departments workload and priorities affect coordination and response times, leading to delays in collaboration.
Cultural dynamics	Social	Cultural and professional dynamics still influence interactions with specialists, affecting response times and patient management.
Ultimately responsible physician	Social	Assigning responsibility requires coordination between multiple specialists, potentially leading to delays due to differing perspectives and workloads.
Patient inflow with alternative care options	Social & technical	Socially, referral patterns and urgency perceptions influence admissions. Technically, non-urgent cases impact ED resource allocation.
Triage process variability	social & technical	Technically, different triage methods create inconsistencies in urgency assessments. Socially, verbal triage communication impacts workflow efficiency.
Formation shortage of ED physicians	Technical	Workforce shortages affect the availability of ED physicians, impacting patient flow and care delivery.
Delays in obtaining test results	Technical	Non-compliance with established diagnostic protocols disrupt workflow efficiency and extend patient stay.
Inefficiencies in ED outflow	Technical	Staff shortages in nursing departments require ED staff to assist with patient transfers, limiting their time for direct patient care.
Absence of structured data on patient flow	Technical	The lack of structured data recording limits hospitals' ability to analyze performance and optimize operational processes.

In addition, no issues were found related to the physical system. The hospital's infrastructure, including communication tools and monitoring equipment, functioned as intended and did not contribute to any of the observed challenges.

7

Snapshot study

This chapter explores how many patients could be treated in alternative care settings and provides an initial overview of the size and characteristics of this group.

7.1. Patient inflow with alternative care options

As discussed in Chapter 6, it is expected by Emergency Department physicians that some patients could have been more appropriately treated in other care settings. Although these patients present at the ED, their condition may not require acute emergency care, thereby increasing pressure on emergency services and straining available resources. In response to growing healthcare demand and this expectation, it was decided in consultation with Deventer Hospital to further investigate the potential for patient redirection. This group likely includes patients with low-complexity conditions, non-urgent exacerbations of chronic illness, or referrals made primarily for logistical convenience rather than medical urgency. Reducing the number of such 'non-urgent' patients is expected to ease workload pressures, improve the distribution of patients per physician, and enhance overall efficiency. This analysis explores the potential for redirection to optimize emergency care capacity.

7.2. Snapshot results

This section presents the results of the snapshot analysis, focusing on the number of patients potentially eligible for redirection. In addition, it explores which alternative care settings may have been more appropriate for specific patient groups.

7.2.1. Patients in the emergency room

Figure 7.1 presents the daily number of patients during the snapshot week who, according to ED physicians, could have benefited from more appropriate care in a different healthcare department. The figure includes patients classified as not requiring ED treatment (in red), as well as patients for whom there was doubt about the necessity of ED care (in blue). This uncertainty does not imply hesitation in treatment by healthcare professionals, who are obliged to provide care regardless, but rather reflects retrospective uncertainty about whether the ED was the most appropriate setting. The data illustrate that, daily, a portion of ED visits may have been avoidable with better alignment to alternative care pathways.

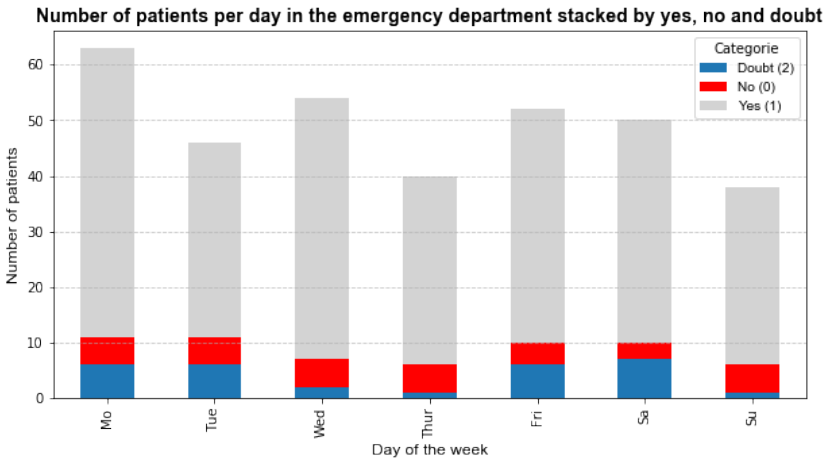

Figure 7.1: Patients receiving the right care and patients eligible for redirection

Figure 7.2 provides an overview of patient classifications in the ED during the study week. The data indicate that the proportion of patients potentially receiving unnecessary ED care varies per day. The highest percentages of patients classified as No, indicating they could have been treated elsewhere, were observed on Thursday (12.5%) and Sunday (13.16%), suggesting that on these days, a relatively larger share of patients might have been more appropriately managed in an alternative healthcare setting.

Similarly, the proportion of Doubt cases fluctuates throughout the week, with the highest percentages recorded on Saturday (14.00%) and Tuesday (13.04%). This variation suggests that on these days, there was greater uncertainty regarding whether the patients required ED care or if they could have been directed to a different care department.

Day	Doubt	No	Yes	Total	No %	Doubt %
Mo	6	5	52	63	7.94	9.52
Tue	6	5	35	46	10.87	13.04
Wed	2	5	47	54	9.26	3.7
Thur	1	5	34	40	12.5	2.5
Fri	6	4	42	52	7.69	11.54
Sa	7	3	40	50	6.0	14.0
Su	1	5	32	38	13.16	2.63

Figure 7.2: Patients receiving appropriate care for each day of the week

Figure 7.3 provides a summary of the classification of patients visiting the ED during the data collection period. The data indicate that a significant proportion of patients (82.2%) were deemed appropriate for ED care. In total, 391 patients were assessed during the study week, with the majority classified as requiring ED treatment.

However, a smaller subset of patients may have been suitable for redirection to an alternative healthcare department. Specifically, 32 patients (9.3%) were identified as potentially better suited for care outside the ED. Additionally, in 29 cases (8.5%), there was uncertainty regarding the necessity of an ED visit. Collectively, these two categories represent 17.8% of the patient population, suggesting that a proportion of ED visits may have been avoidable through alternative care pathways.

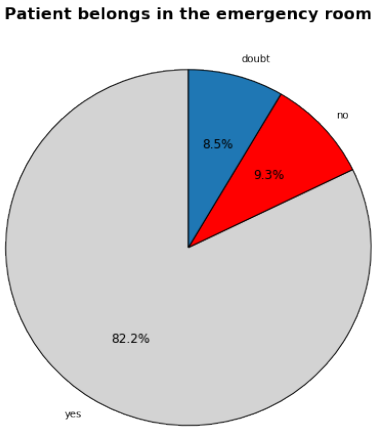

Figure 7.3: Percentage of patients receiving the right, doubtful or wrong care

7.2.2. Where could patients have been seen

Figure 7.4 presents an overview of alternative healthcare settings for patients who, according to ED physicians, did not require emergency care. In this subset, the outpatient clinic accounts for the largest share (46.7%), indicating its potential role in alleviating ED pressure. The urgent spaces in outpatient clinics designated for emergencies within specific specialist departments constitute a lower proportion (23.3%) compared to the overall distribution. These urgent outpatient spots are not universally available across all clinics; they are designated in specific departments for acute cases requiring urgent specialist assessment. This system enables patients with urgent yet specialized medical requirements to bypass the ED and consult directly with the relevant specialist.The general practitioner is a notable alternative care provider, accounting for 16.7% of cases, whereas the No Care Needed and Pediatrics categories represent a smaller proportion.

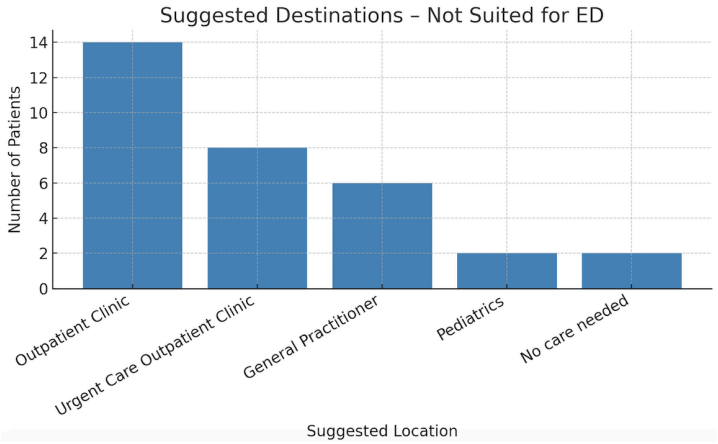

Figure 7.4: Where could patients have been seen elsewhere who don't belong at the ED

Figure 7.5 shows alternative healthcare settings for doubtful situations and patients who didn't belong at the ED. It indicates that the most frequently suggested alternative healthcare settings are the urgent outpatient clinic spots(36.7%) and the outpatient clinic (30.0%). Additionally, in 23.3% of cases, the general practitioner was identified as a more appropriate point of care. Smaller categories include pediatric care (5.0%) and cases where No Care was needed (5.0%). This distribution indicates that a considerable percentage of patients may have been diverted to specialized care pathways in primary or outpatient care settings instead of the ED.

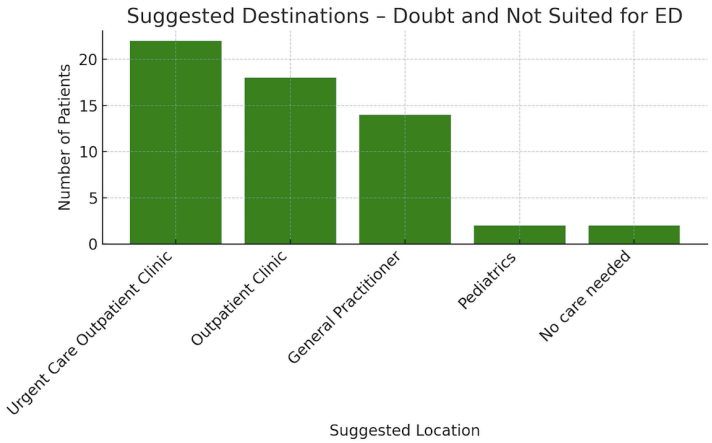

Figure 7.5: Where could patients have been seen elsewhere of patients who don't belong there and doubt cases

This distribution shows that patients deemed inappropriate for the ED were more often considered suitable for outpatient clinics, while doubtful cases were more frequently associated with urgent care facilities. The difference likely reflects uncertainty about the urgency of these cases. This ambiguity makes it harder to identify the most appropriate care setting.

7.3. Process

The analysis reveals that a substantial percentage of patients who attended the ED could have been treated at alternative healthcare facilities, such as outpatient clinics or general practitioners. These alternative care pathways indicate a possible decrease in ED patient influx, thus relieving pressure on emergency services. The IDEF0 model has been employed to re-evaluate the patient flows for enhanced clarity. This method facilitates a systematic depiction of patient flow and underscores potential redirection pathways for patients who might have received treatment elsewhere.

7.3.1. Redirection of patients

Figure 7.6 shows the updated patient flow, including possible routes outside the ED. Red arrows indicate alternative care paths to general practitioners, specialist outpatient clinics, or urgent care facilities, depending on the patient's condition and service availability. The model shows how clinical decisions and available information can guide patients toward a more appropriate setting.

The figure distinguishes between green and grey blocks. Green steps take place inside the ED, grey blocks denote activities that happen outside the ED. This visual helps clarify which steps can be handled outside the ED and supports identifying opportunities for patient redirection.

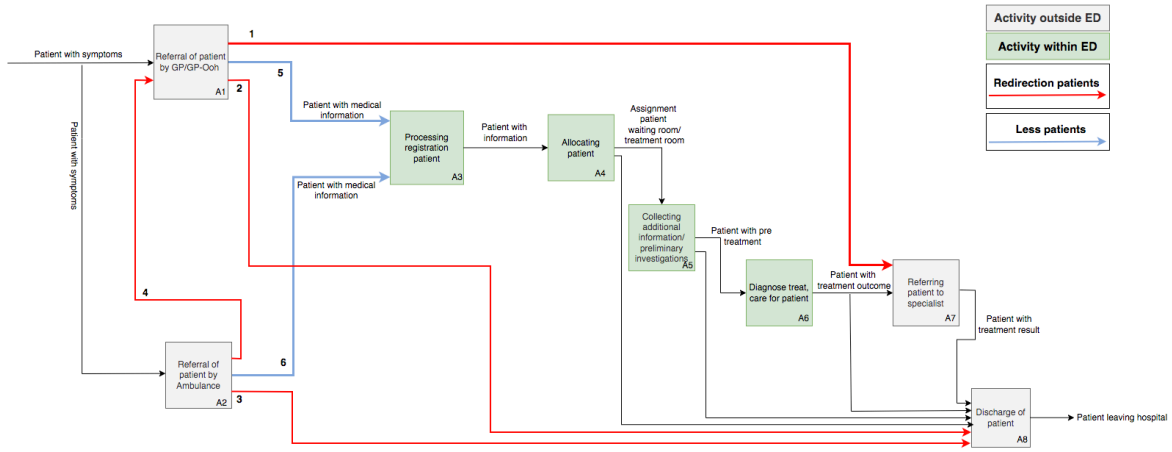

Figure 7.6: IDEF0 process with redirection of patient flow

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours)

A1: GP/GP-Ooh

The GP and the GP-OoH are pivotal in evaluating and referring patients, differentiating between those suitable for first-line care and those requiring specialised or emergency treatment. First-line care denotes healthcare services that are readily accessible without a referral, including general practitioner services, physiotherapy, and social work. The general practitioner serves as a gatekeeper for secondary care, assessing whether a patient can be treated within this accessible level of healthcare. Secondary care includes specialised medical services needing a referral, including treatments administered by medical specialists in hospitals, shown in Figure 7.7.

If the GP determines that a patient is eligible for first-line care, treatment may start immediately, allowing the patient to exit the process without imposing further demands on the ED or specialists. This is depicted by Line 2 in Figure 7.6. When the general practitioner determines that the patient needs specialised medical care without requiring emergency intervention, the patient is referred to secondary care, such as a specialised outpatient clinic or an urgent place in the outpatient clinic, if accessible. This is illustrated by Line 1 in Figure 7.6.

If the GP suspects that the patient necessitates acute care beyond the capabilities of primary care or a standard outpatient clinic, a referral to the ED may be warranted. This generally transpires in instances of potentially life-threatening conditions, critical injuries, or abrupt decline in the patient's health. This scenario is represented by Line 5 in Figure 7.6.

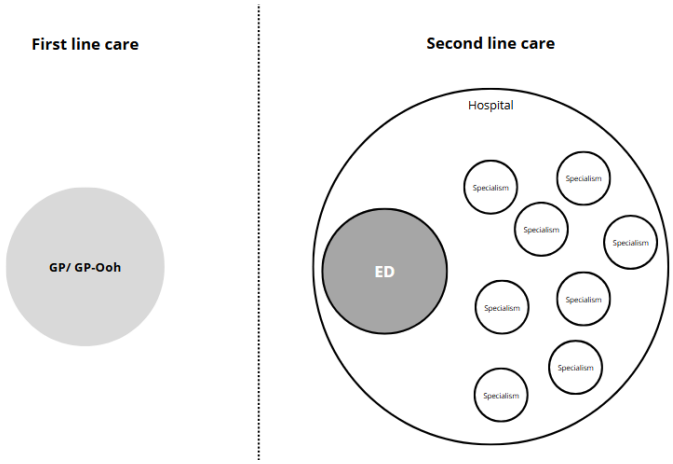

Figure 7.7: First-line care and second-line care

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours)

A2: Ambulance personal

Ambulance personnel are essential in triaging emergency calls and assessing the necessity of patient transport to the ED. Analysis reveals that a segment of patients conveyed to the ED by ambulance ultimately does not require acute hospital care. This underscores the necessity of assessing the criteria employed by ambulance personnel to determine whether a patient should be conveyed to the ED or managed via an alternative care pathway.

Three potential outcomes may arise following an ambulance response. In certain instances, ambulance personnel may conclude that transport to the ED is unnecessary, allowing the patient to remain at the scene with guidance for subsequent care. This situation is illustrated by Line 1 Figure 7.6. In circumstances requiring emergency care, the patient is conveyed to the ED, as noted in Line 6. Furthermore, ambulance personnel may determine that the patient does not necessitate immediate hospital care but would benefit from assessment by a GP or GP-Ooh. In such instances, the ambulance team may directly contact a general practitioner or recommend that the patient arrange an appointment autonomously. This route is denoted by Line 4.

Directing patients to suitable care options during the prehospital phase can enhance the efficient utilisation of emergency care resources.

A7: Specialists

Besides general practitioners and ambulance personnel, medical specialists significantly contribute to the management of patient flow within the healthcare system. Specialists evaluate and manage not only patients referred from the ED but also those referred to specialised care by general practitioners. Hospital specialists assess whether a patient necessitates admission or may proceed with outpatient treatment. How these decisions are made affects the degree to which the ED operates as a transitional juncture within the comprehensive care continuum.

An increase in patients following the red pathways indicates that more individuals are being directed to primary care or outpatient clinics instead of the ED. As a result, the volume of patients entering the ED via general practitioners or ambulance services would decrease.

This shift suggests that non-urgent patients are increasingly managed outside the ED, potentially relieving pressure on emergency services. At the same time, it places greater responsibility on primary and outpatient care providers to accommodate these redirected cases.

7.4. Data analysis characteristics of patients

This section explores the characteristics of patients who may be suitable for redirection to alternative care settings.

7.4.1. What times do potentially diverted patients come in

Figure 7.8 illustrates the distribution of patient arrivals at the ED per hour throughout the day. The data reveal distinct peaks in patient arrivals, particularly around midday (12:00) and late afternoon (16:00-18:00). These peak periods may align with the end of general practitioner consultation hours and the closure of primary care facilities, resulting in a heightened influx of patients seeking emergency care.

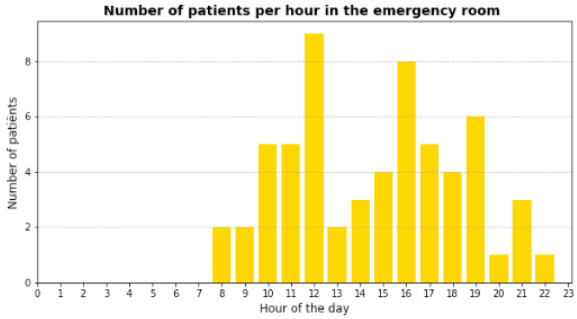

Figure 7.8: Average number of patients per hour in the ED

Notably, these peak hours align with previously observed arrival patterns in the 2024 data, suggesting a consistent trend in ED utilization. This recurrence indicates that external factors, such as the availability of alternative healthcare services, may have a structural influence on ED visit patterns. The relatively lower number of arrivals during early morning and late evening hours further supports the notion that most patients seek emergency care during standard daytime and early evening periods.

If these peak hours can be mainly attributed to patients who might be redirected to alternative health departments, this could impact overall ED capacity. A decrease in patient volume during peak periods may facilitate a more equitable distribution of resources, potentially relieving pressure on the ED and enhancing overall efficiency.

7.4.2. What are the times the patients occupy

This analysis explores how patients, who may not require ED care, influence throughput by examining their average length of stay and time to first physician contact. Figure 7.9 compares these metrics across three groups: the full ED population during the study week, patients classified as not requiring ED care, and those with unclear indications grouped with the non-ED patients. A detailed overview of this analysis is included in Appendix E.

If these groups show prolonged ED stays, it may suggest disproportionate use of resources such as staff, beds, and treatment space. Recognizing these patterns is key to assessing whether redirecting non-urgent patients can improve ED capacity distribution.

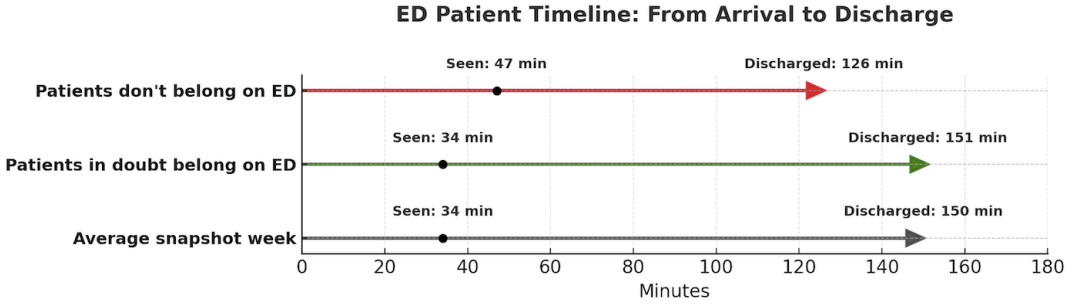

Figure 7.9: Time differences by patient category for total stay and first contact

Abbreviations: ED = Emergency Department

The data reveal that patients deemed not in need of ED care experience an average wait time of 47

minutes before consulting a physician, with a total duration of stay amounting to 126 minutes. This indicates that they endure a 13-minute longer wait for the initial assessment relative to the general ED population, whereas their total length of stay is 24 minutes shorter than the overall average.

For patients with an unclear indication for ED treatment, the waiting time for the initial assessment is identical to the general average (34 minutes), and their total length of stay (151 minutes) is nearly the same as that of the overall ED population.

The most significant finding is that patients deemed not in need of ED care experience an average wait time of 13 minutes longer for their initial assessment than other groups. This indicates that these patients may be deemed less urgent and consequently experience longer wait times before consulting a physician. At the same time, their total length of stay is 24 minutes shorter than the general ED population, which may indicate that their cases are processed more quickly potentially because they require less complex care or can be redirected more efficiently to an alternative healthcare setting. Although these patients suffer an extended initial wait time, they are ultimately discharged more rapidly.

Distribution of the length of stay

Figure 7.10 shows that most patients remained in the ED between 60 and 180 minutes. This indicates that even non-urgent cases can occupy resources for a substantial amount of time. A small group of patients stayed over 300 minutes, suggesting possible delays in redirection or complexity in their cases. Only a few (6 patients) left within 50 minutes, highlighting that quick redirection is rare and even low-acuity patients require time and attention.

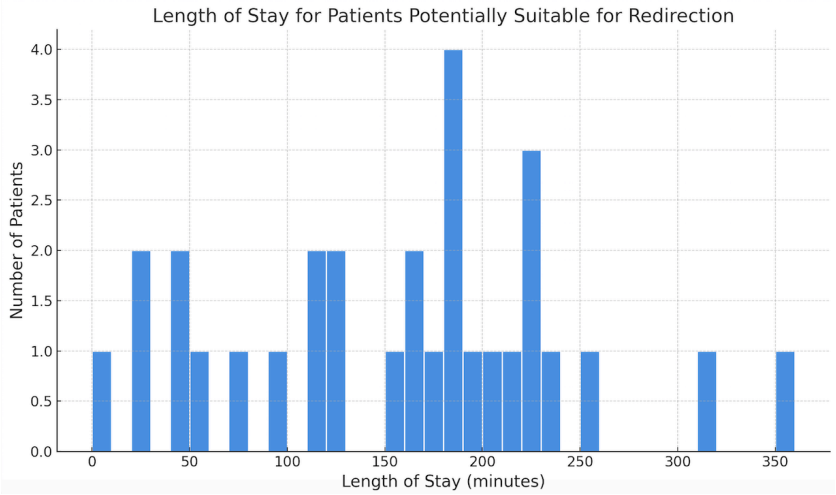

Figure 7.10: Distribution of the length of stay for patients potentially suitable for redirection

Redirecting the group of patients with longer stays could therefore offer the greatest potential for relieving pressure on the ED by freeing up beds and staff time. In contrast, the very short-stay patients form only a minor share of the group and are unlikely to significantly reduce overall crowding, underlining the importance of targeting high-impact cases for redirection strategies.

7.4.3. Characteristics in general

The visualizations in Figure 7.11 reveal differences in the characteristics of patients visiting the ED, depending on whether they are classified as appropriately placed in the ED.

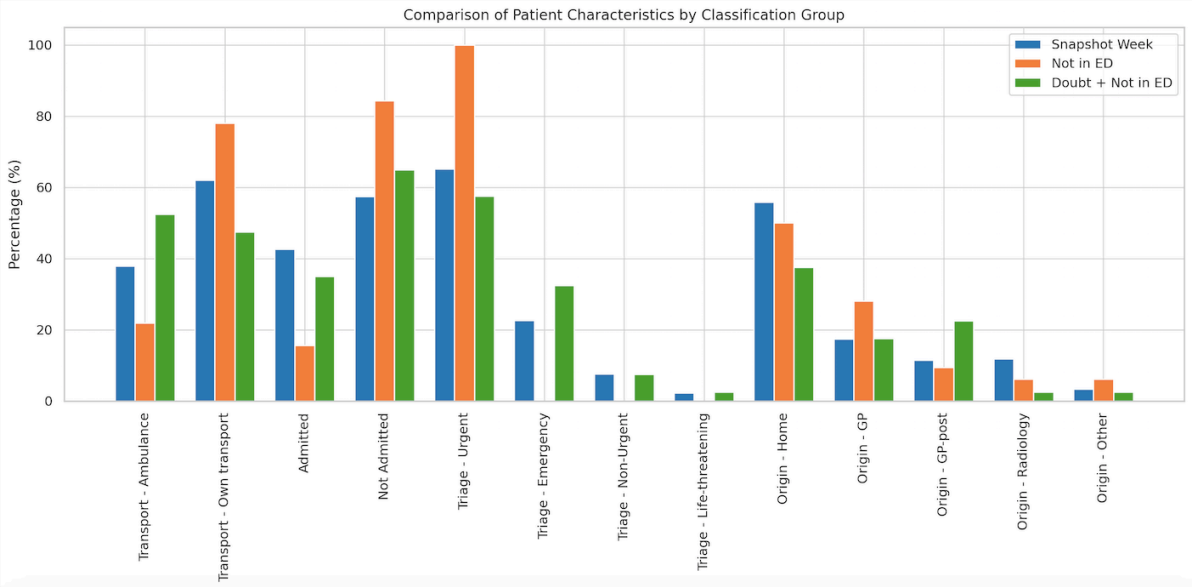

Figure 7.11: The comparison between the three groups

Explanation results

Mode of Transport: Most patients in the general population (63.9%) arrived at the ED via private transport, while 36.1% arrived by ambulance. In the 'Not in ED' group, this difference was more pronounced, with 78.1% arriving by private transport and only 21.9% via ambulance. In contrast, the combined group (Not in ED + Doubt) showed a more balanced pattern, with 47.5% arriving by private means and 52.5% by ambulance.

Admission Rate: Among all patients, 42% were admitted to the hospital, while 57.4% were discharged after treatment. In the group not requiring ED care, the admission rate was significantly lower at 15.6%. The combined group showed a higher admission rate of 35%, suggesting a more mixed clinical picture.

Origin of Referral: Over half (55.8%) of the general ED population arrived from their home environment, and 17.4% were referred by a general practitioner. The 'Not in ED' group showed similar patterns, with 50% coming from home and 28.1% referred by a GP. The combined group showed slightly lower rates of home-origin (37.5%) and 22.5% GP referrals. However, it is important to note that arriving from home does not necessarily imply that patients were self-referred; many may have consulted a GP prior to arrival. In fact, the share of direct self-referrals in the dataset is minimal and does not significantly influence the observed distributions.

Triage Classification: The general ED population was predominantly classified as urgent (65.2%), with 22.6% requiring immediate attention, and a small portion (7.6%) being non-urgent. All patients in the 'Not in ED' group were classified as urgent, while in the combined group, classification varied: 57.5% were labelled urgent and 32.5% emergency, with the remainder falling into non-urgent or life-threatening categories.

Notable findings

Patients in the 'Not in ED' group were more likely to arrive independently and had the lowest hospital admission rate. This likely reflects the fact that these patients did not present with severe or acute conditions requiring hospitalisation, which aligns with expectations for this group.

Despite this, all were labelled as urgent at triage, which raises questions about the alignment between triage classification and actual care needs. However, further investigation into this group revealed that triage data was only recorded for one patient, suggesting that the observed uniformity is more likely due to documentation gaps than clinical overestimation. This highlights the need to interpret triage data with caution, as missing or incomplete registration may distort the true urgency profile of these patients.

In contrast, the combined group of doubtful and non-ED patients showed more variation in triage classification and a considerably higher hospital admission rate. This suggests that some patients in this group presented with more severe or complex symptoms than typically expected for cases suitable for redirection. Since a portion was admitted or classified as urgent or emergency, it remains unclear why they were initially categorised as doubtful. Additionally, incomplete or inconsistent registration may have influenced these classifications. Further investigation into this group may offer useful insights, though such analysis falls outside the scope of the present study.

7.4.4. The departments to which patients are admitted

To complement the previous analysis of patient characteristics, admissions were further examined by medical specialty. Figure 7.12 shows the distribution of admissions for the three different groups.

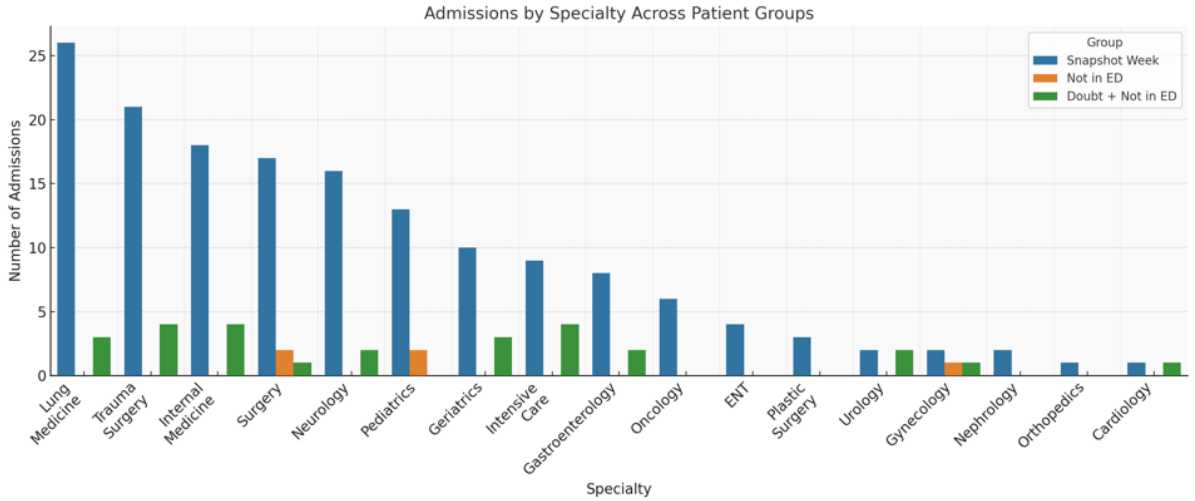

Figure 7.12: The departments to which patients are admitted

In the snapshot week, admissions occurred across a broad range of specialties. The most common were lung medicine, traumatology, and internal medicine, followed by surgery, pediatrics, and neurology. This distribution reflects the general diversity in patient needs during the week.

Among patients classified as not needing ED care, only three specialties appear: surgery, pediatrics, and nephrology. The limited number and nature of these admissions suggest that many of these patients could potentially have been managed outside the ED, for example, through scheduled follow-up at outpatient clinics or referrals to a general or specialist practice.

Incorporating the doubtful cases broadens the range of admitted specialties, although the overall diversity remains lower than in the general ED population. The presence of intensive care and geriatric admissions within this group is notable. Intensive Care (IC) admissions are generally associated with critically ill patients requiring continuous monitoring and high complexity interventions. The presence of IC admissions among patients initially classified as potentially suitable for redirection is therefore unexpected and may warrant closer examination. In addition, geriatrics appears in this group, which may reflect that older patients are more frequently placed in the doubtful category, possibly due to less clear-cut presentations or more complex underlying conditions. These observations suggest that the doubtful group includes a heterogeneous mix of patients and should be assessed with care.

7.4.5. Results logistical regression

The logistic regression analysis reinforces the findings from the previous sections: while some differences between patient groups were explored, no clear or consistent profile emerged that could reliably identify patients who were systematically misallocated to the ED. In the initial model, all relevant variables were included to assess their potential predictive value. However, none of the predictors were found to be statistically significant ($p > 0.05$).

Several patient characteristics, such as time of arrival and chief complaint, were examined in more detail (see Appendix E). Even when complaints were grouped into broader categories to reduce model complexity, no significant associations were found. Similarly, the dummy variables representing time of arrival (morning, afternoon, evening, night) yielded extremely high p-values (up to 0.998), indicating that these factors offered very limited discriminative power in predicting the appropriateness of ED visits.

The only variable that showed statistical significance in a later iteration of the model was the admission indicator ($p = 0.006$). Patients who were admitted had a higher likelihood of being classified as appropriate for ED care. This is in line with earlier descriptive results, which showed that most patients considered suitable for redirection were not admitted. See Appendix E for more details.

Due to the absence of statistically significant predictors, it is difficult to extrapolate these findings to estimate how many patients could realistically be redirected over a longer period, such as an entire year.

7.5. Key findings

The analysis shows that 17.8% of all ED patients during the snapshot week were potentially suitable for redirection. Many of these patients could likely have been treated in outpatient clinics, urgent care units, or by a general practitioner.

Most patients in this group stayed at the ED between 60 and 180 minutes, suggesting a substantial use of time and resources. Only a very small number (6 patients) left within 50 minutes, indicating that rapid redirection or discharge is relatively rare. These patients also tended to arrive during peak hours, reinforcing the idea that redirection during these times could ease pressure on ED capacity.

Patients classified as not requiring ED care more often arrived via private transport and had a significantly lower admission rate (15.6%), supporting the notion that they presented with less acute conditions. However, nearly all triage data for this group were missing, which complicates the interpretation of urgency classifications. This lack of triage registration is in line with previously identified process dynamics regarding incomplete data registration. Without accurate and complete data, it becomes difficult to identify and resolve system bottlenecks, thereby limiting the effectiveness of operational improvements.

Patients in the doubtful group had a more varied triage classification and a higher admission rate (35%), suggesting that some of them may have had more complex or unclear symptoms. Notably, a small number were admitted to intensive care or geriatrics departments, typically associated with high-complexity cases, which raises questions about the accuracy of initial classification and the clarity of redirection criteria.

Logistic regression analysis did not reveal a consistent profile for patients who could be redirected. Most patient characteristics, such as time of arrival or referral type, were not statistically significant predictors of inappropriate ED use.

8

Stakeholder perspectives on patient redirection

This chapter explores, through semi-structured interviews with healthcare professionals, why patients continue to use the Emergency Department even when their care needs could be addressed elsewhere.

8.1. Interview Results

The following sections present the key findings from the semi-structured interviews, structured around the four main themes.

8.1.1. Perception inefficiencies in emergency patient flow

A consensus exists among various medical disciplines that a subset of patients arriving at the ED could have received treatment in alternative settings. The perceived intensity and effect of this issue differ depending on the specialty. Some specialists assert that the issue is relatively limited in Deventer (Interview 1), while others estimate that between 5% and 15% of patients could have been treated in an alternative setting (Interview 1,2). The neurologist indicates an overwhelming volume of referrals, resulting in increased pressure on the ED (Interview 3).

Ambulance personnel note that certain patients are inappropriately referred to the ED. This is partially attributed to younger paramedics adhering more rigorously to protocols, resulting in increased referrals (Interview 4). Furthermore, the percentage of patients who could have received treatment elsewhere seems to be elevated outside of standard office hours (Interview 1, 5, 6).

In the acute care network, vulnerable populations, including elderly patients and individuals with chronic conditions, are frequently categorised as complex cases, complicating the determination of whether the ED is the most suitable environment for their treatment (Interview 3, 5). General practitioners identify a particular group of patients for whom no immediate outpatient alternatives exist, necessitating their referral to the ED (Interview 6).

Despite certain specialties designating specific urgent consultation spots outside the ED, capacity is still constrained, resulting in a considerable number of patients being referred to the ED (Interview 5, 6).

Table 8.1: Perception of unnecessary ED visits

Interviewed	Perception of unnecessary ED visits
Medical specialist (Interview 1)	”After 4 p.m., we more often see patients who otherwise could have been seen during the day via the outpatient clinic. Actually, in some cases, these patients could well wait a few weeks.”
Medical Specialist(Interview 2)	”I estimate that possibly 10% of the patients currently coming to the ED would not necessarily need to be seen there.”,
Medical specialist (Interview 3)	”Yes, I think there are far too many referrals.”
Ambulance (Interview 4)	”I think patients are coming into ED who don’t belong there.”

Medical Specialist (Interview 5)	”Most referrals are justified. Unjustified referrals occur occasionally, but often outside office hours.”
Gp/ Gp-Ooh (Interview 6)	”This concerns a specific group of patients whom we, as general practitioners, want to have assessed the same day, but for whom no acute outpatient clinic is available. As a result, when referring them, we sometimes hear from the specialists: ’Just send the patient to the ED.’”
Medical Specialist (Interview 7)	”I think there are too many referrals.”

8.1.2. Reasons why patients end up in the ED

Patients arrive at the ED for diverse reasons, despite the availability of more suitable care alternatives. In addition to medical urgency, social, logistical, organizational, and financial factors influence the use of the ED. This section explores the main reasons for ED visits, as explained by interviewed healthcare professionals.

Social factors

In several cases, an ED visit is not exclusively motivated by medical necessity but is affected by social factors. This is especially apparent among at-risk elderly patients who do not have a secure living situation, as mentioned above. In instances where nursing home placements are inaccessible or home care is inadequate, the ED is occasionally utilised as a provisional solution (Interview 3,5). Healthcare professionals indicate that these circumstances frequently arise, particularly in the absence of familial support or informal carers.

Furthermore, certain patients arrive at the ED due to the complexity of their healthcare needs, which cannot be adequately managed in primary care or outpatient settings. This is especially pertinent for patients with multiple comorbidities, where identifying the most suitable care pathway may prove difficult (Interview 3). In such instances, general practitioners and specialists may direct patients to the ED as an intermediary measure, facilitating expedited diagnostic assessments and specialist evaluations.

Logistical factors

The ED is often considered the most effective place for evaluating acute medical problems, as it provides quick access to diagnostic evaluations and therapeutic interventions (Interview 1, 7). Conversely, outpatient clinics frequently possess restricted diagnostic capabilities, resulting in patients being referred to the ED, even when their condition does not necessitate urgent intervention. For example, patients needing imaging or urgent laboratory tests may be referred to the ED due to the structural or temporary unavailability of these services in outpatient facilities (Interview 2). Consequently, the ED functions as a quick solution, while referral to an outpatient clinic may result in delays and inefficiencies (Interview 3, 4).

Furthermore, the ED is occasionally perceived as a more secure option (Interview 2). Patients with acute, non-life-threatening conditions, such as suspected severe abdominal pain, may necessitate continuous observation. In the absence of monitoring facilities in outpatient clinics within the hospital, referral to the ED is frequently deemed the most suitable option. This underscores a significant challenge in patient referrals. Although a case may not be critically urgent, the availability of ongoing assessment and expedited diagnostics in the ED often renders it the preferred choice.

Capacity factors

A key reason for referring patients to the ED is the restricted capacity of outpatient clinics. Prolonged waiting periods for routine consultations frequently compel patients with urgent issues to pursue care in the ED (Interview 1, 3). The problem is exacerbated by a scarcity of urgent consultation appointments in specific specialties, rendering timely outpatient care unattainable for certain patients(Interview 6). Consequently, individuals may be directed to the ED not due to medical necessity but merely because alternative care options are not readily accessible.

Claim culture

Healthcare professionals indicate that the escalating culture of medical liability has led to a rise in referrals to the ED (Interview 4, 6). There is an increased anxiety regarding incorrect clinical decisions, especially in instances where symptoms are ambiguous or nonspecific. To reduce legal risks, healthcare providers frequently adopt a cautious approach, choosing to refer patients to the ED for further evaluation instead of assuming responsibility for a complex case.

This transition has significantly affected ambulance services (Interview 4). Historically, ambulance personnel regularly sought the counsel of general practitioners to determine the necessity of hospital transport. Current protocols, however, assign complete responsibility to ambulance personnel, resulting in an increased tendency to transport patients to the ED, even in ambiguous situations.

Knowledge asymmetry

Furthermore, knowledge asymmetry influences clinical decision-making (Interview 4). In some instances, healthcare providers do not possess adequate information to ascertain the necessity of an ED visit, especially when confronted with complex presentations or ambiguous diagnoses. In these situations, the ED is frequently regarded as the most secure choice, providing extensive diagnostic capabilities and access to multidisciplinary expertise.

This is also because specialists are frequently less accessible for consultations during evening hours. Consequently, patients are frequently relocated because the ambulance lacks precise information regarding the patient's appropriate destination due to knowledge asymmetry. In this context, the ambulance signifies that the ED is consistently accessible and never challenging to reach.

Patient expectations

In addition to logistical and organisational factors, patient expectations also affect the utilisation of emergency care. In the last ten years, patients have shown a growing expectation for immediate access to hospital care, regardless of whether their condition necessitates emergency treatment (Interview 4). Some healthcare professionals indicate that patients frequently anticipate hospital transport upon arriving at emergency services, arriving prepared for admission with their belongings packed, without prior assessment by a general practitioner or other primary care provider. This leads to a heightened frequency of ED visits.

Table 8.2: Quotes supporting the themes why patients end up in ED

Interviewed	Theme	Reason why ending on ED
Medical Specialist (Interview 1)	Capacity factors, logistical factors	”To accommodate more patients through the outpatient clinic, support staff, nurses, and secretaries would need to stay longer, which is not always feasible organizationally and financially.”
Medical Specialist (Interview 2)	Logistical factors	”Especially in cases like a pulmonary embolism, you would want to ensure that care is well guaranteed.”, ”If you need more extensive investigations, such as a pulmonary embolism scan, it becomes very complicated from the outpatient clinic.”
Medical Specialist (Interview 3)	Social factors, capacity factors, logistical factors	”Patients do not always see their general practitioner, especially in emergencies. This makes referrals more accessible.” ”When a situation completely stalls, as a healthcare provider, it is difficult for me to say, ‘No, we will not admit this patient.’ So I often say, ‘Let the patient come through the ED after all.’”

Ambulance (Interview 4)	Claim culture, Knowledge asymmetry, Logistical factors	”In Deventer, we can simply call and say we are coming with a patient. In Zwolle, we sometimes had to convince specialists that the patient needed to be admitted.”, ”People demand more and file complaints more frequently. As a result, healthcare providers are more afraid of making the wrong decision. I think the claim culture plays a role.”, ”But nowadays, we sometimes arrive at a patient’s home, and they are already outside with a bag in hand, ready to go to the hospital.”, ”This person is very sick and has a serious problem, but where exactly? I don’t know. Someone with a high fever, who does not respond to anything, and has low blood pressure, is, for example, simply septic.”
Medical Specialist (Interview 5)	Social factors, logistical factors	”If someone is truly ill, has a high fever, or requires additional diagnostics, then the ED is the right place.”, ”Friday afternoon is often a peak moment because general practitioners are unavailable and family members are concerned. Sometimes, a referral is not necessarily required.”
Gp/ Gp-Ooh (Interview 6)	Claim culture, knowledge asymmetry	”For certain specialties, such as ophthalmology or ear, nose, and throat (ENT), there are always emergency slots available at the outpatient clinic on the same day. However, for acute internal issues, such as lung or heart complaints, we often hear that patients are required to report to the ED.”, ”Ten to fifteen years ago, these patients would have gone to the hospital on their own. Nowadays, people have become much more cautious, partly due to fear of complications and legal consequences.”
Medical Specialist (Interview 7)	Capacity factors, logistical factors	”One important reason why this is difficult to determine is that our ED has a relatively large number of rooms and almost always has space to accommodate these patients. In hospitals where the ED is often full, you are more quickly forced to find alternative ways to help patients.”, ”Most of the time, this is because diagnostics are needed that cannot be performed directly in the outpatient clinic. In the ED, for example, lab tests can be taken immediately, but the results take some time. Additionally, cultures sometimes need to be collected, which complicates the process if it has to be arranged outside the ED.”

8.1.3. Benefits patient redirection

Redirecting patients who do not require urgent emergency care to alternative healthcare facilities, particularly urgent outpatient clinics, benefits both patients and hospital efficiency. This section outlines the key advantages of patient redirection, based on insights from interviewed healthcare professionals.

Hospital resources

Effective patient redirection enables the ED to focus on the most critical cases while patients with non-urgent conditions receive timely and appropriate care in a more suitable setting. Redirecting non-urgent patients to outpatient or urgent care facilities mitigates the strain on the ED, enabling the more efficient allocation of resources and personnel for patients with acute medical requirements (Interview 4). By reducing the influx of non-urgent cases, ED physicians and nurses can concentrate on life-threatening emergencies, thereby enhancing the quality and efficiency of care for these critical patients (Interview 2).

Additionally, streamlining patient flow through targeted redirection enhances efficiency for specialists. Patients can be directed to the appropriate department without unnecessary intermediate steps through the ED, reducing delays and optimizing specialist consultation (Interview 3, 7). This contributes to a smoother hospital workflow, minimizing overcrowding in emergency care and ensuring resources are allocated where they are most needed.

Patient experience

A key benefit of patient redirection is the ability to reduce waiting times. Patients receiving treatment at urgent outpatient clinics typically encounter reduced waiting times relative to those attending the ED, where delays may persist for several hours owing to the prioritisation of severe cases (Interview 2,5). The decrease in waiting time enhances the efficiency and responsiveness of the healthcare delivery system.

Furthermore, outpatient settings generally offer a more tranquil environment compared to the high-pressure atmosphere of the ED. This is especially advantageous for susceptible patient demographics, such as elderly individuals, who may exhibit heightened sensitivity to overstimulation and stress (Interview 5). Experiencing care in a more tranquil environment can improve patient comfort and alleviate anxiety, resulting in a more favourable overall healthcare experience.

Furthermore, optimising patient flow via strategic redirection improves the patient experience. Patients can be referred directly to the appropriate department, bypassing unnecessary intermediate steps through the ED, thereby minimising delays and enhancing specialist consultation (Interview 6, 7). This facilitates a more efficient hospital workflow, reducing congestion in emergency care and ensuring resources are distributed where they are most essential.

Targeted care

Subsequently, direct referral to a specialised outpatient clinic provides substantial benefits for particular patient populations, including geriatric patients and those with chronic conditions. This method enables physicians to perform a more thorough evaluation, incorporating an extensive medical history gathered from family members, thereby facilitating a treatment plan that is more precisely aligned with the patient's requirements (Interview 5).

Moreover, facilitating a more efficient patient flow to the relevant specialists enhances continuity of care. Patients obtain more prompt consultations with their assigned specialist, thereby expediting the diagnostic process and boosting patient confidence through direct access to a known healthcare provider (Interview 3, 6, 7).

Hospital admissions

A significant advantage of patient redirection is decreased unnecessary diagnostic procedures and hospital admissions. Direct referrals of patients to a specialist outpatient clinic or a general practitioner can prevent unnecessary diagnostic testing in the ED. Numerous standard examinations, including blood tests, can be effectively conducted in an outpatient environment without imposing further pressure on emergency services (Interview 1, 2). Consequently, they do not require admission via the ED before being directed to the appropriate department.

Cost Reduction

Another direct advantage of patient redirection is its potential to reduce healthcare expenditures. Minimising superfluous ED visits allows for more efficient allocation of emergency care resources, ensuring that costly acute care services are designated for patients who truly need them (Interview 1, 2).

Compared to emergency services, outpatient care generally involves lower costs for hospitals. ED visits frequently incur elevated expenses owing to the necessity for specialised emergency personnel, comprehensive diagnostic evaluations, and possible hospital admissions. By enabling expedited and efficient patient management via outpatient clinics, healthcare costs can be regulated, fostering a more sustainable care model (Interview 3).

Table 8.3: Benefits redirection

Interviewed	Themes	Benefits redirection
Medical specialist (Interview 1)	Hospital admission, Cost reduction	”That likely led to fewer patients actually being admitted in the end, which saved costs for the patients.”
Medical specialist (Interview 2)	Hospital resources, Patient experiences, Hospital admission, Cost reduction	”ED physician and nurses can focus on severe and complex emergency cases, improving the quality and speed of care for these patients.”, ”Patients treated at an urgent care clinic often have shorter wait times compared to the ED, where they may spend several hours before being seen.”, ”Reducing the number of unnecessary ED visits can lead to lower healthcare costs by ensuring that expensive emergency care is only used where it is truly needed.”
Medical specialist (Interview 3)	Targeted care, Cost reduction, Hospital resources	”Specialists can see and treat their own patients more quickly, which can lead to better continuity of care and faster diagnostics.”, ”Outpatient care is often cheaper and less demanding on the hospital than acute ED care, contributing to a more sustainable healthcare system.”
Ambulance (Interview 4)	Hospital resources	”By directing patients who do not require acute emergency care to an outpatient clinic or urgent care center, the workload in the ED is reduced. This allows available resources and staff to be better utilized for patients with urgent medical needs.”, ”But well, if there’s a way to arrange it so that we can call and take the patient directly to the urgent care center, that’s fine. That could work well. It doesn’t matter to me.”
Medical specialist (Interview 5)	Patient experiences, Targeted care	”A potential downside of the ED is that patients often have to wait a long time, sometimes up to five or six hours.”, ”Sometimes, I prefer a patient to come to my outpatient clinic because I can get a more detailed history from the family. This provides a better overall picture compared to an ED visit with a neighbour or someone else with little medical background.”, ”An outpatient clinic or urgent care center generally offers a calmer environment than the ED, contributing to a more pleasant experience for the patient.”
Gp/ Gp-Ooh (Interview 6)	Targeted care, Patient experiences	”If it were easier to refer patients to an urgent care facility elsewhere, it would likely be beneficial. In that case, these patients could be directed to a more suitable location more easily.”, ”In an urgent outpatient clinic, this process works differently. There, a patient is seen directly by a doctor, often just once, who then determines which further examinations are needed. This provides more clarity and a more direct approach.”

Medical specialist (Interview 7)	Hospital resources, Patient experiences, Targeted care	”If an urgent outpatient clinic is well organized, patients will likely have shorter wait times for a consultation or treatment. They would see a specialist more quickly and receive the right care immediately, without the intermediate steps that are often required in the ED.”, ”For oncology, such an approach could also be beneficial. Patients with oncological complaints would be seen by their specialist more quickly, which is not only more efficient but also provides greater reassurance than having to repeatedly explain their situation to different doctors.”

8.1.4. Obstacles to the redirection of patients

Although redirecting patients to alternative care pathways presents evident advantages, numerous substantial obstacles hinder its execution. These barriers can be classified into financial and organisational limitations, capacity constraints, communication barriers, logistical challenges, and patient inclinations. This section analyses the primary obstacles recognised by interviewed healthcare professionals.

Financial and organizational constraints

Increasing urgent outpatient facilities in clinics could, theoretically, reduce the strain on EDs. Nonetheless, this transition poses significant financial and organisational difficulties in practice. Hospitals have to allocate additional staff and resources to urgent care outside the ED, leading to increased costs and logistical challenges (Interview 1, 2). Nursing staff, administrative personnel, and support staff must extend their availability to maintain urgent care services, which is often impractical due to current resource limitations (Interview 1).

Moreover, outpatient clinics are not intended for acute care (Interview 3). They frequently lack monitoring facilities, prompt laboratory testing, and imaging capabilities, complicating the evaluation of patients with acute conditions. The ED provides prompt access to laboratory testing, radiology, and other diagnostic resources, which are less accessible in an outpatient environment, where diagnostic delays can hinder timely decision-making. Consequently, even non-acute cases may be referred to the ED as a precautionary measure to ensure thorough evaluation and reduce clinical risks (Interview 7).

Outpatient clinics in hospitals depend on a constant flow of new patients to remain financially viable. Allocating additional urgent care slots may reduce routine consultations, negatively impacting the financial viability of outpatient services. Given these economic factors, hospitals and medical specialists may find it less desirable to designate dedicated capacity for urgent outpatient care, thereby increasing reliance on EDs to evaluate and treat patients (Interview 2).

Capacity shortages

Many outpatient clinics have limited capacity, making it difficult to add extra slots for urgent care. More emergency consultations can lead to longer wait times for regular appointments, affecting routine and chronic care. Balancing urgent cases with planned patient care is essential (Interview 2).

The need for urgent outpatient care varies by specialty. Some departments, like geriatrics, keep flexible slots for urgent cases, which can be given to routine patients if unused. Others, like pulmonology and gastroenterology, operate at full capacity, leaving little room for extra urgent consultations without affecting regular patient care (Interview 1, 2, 5).

A further challenge in outpatient clinics is the inconsistent use of urgent care slots. Experts note that predicting demand for these appointments is difficult. Too many urgent slots may go unused, leading to longer wait times for regular patients and reducing efficiency in balancing urgent and routine care. It may also impact financial revenue.

For specialists, assessing new patients in the ED takes more time than seeing familiar patients in an outpatient setting. New patients require a full diagnostic evaluation, making consultations longer and using more resources. In contrast, established patients have known medical histories and treatment plans, allowing for quicker assessments and decisions (Interview 6).

Communication and triage

A significant barrier to redirecting patients to alternative care pathways is inadequate communication among general practitioners, ambulance services, specialists, and ED physicians. At present, the coordination among these healthcare providers is suboptimal, resulting in instances where patients are directed to the ED without prior specialist consultation, as mentioned before (Interview 2). This contributes to the strain on emergency services and hinders the optimal allocation of care.

Again, it is evident that in numerous instances, ambulance personnel lack immediate access to a patient's comprehensive medical history, complicating the assessment of the urgency of their condition. Moreover, specialists, owing to their demanding schedules and clinical obligations, are not consistently accessible for consultation, especially during peak times such as busy outpatient clinic days or shift transitions (Interview 4, 6). Consequently, precautionary referrals to the ED are frequently executed, despite the potential suitability of an urgent outpatient clinic or alternative care setting (Interview 4, 6).

Patient perception

Some patients find waiting in an outpatient clinic more stressful than waiting in the ED. In the ED, nurses monitor patients, and diagnostics usually start within an hour (Interview 6, 7). In outpatient clinics, patients may wait longer without direct medical supervision, which can feel like a delay in care (Interview 1).

Table 8.4: Obstacles for patient redirection

Interviewed	Themes	Dynamics
Medical specialist (Interview 1)	Financial and organisational constraints, Capacity shortages, Patient perception	”Patient satisfaction is often higher when they receive care through the ED.”, ”But at the moment, the clinic is quite full.”, ”In addition, you have to take logistics into account. For emergency patients, we often have to arrange examinations on the spot, which takes longer.”
Medical specialist (Interview 2)	Financial and Orginisational constraints, Capacity shortages, Communication and triage	”Money is made with new patients, so you have to make choices about where to allocate space for emergency care.”, ”New patients eventually become follow-up patients. And everyone you take in needs to be properly cared for over time. That's exactly why I use 132% of my outpatient capacity, you try to do your best for everyone you admit”, ”I think GP sometimes finds it difficult to reach me.”, ”Specialists often have fully booked schedules and cannot easily accommodate extra ED patients without it affecting regular patient care.”
Medical specialist (Interview 3)	Financial and organisational constraints	”Some patients who are referred to an urgent care clinic turn out to need acute care after all. This can result in a delay in the appropriate treatment.”, ”It is not possible to take a patient to the urgent care clinic by ambulance; I have tried this before.”
Ambulance (Interview 4)	Communication and triage	”Well, you know what the issue is with an urgent care clinic? You are then dependent on our assessment of where the patient would be best treated.”, ”This person is very sick and has a serious problem, but where exactly? I don't know.”

Medical specialist (Interview 5)	Capacity challenges, Financial and organisational constraints	”By keeping those extra slots open, there are times when they remain unfilled.”, ”The ED has facilities such as blood tests, CT scans, and ultrasounds readily available. In outpatient clinics and urgent care centers, these options are often more limited, which may result in patients needing to go to the ED later for further diagnostics.”
Gp/ Gp-Ooh (Interview 6)	Capacity shortage	”Assessing new patients in the ED takes more time than seeing familiar patients in an outpatient setting”
Medical specialist (Interview 7)	Financial and organisational constraints, Patient perception	”The goal of an urgent outpatient clinic is to relieve pressure on the ED, but the workload still needs to be managed somewhere. If this results in longer wait times for regular patients, the effect could be negative.”, ”In the ED, patients know they will be seen by a nurse right away, have blood tests taken, and receive the first results within an hour. In the urgent care clinic, this process may take longer.”, ”You shouldn’t fill up your schedule. Leaving some flexibility ultimately makes your work more efficient.”

8.1.5. Key findings

Figure 8.1 provides a summary of the key findings from the interviews.

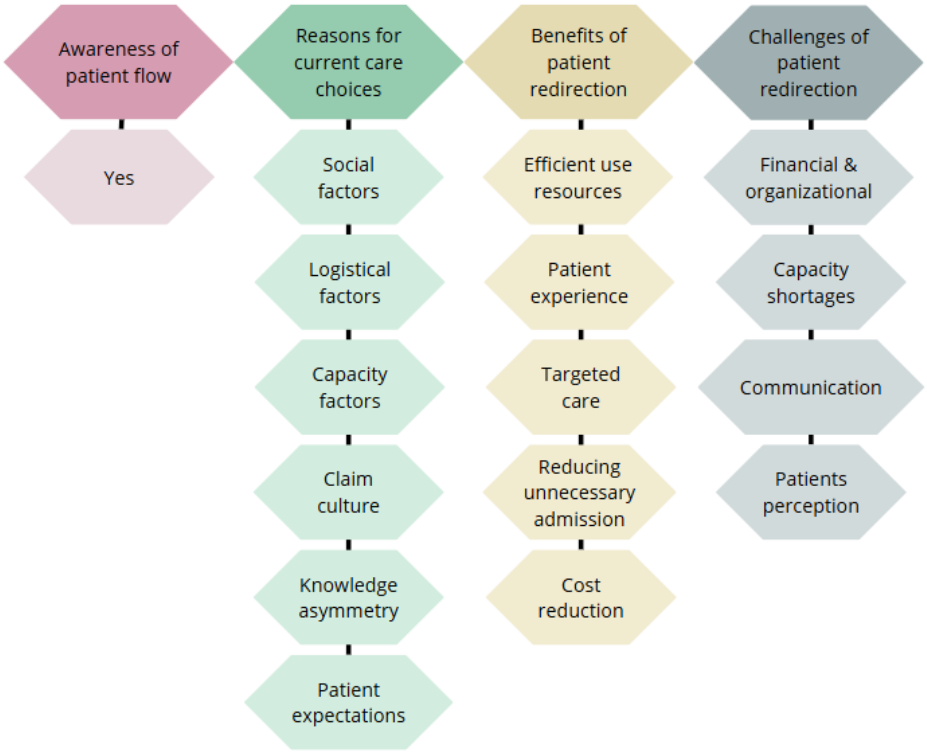

Figure 8.1: Key findings of interviews

Diverting patients to alternative care facilities may theoretically reduce the load on the ED. However, logistical and social factors hinder its feasibility and efficacy. A key challenge is the limited capacity in

outpatient clinics, where long wait times and high occupancy hinder the addition of emergency appointments without affecting routine care. Beyond capacity, financial and organizational factors also play a role: hospitals depend on a steady outpatient flow, and reserving emergency slots may reduce routine capacity and revenue. Cost savings from fewer ED visits must be weighed against potential outpatient losses.

In addition to the identified logistical barriers, social obstacles were also revealed. Efficient patient diversion requires a robust communication framework among general practitioners, ambulance services, and specialists. In practice, this consultation is often suboptimal, as patients are occasionally directed to ED without prior specialist counsel. The growing claims culture influences the referral practices of healthcare providers. Concerns regarding legal liability and potential complaints compel general practitioners and ambulance personnel to refer patients to the ED more frequently as a precaution, despite the availability of more suitable care alternatives. This defensive referral behaviour not only impacts the workload in EDs but also signifies a broader transformation in healthcare, where risk aversion increasingly influences medical decision-making.

9

Interventions

This chapter combines insights from the technical and social dynamics to formulate potential interventions for the capacity management of Deventer Hospital.

9.1. Technical-based interventions for rerouting

Based on the analysis of patient redirection and insights from semi-structured interviews regarding why patients ultimately present at the ED, it becomes clear that targeted interventions are possible to improve the logistical aspects of patient flow.

Data analysis indicates that approximately 9% of ED patients could potentially have been managed in alternative care settings. Within this group, around 70% might have received appropriate treatment in either a regular or urgent outpatient clinic, see Figure 7.4. Given the size of this subgroup, this category likely represents the greatest opportunity for targeted interventions. Redirecting these patients away from the ED toward outpatient clinics could help reduce pressure on acute care services and may contribute to a more efficient allocation of healthcare resources.

9.1.1. Potential Focus Areas

Below, possible interventions are described.

Expand urgent outpatient clinic spots

At present, not all specialties within the hospital offer urgent outpatient clinic appointments, which may contribute to unnecessary referrals to the ED for patients who do not require acute care (Interview 3). Expanding urgent appointment slots, particularly in specialties where they are currently lacking, could offer an alternative route for these patients (Interview 7). This would allow them to be assessed directly by the appropriate specialist, thereby alleviating pressure on the ED. To achieve this, a structured assessment could help to identify which specialties would benefit most from urgent outpatient capacity and whether the current infrastructure can support such an expansion.

A key challenge in implementing this intervention is the difficulty of predicting demand. Over-allocating urgent slots may lead to unused appointments, longer wait times for regular patients, and inefficient use of resources.

This creates a trade-off between urgent and non-urgent care, with potential financial risks for high-volume specialties. Effective implementation requires careful estimation of required slots per specialty and time, considering patient flow, staff availability, and scheduling constraints. This could be explored by monitoring appointment data over a longer period, combined with interviews to identify patterns in urgent demand and assess capacity constraints per specialty.

Accessibility of urgent outpatient clinics

In Deventer Hospitals, outpatient clinics are not easily accessible for ambulance arrivals (Interview 4). As a result, patients who could potentially be seen directly by a specialist may first be routed through the Emergency Department. Small adjustments, such as improving internal transport routes or introducing a central intake point, could make direct referral by ambulance more practical (Interview 3).

These logistical suggestions may contribute to a better distribution of hospital capacity and improved access to emergency care for those who need it most.

9.2. Feasibility of established interventions

In designing these potential interventions, it is essential to consider both logistical and social dimensions. Semi-structured interviews with healthcare professionals revealed that patient redirection is not only hindered by logistical inefficiencies but also by limited collaboration between involved actors and legal uncertainties. These broader system constraints reduce the feasibility of purely technical solutions unless they are supported by social interventions.

Therefore, the following section focuses on social interventions that are critical to enabling and sustaining potential changes in patient flow and system-wide capacity. Effective implementation could depend on shared referral criteria, clear communication, and coordination across the acute care chain. Strengthening these social components can support technical improvements and could support the feasibility and potential effectiveness of redirection efforts in real-world settings.

9.3. Interventions involving social components for rerouting

9.3.1. Feedback system

To create a shared referral criteria, an efficient feedback system can give more insight into which patients do not need emergency care and how to prevent such cases in the future. Systematic feedback to general practitioners, specialists, and ambulance personnel concerning unnecessary ED referrals initiates a learning process that could enable healthcare professionals to enhance their decision-making and establish more efficient care pathways.

Implementing this mechanism requires a systematic approach wherein patient data is analysed and feedback is incorporated into current workflows. This can be accomplished via automated feedback systems, routine multidisciplinary case discussions, and targeted education modules.

Automated feedback systems

A structural feedback mechanism starts with the smart use of existing digital systems. In the electronic health record (EHR), ED physicians can indicate whether a patient was appropriately referred or might have been better managed elsewhere. This assessment can be automatically shared with the referring provider, such as the GP or ambulance staff, which could offer direct insight into specific cases.

Without adding extra administrative burden, this could create a low-threshold feedback loop between the ED and referring professionals. If such feedback is consistently recorded over time, the accumulated data can be used to identify broader referral patterns. The resulting insights could inform care allocation and capacity planning.

Routine multidisciplinary case discussions

In addition, regular interprofessional feedback sessions, such as brief case discussions or monthly meetings between GPs, ED physicians, and ambulance staff, can help promote mutual understanding. By jointly reviewing why a patient was referred, professionals gain insight into each other's context and decision-making processes, which can help prevent future referrals or duplications.

Low-threshold feedback methods could also be actively encouraged, such as:

- A short email from an ED physician to a GP about a notable referral,
- A quick phone call to discuss a case shortly after presentation,
- A brief discussion of two notable referrals during a routine meeting.

These interventions require minimal time but can have a significant learning impact, especially when embedded in existing contact moments. They normalise feedback as a natural part of collaboration and help build trust between partners in the care chain.

Targeted education modules

Awareness of appropriate patient referral should be fostered early in healthcare education. Case-based modules can help students practice triage decisions: when to refer to the ED and what alternative care options exist.

In addition to building knowledge and skills, this could also foster understanding of different perspectives. Role-playing exercises, in which participants take on each other's roles and try to convince one another of the most appropriate care setting, strengthen their understanding of each other's work environment and improve real-world communication.

These measures could allow healthcare professionals to evaluate referral decisions and make more precise choices in similar future cases.

9.3.2. Communication links

Effective collaboration between general practitioners, specialists, and ambulance services is key to successful patient redirection. Faster and more direct communication can improve triage, reduce unnecessary ED visits, and ensure that patients receive appropriate care sooner. Currently, communication between primary care and specialists is not always optimal, which may contribute to some unnecessary ED referrals (Interview 4).

Better collaboration between general practitioners and specialists can improve triage efficiency. Quick and direct specialist consultations allow GPs to determine whether a patient needs emergency care or if another care pathway is more suitable (Interview 3, 6). This could reduce pressure on the ED by supporting more appropriate referrals, which may help minimize wait times and alleviate strain on acute care services.

Strengthening collaboration and establishing clear patient redirection protocols can lead to systemic improvements in healthcare. The communication links are shown in the figure below, marked by blue arrows. Creating awareness among care providers that suboptimal communication affects capacity can already drive change, especially when all parties recognize that better coordination benefits patients, professionals, and the healthcare system as a whole.

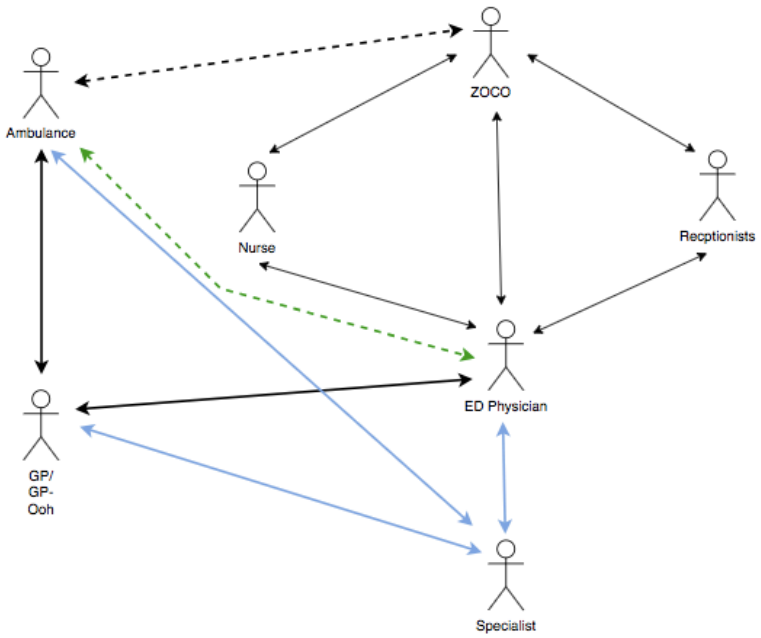

Figure 9.1: Intervention of communication links

Abbreviations: ED = Emergency Department, GP(Ooh) = General Practitioner (Out of Office Hours)

Moreover, an additional communication channel has been incorporated into the system, represented by the green arrow. Currently, ambulance personnel often transport patients directly to the ED without consulting a specialist or ED physician, which can lead to unnecessary admissions (Interview 4). In

cases of uncertainty, they typically contact the patient's general practitioner or the out-of-hours GP service, as these providers often have access to the patient's medical history. However, data analysis in Chapter 7 shows that a portion of the patients brought to the ED by ambulance could have been treated by a GP or required no follow-up care at all. This suggests that redirection, even when GPs are involved, is not always effective. One reason may be that GPs refer patients out of caution or overestimate the urgency of the situation (Interview 4). Another important factor could be the current shortage of GPs and their high workload, which limits their ability to be more actively involved in pre-hospital decision-making.

A potential intervention is to facilitate more frequent direct consultation between ambulance personnel and ED physicians in cases of doubt. ED physicians assess emergency cases daily and have real-time insight into the current workload and capacity of the department. This direct line of communication could also reduce reliance on intermediaries such as the ZOCO, thereby speeding up decision-making and improving care coordination. It could increase the flexibility and responsiveness of the acute care system. Although legally permitted, direct consultation between ambulance staff and ED physicians is not yet a common practice. By setting up a dedicated consultation line and embedding it into protocols and training, this collaboration could become a structural part of the triage process.

At the same time, this form of consultation requires time and availability from ED physicians, which may add pressure during busy shifts. The potential benefit of reducing unnecessary ED visits should therefore be weighed against the required time investment. Pilot programs could help assess the net effect on patient flow and system pressure.

It is important to note that the final medical responsibility always remains with the ambulance staff, as outlined in national guidelines (Interview 4). Even if consultation takes place with a GP or ED physician, legal accountability stays with the ambulance professionals. This likely contributes to their decision to transport patients to the ED in cases of uncertainty, as they may prefer to avoid the risk of underestimating the severity of the situation.

At the same time, advice from the ED team could help support clinical decision-making in these situations. While GPs may sometimes refer to "just to be safe", ED physicians assess emergency cases daily and have specific expertise in determining urgency. Ambulance staff may perceive their advice as more reassuring and well-founded, which could support the decision not to transport in certain situations. Since ED physicians are also aware of the limited capacity of the department, they are likely to recommend admission only when it is truly necessary. This form of consultation could therefore contribute to avoiding unnecessary inflow and improving the efficient use of acute care resources.

This cautious attitude among ambulance personnel reflects a broader trend in healthcare: the increasing influence of risk aversion and liability concerns. The next intervention addresses this dynamic.

9.3.3. Claim culture

A significant factor affecting patient flow is the growing culture of claims within healthcare. Healthcare providers experience increasing pressure to refer patients to the ED as a precaution, driven by fear of legal liability in cases of missed diagnoses. This defensive referral behavior contributes to a rise in avoidable ED visits, further straining acute care services.

Addressing this issue may require a structured approach across legal, organizational, and professional domains. Clear legal protections could support healthcare professionals in making informed, evidence-based triage decisions. In addition, education and training may help reduce defensive behavior, particularly among less experienced staff who may lack confidence in uncertain situations. Strengthening their ability to apply risk-based decision-making could help reduce unnecessary referrals made "just in case.

This shift in behavior could also reflect broader societal changes. In the past, legal claims were relatively rare and professional judgment was more readily accepted, even under uncertainty. Today, patients and families often expect definitive answers and are more inclined to pursue complaints or legal action when outcomes do not meet expectations. This cultural shift increases the perceived legal risk of clinical decision-making.

Compounding this is a change in liability structures. Until a few years ago, general practitioners con-

sulted over the phone and shared responsibility with the ambulance team. Now, the full legal accountability lies with the provider who physically assesses and treats the patient. While this change is generally seen as appropriate, given that remote providers do not examine the patient, it also increases the burden on those making the final triage decision. A possible approach to reduce the legal pressure associated with triage decisions without altering the formal distribution of liability is the implementation of a system of documented collaborative decision making. During telephone or digital consultations between, for example, ambulance personnel and an ED physician or general practitioner, it would be briefly recorded that a consultation took place, including a short rationale for the decision made. While this form of documented professional consultation does not create shared legal accountability, it could demonstrate that the decision was made carefully and with input from a second healthcare professional. This may increase confidence among the provider, making the final decision and could serve as a mitigating factor in the event of a complaint or legal claim.

To help professionals feel more supported in this high-responsibility context, reflective learning strategies could be an effective tool. For example, training programs for junior ambulance staff could use realistic triage scenarios featuring time pressure or incomplete information to help them become familiar with making decisions under uncertainty. In addition, real-life triage cases that have resulted in legal claims could be anonymously integrated into group discussions without participants knowing in advance which cases were legally challenged. When it becomes clear that many would have made similar decisions, this could reduce fear and highlight that a claim does not necessarily indicate poor clinical judgment. Furthermore, legal literacy workshops could provide clarity on what constitutes reasonable clinical decision-making across various contexts. Finally, transparent communication with patients plays a key role. Clearly explaining the reasoning behind triage decisions, addressing uncertainty when necessary, and offering concrete follow-up plans could reduce dissatisfaction and mitigate complaint risks. Public campaigns that clarify the purpose of triage and the scope of emergency care may also help adjust societal expectations and strengthen trust in professional judgment.

In addition, the potential intervention involving structured feedback systems on triage decisions allows professionals to receive constructive insights into their clinical reasoning and outcomes. This could support continuous learning, build confidence, and help normalise clinical uncertainty rather than encouraging its avoidance. Furthermore, improved communication links between care providers, such as ambulance staff, general practitioners, and ED physicians, could further reduce defensive practices. The ability to consult a colleague in real time during moments of doubt could provide reassurance, share responsibility, and result in more balanced referral decisions. This could be especially beneficial for trainees and early-career professionals.

The culture of claims presents a complex and evolving challenge. Addressing this issue may require a combination of legal safeguards, professional support, learning from real cases, and open communication both among healthcare providers and with patients.

9.4. Addressing previously identified dynamics

These interventions could also address previously identified dynamics from Chapter 6. The two dynamics that may benefit from these measures are described below.

9.4.1. Dynamics asymmetric information

Chapter 6.1.2 highlights the issue of asymmetric information, where healthcare providers often have limited insight into each other's workflows and department demand levels. This lack of information can hinder coordination and create inefficiencies.

Setting up a systematic feedback mechanism may help address this information gap between departments. Regular case discussions and feedback exchanges could enable healthcare professionals to better understand each other's capabilities, decision-making processes, and triage approaches. This may contribute to more efficient referrals and could strengthen mutual understanding and cooperation within the broader healthcare network.

Implementing structured feedback may reduce information asymmetry between departments, as case-based dialogue can increase awareness of challenges and needs in various parts of the care pathway. Improved communication could support a more integrated and responsive healthcare system.

9.4.2. Dynamic responsibility

Chapter 6.1.3 highlights the challenges of assigning treatment responsibility, which can lead to delays in care. In complex cases involving multiple specialists, unclear role definitions may hinder timely decision-making and prolong a patient's stay in the ED.

Promoting risk-based decision-making and reducing the influence of the claims culture may play a role in addressing current coordination challenges. When healthcare professionals feel supported and legally protected in making informed triage decisions, they may be more inclined to take responsibility for referrals and care transitions. Interventions such as clearer legal guidance, documented collaborative decision-making, and access to professional support could help reduce the perceived risk of personal liability and lower the threshold for assuming the coordinating physician role.

These developments may strengthen interdepartmental collaboration and contribute to improved patient flow across the acute care network. As responsibilities become clearer, referrals could be handled more efficiently, and emergency physicians may spend less time coordinating follow-up care, which in turn could ease their workload and support continuity of care.

9.5. Key findings

Technically, the greatest opportunity lies in redirecting patients to urgent outpatient clinics, though success depends on capacity planning and accessibility. Socially, structured feedback systems and improved communication between GPs, ambulance staff, and ED physicians can reduce unnecessary ED referrals. Defensive referral behaviour, driven by claim culture and legal pressure, particularly among less experienced staff, can be addressed through legal literacy training, reflective learning, and documented collaborative decision-making. These measures also help reduce information asymmetry and clarify triage responsibilities within the acute care network. Structural improvements are unlikely to succeed without mutual understanding and collaboration between professionals.

10

Conclusion

In this conclusion chapter, an answer will be formulated to the main research question of this master thesis, based on the subsequent findings of the three sub-questions, which are answered throughout this research thesis.

How can the Emergency Department be represented within a socio-technical system landscape?

The ED of Deventer Hospital functions as a socio-technical system, where capacity is shaped by formal processes and how professionals interact. The IDEF0 model illustrated how patients progress through the ED, including triage, diagnostics, and referrals, while also highlighting how protocols and regulations structure these steps.

Observations, informal conversations and open interviews further showed that these processes depend not only on formal procedures but also on the coordination efforts of ED physicians and informal collaboration between departments. This indicates that capacity management is influenced as much by interpersonal dynamics and professional practice as by planning and infrastructure.

Using the IDEF0 was valuable in this regard, as it provided a structured framework to represent both technical processes and social factors. It helped to reveal how the organizational context and key actors influence the functioning of the ED. In addition, the stakeholder analysis further enriched the understanding of social dynamics by offering deeper insights into communication patterns, knowledge sharing, and power-interest relationships.

What are the key social and technical dynamics that influence the actual care capacity?

The ED's capacity is governed by both social and technical factors related to input, throughput, and outflow. Non-urgent patients put a strain on resources, while discrepancies in triage and inadequate information-sharing between departments interrupt patient flow. Staff shortages, particularly among ED physicians, and diagnostic delays lengthen patient stays. In the outflow phase, unclear responsibilities and staff shortages in other departments contribute to extra delays.

How can partial redistribution of patient flow contribute to improving acute care capacity, viewed from a socio-technical perspective?

Partial redistribution of patient flow can help relieve pressure on the ED. The snapshot analysis showed that approximately 9% of patients could have been treated in alternative settings, such as urgent outpatient clinics. While this is not a large proportion, it represents a meaningful opportunity to ease ED crowding and use healthcare resources more efficiently. Especially given the magnitude of the capacity problem, where even small improvements could make a difference.

The analysis showed that barriers are not only logistical but also rooted in professional routines, communication gaps, and legal concerns. For redistribution to succeed, interventions must do more than adjust capacity, they must also strengthen trust, coordination, and clarity across the acute care chain.

To be effective, interventions should address both technical conditions, like accessibility of alternative care and social dynamics, such as trust, collaboration, and role clarity. Only by strengthening both sides of the system can redistribution contribute meaningfully to improving coordination and capacity across the acute care network.

After analyzing the sub-questions, an answer could be formulated to the main research question of this study:

How can Emergency Department capacity challenges be improved using a social-technical approach?

A socio-technical systems approach provided a more comprehensive understanding of ED capacity than a purely technical analysis. Instead of focusing only on resource availability and process optimization, it also revealed how organizational structures, communication, and professional roles affect patient flow and care coordination.

One key insight was that challenges such as unclear responsibility dynamics, limited collaboration between ED physicians and specialists, and the influence of claim culture are just as impactful as logistical bottlenecks. These social dynamics shape how referrals are handled and decisions are made, and would likely have remained underexplored in a purely technical analysis.

While the technical analysis identified opportunities for patient redirection to urgent outpatient clinics, the socio-technical lens showed that such solutions can only succeed when supported by trust, clear communication, and well-defined roles. Improving ED capacity, therefore, requires more than increasing efficiency; it involves strengthening both logistical systems and the collaborative practices that support them.

This integrated perspective allowed the study to propose interventions that are not only technically feasible but also socially grounded and more likely to succeed in the current healthcare context.

11

Discussion

This study examines both technical and social factors influencing Emergency Department capacity through a socio-technical system analysis. Rather than solely analyzing patient flows and resource allocation, this approach provides an integrated view of the dynamics within acute care.

This discussion puts the findings in the larger context of capacity management and considers the interpretation of results, limitations, and potential for future research.

11.1. Academic contribution

The findings emphasize that improving ED capacity is not just a technical issue, but a collaborative challenge involving all professionals in the acute care chain. In practice, this means ED staff, hospital specialists, general practitioners, and ambulance personnel must work more closely to ensure patients are treated at the right place.

11.1.1. Scientific contribution

This research advances the scientific understanding of emergency care systems by clearly demonstrating the added value of a socio-technical perspective in addressing ED capacity challenges. Whereas previous studies mainly approached ED crowding through process optimization or quantitative analyses [24, 50, 26], this thesis shows that integrating both social and technical dimensions provides a deeper and more comprehensive understanding. Consistent with socio-technical systems theory, the findings confirm that technical efficiency and human factors are fundamentally interconnected in healthcare. This study offers empirical support for earlier work emphasizing the role of team dynamics and organizational culture alongside technical systems [23].

By combining IDEF0 modeling with qualitative insights, this research reveals critical socio-technical dynamics often overlooked in traditional capacity analyses, such as asymmetric information between departments and deeply rooted cultural patterns. Moreover, the finding that successful patient redirection depends on changes in both technical processes and social perceptions highlights this finding.

These insights reinforce the conclusions of Borycki and Kushniruk [40], who argue that integrating social and technical factors is crucial for identifying the true causes of operational bottlenecks. This study not only applies this integrated perspective but also demonstrates its practical value by uncovering hidden constraints that would remain invisible through purely quantitative methods.

11.1.2. Policy contribution

The findings of this study underline that policies aiming to improve acute care capacity should be interpreted in a broader systems context. While redirecting approximately 9% of patients to urgent outpatient services appears technically feasible, its effectiveness depends on several interrelated conditions that policy must account for.

Firstly, such technical measures only become viable when embedded in a policy framework that ensures sufficient capacity and accessibility in alternative care settings. This implies a need for structural investments and long-term planning in outpatient services, beyond temporary capacity expansions. Secondly, the results suggest that social dynamics, such as trust, communication, and role clarity, are just as critical. Current policy and governance structures often do not explicitly address these social dimensions of coordination. For example, unclear decision-making roles between ED physicians and

medical specialists can make patient redirection more difficult. Clearer agreements at the policy level could help professionals make better and faster decisions.

Altogether, these insights imply that redirecting patient flows should not be seen as a standalone technical intervention, but rather as part of a broader policy agenda that addresses structural, social dimensions of the acute care system.

11.2. Limitations of results

11.2.1. Socio-technical system approach in healthcare

Although applying socio-technical systems theory in healthcare provides valuable insights, it also comes with some fundamental challenges. These challenges arise from the complexity and constant changes in healthcare systems, which affect how effectively STS can be used in practice.

Complexity and unpredictability

Healthcare systems are highly complex and non-linear, with many interacting components. The connections between social and technical factors make it difficult to understand fully how the system works. As a result, outcomes are not always predictable based on individual parts alone [109]. This means that an intervention that seems effective in theory may have unexpected results in practice due to unforeseen interactions within the system.

Healthcare systems are constantly changing. Factors such as fluctuating patient numbers, new policies, varying staff expertise, and advances in medical technology make it difficult to implement stable, long-term solutions [109]. Therefore, it is important to approach acute care capacity management as a dynamic and continuous learning process, as also proposed in the potential interventions. Changes in one part of the system can lead to unexpected effects elsewhere, complicating the evaluation and management of interventions.

In this study, this means that the identified dynamics and interventions may not be exactly the same in another hospital, as both internal and external factors keep changing. The complexity of STS makes the analysis not fully predictable, and some findings depend on the specific situation at Deventer Hospital. While the STS approach has been useful in identifying problems and possible solutions, it is important to recognize that healthcare systems are dynamic. This highlights the need for continuous monitoring and flexible strategies when applying STS-based improvements.

11.2.2. Perception of involved stakeholders

The interpretation of this study's findings is influenced by the perspectives of the stakeholders involved. Since part of the data collection was based on open interviews and informal conversations with healthcare providers, the insights are shaped by their professional roles, experiences, and perceptions. This section outlines several limitations related to the scope of stakeholder involvement.

Limited stakeholder perspective

The socio-technical dynamics identified in Chapter 6 are primarily based on open interviews and informal conversations with ED physicians. While this has given valuable insights into the operational challenges within the ED, it also means that perspectives from other key stakeholders, such as general practitioners, ambulance personnel, and outpatient specialists, were not included in finding these current dynamics. As a result, certain dynamics that are not directly observed by ED physicians may have been overlooked. However, the major dynamics affecting the ED have likely been captured.

Sensitivity of the topic

It has been assumed that the identified dynamics provide a representative view of the key challenges within the ED. However, it is possible that certain issues, due to their complexity or sensitivity, were not explicitly mentioned by the interviewed healthcare providers. This could result in an incomplete picture of the underlying system dynamics and the factors influencing ED capacity. Social and organizational aspects, such as internal hierarchies, cultural norms within the healthcare institution, or personal experiences with policies and management, may have been discussed less openly. This introduces the potential risk that not all relevant dynamics have been identified, which could affect the robustness of the results.

Capacity perception

To assess the feasibility of patient diversion, semi-structured interviews were conducted with healthcare providers. During these semi-structured interviews, it was frequently mentioned that alternative care pathways, such as referrals to outpatient clinics or general practitioner services, were difficult to implement due to capacity constraints within these institutions. These insights were based on the professional experience and perception of the interviewed providers. Although this offers valuable context, the actual availability of alternative care options was not systematically measured.

This represents a methodological limitation, as conclusions are drawn from a limited number of perspectives, primarily from specialists within the ED. As such, the interpretation of findings should be approached with some caution, especially regarding broader system-level feasibility. A more comprehensive analysis of outpatient and primary care capacity might yield additional insights into redirection potential. Still, the perspectives gathered in this study offer a meaningful starting point for understanding the perceived barriers in practice.

No inclusion of patient perceptions

This study did not include direct patient perceptions regarding their preferences for healthcare services. Instead, healthcare providers assessments were used to determine which care pathways would be suitable for patients. This indirect approach introduces potential bias, as providers may make assumptions about patient preferences that do not fully align with patients actual choices and motivations.

For example, patients may have a strong preference for the ED due to the speed of diagnostics and treatment, even when an alternative care pathway is medically appropriate and logistically more efficient. As a result, the implementation of alternative care pathways may prove to be less effective than theoretically assumed.

11.2.3. Redistribution of patients analysis

This section provides an initial exploration of the potential to redirect ED patients to alternative care settings. An estimated 9% of patients were classified as potentially redirectable. However, this outcome is based on a narrow definition and a small data sample and should therefore be interpreted with caution. It remains uncertain what the actual impact of such redirection would be on staff workload, patient flow, and overall system dynamics in practice. The following subsections reflect on key limitations affecting these findings.

Focus of the patient inflow

This study focuses on the inflow of patients to the ED, as chosen in collaboration with Deventer Hospital. It was assumed that targeting inflow could offer meaningful improvements for patient flow throughout the system. While inflow is a relevant and often examined aspect of ED crowding, literature also highlights the influence of throughput and outflow factors, such as delays in ward admissions and limited discharge capacity, as important contributors to system pressure [110]. The findings of this study indicate that, in addition to inflow, these other parts of the care chain may also hold potential for improvement and should be considered in future research or interventions.

Data collection of patient redistribution

The assessment of whether a patient could have been treated in an alternative care setting was based on clinical evaluations by ED physicians during the registration week. These evaluations were made without direct input from general practitioners, medical specialists, or patients. As a result, the classification of redirection suitability reflects the perspective and working context of ED staff. In some cases, patients may have been considered eligible for redirection by ED staff, while other healthcare providers might have assessed the same situation differently. This means the outcomes offer a useful indication from the ED's point of view but do not necessarily represent how the broader healthcare system would classify these cases. Additionally, while 8.5% of cases were classified as 'doubtful,' this may reflect not only medical uncertainty but also habitual referrals to the ED when other care options are less accessible.

Observation period representativeness

The analysis of patient flows and redistribution options is based on a one-week snapshot. This week was selected based on availability within the research period and was considered representative of

an average workweek. Compared to other weeks, this period was generally normal, as the preceding weeks experienced significant peaks due to icy conditions, which had subsided. However, various external factors may influence its representativeness, meaning the findings may not be fully generalizable to other periods or situations. Seasonal variations can affect representativeness. During flu outbreaks or holiday periods, both patient flows and healthcare staff availability may differ from the average. Additionally, external factors such as policy changes or temporary capacity issues at general practitioner services may impact the findings. As a result, the proportion of patients identified as potential redirection may fluctuate across different periods.

Results logistical regression

Although the logistic regression did not yield any statistically significant results, this outcome should be interpreted in the context of the limited scope of the study. The analysis examined whether certain patient characteristics could help predict which patients might be suitable for redirection. However, the data were based on a one-week snapshot, during which only a small number of patients were assessed as potentially redirectable. As a result, both the number of observations and the diversity in patient profiles were limited.

If data had been collected over a longer period or across multiple time points, more patient data would likely have been identified as eligible for redirection. This would have increased the available dataset and improved the chances of identifying relevant patterns in patient characteristics. The absence of statistically significant results should therefore not be interpreted as proof that no predictive factors exist, but rather as a reflection of the small and selective dataset used in this exploratory analysis.

In addition, privacy regulations limited access to detailed patient information, such as individual medical histories or social and behavioural factors. As a result, the analysis could not fully explore how such characteristics may influence healthcare use or the appropriateness of redirection.

Finally, the categorization used in this study E.2.1, in which patients were classified into post-surgical, fractures and wounds, was based on an initial selection by researchers. While this provides a structured foundation, it is possible that an alternative categorization could have revealed different patterns, which could have led to different outcomes. However, due to the limited dataset and low statistical power, major differences in outcomes resulting from alternative categorizations are not expected.

11.3. Further research

The findings of this study provide insights into the dynamics within the ED and potential interventions for influencing capacity management. At the same time, several limitations and unanswered questions have emerged, leading to two directions for further research.

11.3.1. Further research expanding on findings

Further exploration of socio-technical dynamics

Building on the findings of this study, future research could further investigate how the identified socio-technical dynamics influence different phases of patient flow within the Emergency Department. While this study primarily focused on inflow, tackling dynamics such as claim culture, communication patterns, and feedback systems may also significantly affect flow-through and outflow processes.

Exploring these dynamics in greater depth could reveal how they contribute to bottlenecks or inefficiencies, but also where they might enable smoother coordination and faster throughput when functioning well. For example, timely communication between departments may help reduce diagnostic delays or support quicker patient transfers, thereby easing pressure on treatment spaces.

Moreover, quantifying the impact of these socio-technical factors could inform more adaptive capacity strategies, such as dynamic staffing models, workload distribution, and resource allocation. By extending the lens beyond inflow, and linking socio-technical insights to operational planning, future research could support a more complete understanding of capacity challenges and help identify additional opportunities for systemic improvement.

In this context, it would also be valuable to assess how redirecting approximately 9% of patients affects staff workload, patient flow, and the overall efficiency of ED operations, providing further input for

optimizing resource planning and organizational design.

Further research of proposed interventions

Further research could focus on further developing the proposed interventions from Chapter 9. It could explore how these interventions perform in practice by studying pilot implementations and evaluating their impact on patient flow, professional behavior, and interdepartmental collaboration. Future studies should take into account both quantitative outcomes and qualitative factors to assess the feasibility and sustainability of these interventions within different hospital contexts.

11.3.2. Further research based on limitations

Including more actor perceptions

A fundamental aspect of capacity management in acute care is not only the perception of healthcare providers but also the extent to which patients are central to decision-making and how their perceptions influence healthcare use. By systematically involving patients in future research, a deeper understanding can be gained of the factors that shape their preferences and choices. This could contribute to a more precise understanding of patient needs and more targeted interventions. By integrating this knowledge into the development of healthcare interventions that align with patient expectations and requirements. This could enhance the long-term effectiveness of interventions and facilitate the implementation of alternative care pathways.

Communication and collaboration within the acute care chain

Further research should explore communication patterns and connections between healthcare providers to understand where key challenges arise and what causes them. Identifying these factors can help develop targeted improvements that strengthen coordination and efficiency within the acute care chain. This is especially important as this study found that issues with communication and collaboration repeatedly affected patient flow, decision-making, and cooperation between departments. Addressing these challenges can lead to improving the capacity within the ED.

One such improvement could involve strengthening direct consultation lines between ambulance personnel and ED physicians, as explored in the proposed intervention. This targeted measure addresses a specific communication gap identified in both the data and interviews and exemplifies how better interprofessional coordination can contribute to a more responsive and efficient acute care system.

Financial considerations

Future research could focus on the impact of financial reimbursement structures and institutional collaboration mechanisms on patient distribution within acute care. Integrating these aspects into capacity management analysis can provide a better understanding of the incentives and structural factors that either facilitate or hinder the effectiveness of patient diversion strategies or affect overall system capacity. This aspect was not examined in the current study but could influence capacity, as financial and institutional arrangements may affect decision-making within capacity challenges.

Data considerations for future research

To effectively investigate the feasibility and impact of patient redirection, future research should take into account additional variables and an extended data collection period. Including factors such as patient demographics, medical history, seasonal fluctuations, staff workload, and the capacity of alternative care settings could yield more accurate insights into redirection patterns and their effects on ED operations.

Collecting data over a longer time frame would reduce the influence of short-term fluctuations and improve the reliability of trend analysis. A larger and more diverse dataset would enhance the statistical power of predictive models, allowing for a more accurate identification of patients suitable for redirection and the conditions under which alternative care pathways are most effective.

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A

Literature study process and articles

A.1. Chapter 1: Knowledge gap

To identify the knowledge gap, a step-by-step exploratory process was conducted. First, a literature review was performed using PubMed, Google Scholar, and the academic tool Elicit to explore which types of analytical techniques are commonly used to address capacity challenges in emergency departments.

In the next step, these approaches were compared to the analyses and improvement efforts currently in use at Deventer Hospital. This comparison was used to evaluate whether the academic methods and the hospital's own strategies aligned in terms of scope and effectiveness.

Following this comparison, an investigation was carried out to assess whether important elements were missing from either approach. Specifically, the focus was on identifying possible limitations that could hinder a comprehensive understanding of capacity problems. This included evaluating whether current techniques sufficiently accounted for the influence of human behavior, interdepartmental coordination, and organizational culture.

After identifying these limitations, a second round of literature search was conducted to find approaches that explicitly include both quantitative and social dimensions. This led to the selection of the socio-technical systems approach, which integrates technical processes with the social realities of healthcare work.

Terms used in Google Scholar, Elicit and PubMed:

Table A.1: Terms used in finding knowledge gap

Search string focus	Search terms used	Research focus
Capacity approaches in healthcare	((”Emergency Department” OR ”ED” OR ”Healthcare”) AND (”capacity management” OR ”optimization” OR ”patient flow” OR ”throughput”) AND (”Methods” OR ”Models”)	Finding current approaches to tackle capacity issues within healthcare
Social and organisational factors	(”Emergency care” OR ”hospital organisation” OR ”Emergency Department” OR ”Healthcare) AND (”professional behaviour” OR ”team communication” OR ”workflow coordination” OR ”interdepartmental collaboration” OR ”social dynamics” OR ”social factors” OR ”communication”)	Finding the social factors influencing capacity management: Behaviour, communication, collaboration, and organisational structure
Socio-technical systems approach	((”socio-technical system” OR ”socio-technical approach”) AND (”healthcare” OR ”emergency department” OR ”ED”))	Integrated analysis of technical systems and human interaction in care processes

In addition to the database search, snowballing was used to find important studies by looking at the references in key papers.

A.2. Chapter 2: Socio Technical System

Before developing a socio-technical system model tailored to the Emergency Department of Deventer Hospital, it was necessary to understand how this framework is conceptualised and applied in healthcare more broadly. This literature foundation provides the theoretical basis for the STS model presented in this chapter and justifies the integration of both technical and social elements in the analysis of ED capacity.

A literature review was carried out using PubMed, Google Scholar, and the Erasmus University Library to explore how socio-technical approaches are applied in healthcare, with specific attention to emergency care. The AI tool Elicit was also used to quickly identify additional relevant sources that matched the direction of this study.

The following search terms were used, combining Boolean operators to ensure specificity and breadth, and were applied in a stepwise selection process to identify relevant sources.

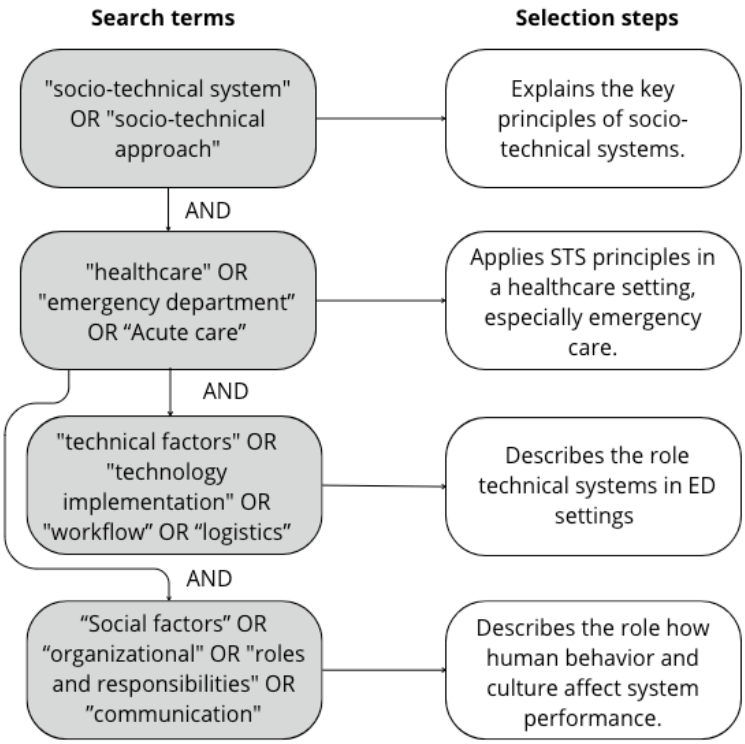

Figure A.1: Search process sources chapter 2

In addition to the database search, snowballing was used to find important studies by looking at the references in key papers. The review was not systematic in nature, but instead aimed to synthesise conceptually rich and practically relevant sources to build a theoretical model tailored to the ED of Deventer Hospital.

B

IDEF0

This appendix includes all of the underlying sections that are relevant to the technical aspect of the IDEF0 model.

B.1. Process ED

Clarifications for patient allocation

B.1.1. Flow chart refferal

The Department of Emergency Medicine has developed a flow chart to help GP/GP-Ooh identify when to send patients to whom.

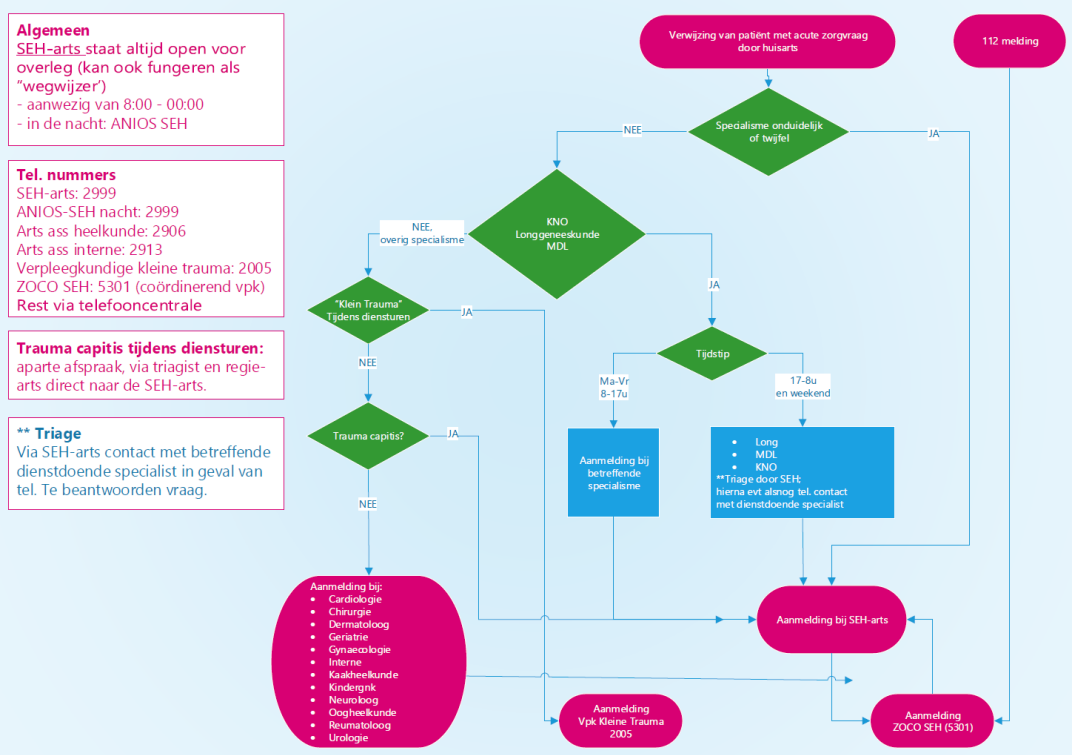

Figure B.1: Flow chart referral process General Practitioners

B.1.2. Registration form

A form that an ED physician fills out when the patient is referred by GP/GP-Ooh

Aanmeldingsformulier SEH		
Naam: Geslacht: Geboortedatum: Specialisme: Aanmelder		**B background**
S situation	**A assessment**	**R recommendation**
	A *airway*	
	B *breathing*	
	C *circulation* pols: temp: RR: sat:	Aanrijtijd:
	D *disability*	**Extra aanvulling z.o.z.**
	E *exposure*	

Figure B.2: Registration form

B.1.3. Display in operation centre

The graphic below displays what's presented in the operation centre.

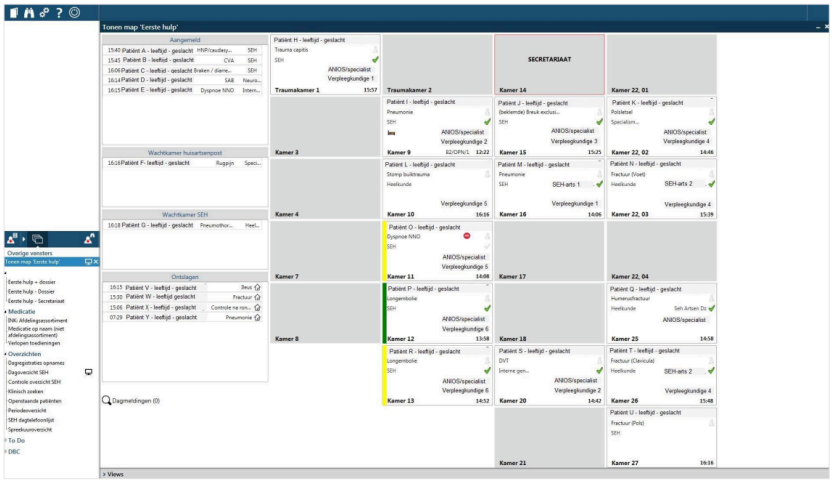

Figure B.3: His display

B.2. Data analysis

The collected data originates from 2024, making it the most accurate and up-to-date dataset available. The data was initially stored in an Excel file and later converted into a CSV format to facilitate easy processing in Python. Before downloading the dataset, measures were taken to ensure that no information could be traced back to individual patients. All personal data was removed, and unique patient identifiers were replaced with anonymized ID numbers to prevent any possibility of re-identification.

B.2.1. Patients admitted after an ED visit

To gain a clearer understanding of where most patients are admitted after an ED visit, the plot below was created. It illustrates the distribution of patient admissions across different medical specialists, highlighting which departments receive the highest number of admissions.

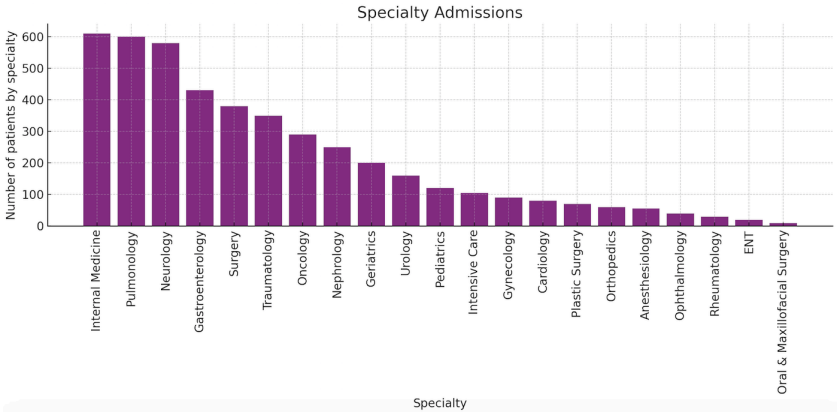

Figure B.4: Patient admission after an Emergency Department visit

Graph 4.6 shows that Internal Medicine, Pulmonology, and Neurology have the most admissions, each with approximately 600 patients. Other specialties, such as surgery, traumatology, and oncology, have relatively high admission rates, but less than the top three. As you move to the right, the number of admissions per speciality decreases, with rheumatology, ENT (ear, nose and throat), and oral and maxillofacial surgery having the fewest admissions.

Average time of patient in Emergency Departmentn

Analysis of average time of patient in Emergency Department.

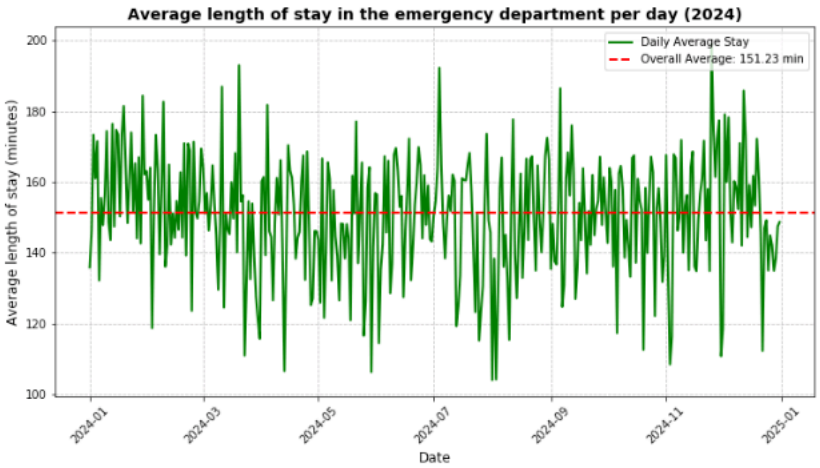

Figure B.5: Average time of patient in Emergency Department

Average time till seen by ED physician

Analysis of average time till seen by ED physician.

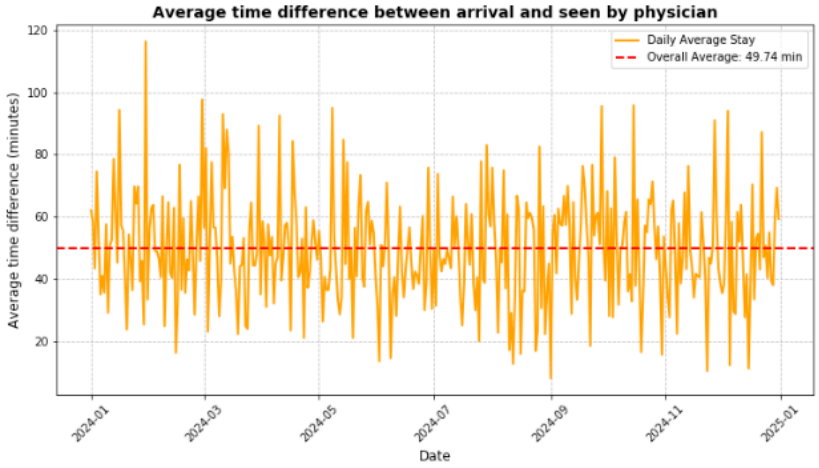

Figure B.6: Average time till the patient is seen by Emergency Department physician

B.2.2. Outliers

Errors in data are observed in the dataset, as revealed during the data analysis. In some cases, certain entries were missing or not properly recorded, leading to extremely long durations within the ED system. This issue is particularly evident in the recorded time until a patient is seen by a physician.

During the analysis, unrealistically high values exceeding 3500 minutes were detected. Since such long waiting times are not feasible, these outliers were removed from the dataset.

Figure B.7 displays the plot before the removal of outliers,

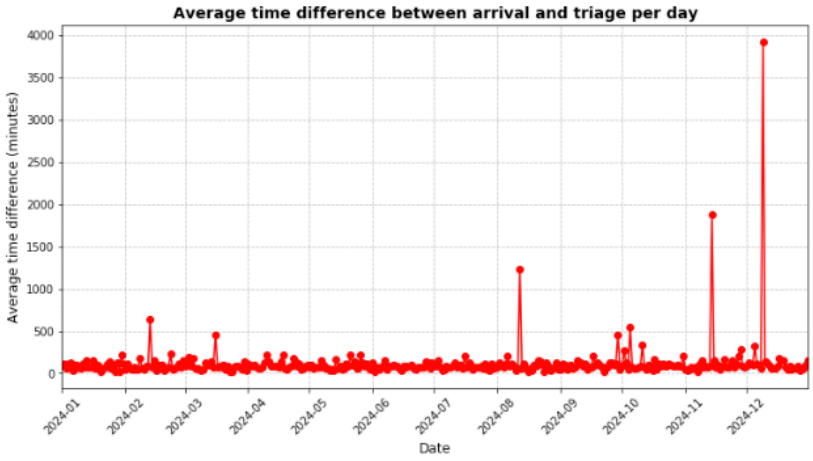

Figure B.7: Time till the patient is seen with outliers

C

Acts Acute Care the Netherlands

C.1. Regulations

This section provides a more in-depth analysis on the regulations established within Deventer Hospital.

C.1.1. The regulations within the process

The regulations affecting the Emergency Department at Deventer Hospital are categorized into regulations applicable at the national level and those established within Deventer Hospital.

C.1.2. National regulations

Below, the nationally defined regulations are further explained.

Physician schedule

Below, the regulations related to the physician schedule are presented.

1. Forward rotation direction.
2. Maximum of 5–6 consecutive shifts.
3. Minimum of 2 consecutive shifts (limits ”isolated” off-days).
4. Maximum of 2–4 similar shifts in a row; for night shifts preferably 1, and maximum 2.
5. Average weekly working hours: 32–38 hours, maximum 4 shifts/days per week.
6. At least 24 hours off after night shifts (first 24 hours not counted).
7. Half an hour break per shift.
8. Shift duration: maximum of 9 hours.
9. The shift must also be at least 9 hours long for the sake of handovers/patient safety.
10. Shift changeovers around 7–15–23h.
11. Predictable shift planning.
12. Maximum 50% irregular hours.
13. Maximum of 1 in 3, preferably 1 in 4 weekends (whole weekend).
14. Input in personal schedule, considering preferences such as fixed days/evenings off.
15. Part-timers work irregular shifts proportional to their contract hours.

Triage

Below, the regulations related to the triage are presented.

GP Out-of-Hours Service The staff at the HAP involved in triage are qualified for their task: they have at least an MBO level 4 diploma in healthcare triage. If the triage nurse handles the triage call independently, a supervising GP authorizes the outcome of the triage call. On average, 90% of the calls at the HAP are handled independently by the triage nurses, with the GP providing authorization based on digital contact. In 98% of cases, this authorization takes place within 2 hours.

Ambulance Care The MKA (ambulance dispatch center) is responsible for the process of intake, assessment, care provision, and coordination and dispatch, 7 days a week, 24 hours a day. The nursing

centralist at the MKA always determines whether ambulance deployment is necessary and, if so, which care is appropriate. The nursing centralists at the MKA are trained to conduct triage independently and to coordinate care.

Emergency Department (ED/SEH) At least one ED nurse per shift is responsible for physical triage. This ED nurse is always available for physical (re)triage. The ED nurse operates according to the established professional profile.

Accessibility and availability standards

This regulation focuses on the accessibility and availability of ED and cooperation with other healthcare providers. A key principle is that all residents of the Netherlands must have access to an emergency room within 45 minutes to ensure equal and timely care. In addition, the ED should be available 24/7, both for direct patient care and for communication with other healthcare providers, such as ambulance services, general practitioners and GP outpatient departments. This promotes efficient coordination and rapid treatment of emergency care requests [102].

In addition, the emergency room should be available 24/7 by telephone to ensure rapid and effective communication with general practitioners and GP surgeries. This contributes to a smooth transition between primary care and acute care and underscores the importance of continuous accessibility and well-organized collaborative arrangements within the emergency care chain [102].

C.1.3. Regulations within Deventer Hospital

Below, the regulations established within the hospital are further explained.

Duration test results

This regulation outlines the procedures and agreements for Emergency Department patients requiring radiological examinations, specifying processing times and responsibilities for different types of examinations both during and outside office hours [104].

For X-ray examinations (bucky images) conducted during office hours, the ED nurse or physician submits a digital request, after which the Medical Imaging and Radiation Expert (MBB-er) performs the X-ray, and the physician reviews the images. The maximum processing time is thirty minutes. Outside office hours, the ED nurse or physician must contact the MBB-er by phone before submitting the request. The MBB-er provides a time estimate and arranges additional staff if necessary. In this case, the maximum processing time is forty-five minutes. In both cases, trauma rooms must not be occupied for more than thirty minutes, except for patients requiring procedural sedation analgesia or resuscitation. Metal-containing clothing and jewelry must be removed before the examination [104].

For ultrasound examinations conducted during office hours, the ED physician submits a digital request, and the nurse coordinates the scheduling with the radiologist. The patient is then transferred to the ultrasound room, where the radiologist performs and assesses the examination within ten minutes. The total turnaround time is a maximum of seventy minutes. Outside office hours, the process is similar, but the ED physician must inform the on-call radiologist by phone. The ultrasound is performed within forty-five minutes, and results are available within fifteen minutes. If the radiologist is not physically present in the hospital, the processing time may extend to sixty minutes [104].

For CT scans without intravenous contrast conducted during office hours, the ED physician submits a digital request, and the MBB-er contacts ZOCO to arrange patient transport. The scan is performed and reviewed by the radiologist, with a maximum turnaround time of thirty minutes for the scan and an additional thirty minutes for the result. When a CT scan with intravenous contrast is required during office hours, the process remains the same, except that a green venflon is placed before the procedure. The scan must be performed within thirty minutes, and results are available within forty-five minutes. Outside office hours, the ED physician must contact the on-call radiologist before submitting the request. The MBB-er coordinates transport and conducts the scan, while the radiologist provides the result within forty-five minutes. For specific cases such as CT scans of the brain or cervical spine, the maximum turnaround time is thirty minutes for the scan and an additional thirty minutes for the radiologist's assessment [104].

In emergency cases, such as a suspected stroke where thrombolysis is considered, the ED physician or ZOCO immediately contacts the MBB-er for an urgent CT scan of the brain. The scan is completed

within ten minutes, and results are available within twenty minutes. Additional CTA or CTP scans may be conducted if necessary. For polytrauma patients, high-energy trauma (HET), or suspected abdominal aortic aneurysm (AAA), the ED physician must also contact the MBB-er directly and, if necessary, activate the trauma protocol. In these cases, the CT scan is performed within ten minutes, and results are provided within twenty minutes, allowing for rapid decision-making regarding further treatment, such as ICU admission, surgery, or transfer to a trauma center [104].

Head of treatment

National The term coordinating practitioner (regiebehandelaar) was introduced by the Dutch Medical Disciplinary Court (Centraal Tuchtcollege) and clarified in the revised KNMG Guideline Division of Responsibility in Collaborative Healthcare (2023). Unlike the former "primary treating physician" (hoofdbehandelaar), the coordinating practitioner is not ultimately responsible for the patient's entire treatment but is tasked with overseeing the coherence and coordination of care. Each healthcare professional remains accountable for their actions. Coordinating practitioners must be appointed in cases of complex care or when multiple providers are involved; in simple or single-provider cases, responsibility lies with the individual treating professional. The coordinating practitioner ensures continuity of care, facilitates adequate information exchange and collaboration among caregivers, and designates a point of contact for the patient. This role does not necessarily need to be fulfilled by a physician—nurse practitioners or physician assistants may also assume this responsibility, provided they are competent and registered under the BIG Act. In the Emergency Department (ED), the treating physician must verify whether the patient is already known within the hospital and whether the current situation requires the appointment of a coordinating practitioner. Often, the ED physician can temporarily take on this role, which may be formally transferred upon admission. Local protocols should clearly define who holds which responsibilities at which point in time, including documentation of the coordinating practitioner and the patient contact person in the EPD. The term primary treating physician is no longer used in official guidance.

Deventer Hospital In addition to laws, there are also guidelines and procedures regarding the head of treatment and the general working methods at the ED of Deventer Hospital.

The ED physician is the primary treating physician for all emergency patients at the ED and is authorized to diagnose, initiate treatment, discharge patients, or indicate hospital admission. If necessary, the ED physician determines when a specialist should be consulted or when the head of treatment should be transferred. When a patient has recently undergone surgery or treatment for a related condition, the ED physician must always contact the treating specialist[105].

Gate specialists are required to be available for emergency patients within their field of expertise. When consulted by an ED physician, a specialist must respond within 20 minutes, except in urgent cases requiring an immediate response. Some patients arrive at the ED without an emergency indication, such as referrals from outpatient clinics due to the available facilities. In these cases, the patient falls under the responsibility of the gate specialist or their A(N)IOS rather than the ED physician. If no ED physician is present, the on-duty A(N)IOS operates under the supervision of the gate specialist, who assumes responsibility for the patient[105].

The distribution of responsibility for referred and non-referred patients is clearly defined. Non-referred patients, including those arriving via 112 or as self-referrals, always fall under the responsibility of the ED physician. Referred patients can be registered in different ways, such as through a general practitioner or specialist. Depending on the referral method and the involvement of a specialist, the head of treatment may be transferred from the ED physician to a specialist [105].

C.1.4. Communication flow within the process

In the first transfer, ambulance personnel communicate with the GP or GP-OoH when they require advice on whether a patient should be transported to the ED. During this discussion, ambulance personnel share essential details such as the patient's symptoms, vital signs, and their preliminary assessment. The GP evaluates this information and advises whether the patient needs to proceed to the ED or whether alternative care, such as a direct referral to a specialist, is sufficient. In certain situations, the ambulance may also consult hospital specialists for guidance. Although it is rare, this communication link could happen.

When the general practitioner determines that a patient needs to go to the ED, an assessment is made

to determine whether the patient can travel independently or requires ambulance transport. If the patient is unable to reach the ED on their own, the GP contacts the ambulance service to arrange transportation. However, in some cases, the GP-OoH visits the patient at home and may arrange for an ambulance if needed. Similarly, the GP can arrange ambulance transport when making home visits during regular hours.

Once the decision has been made to transport a patient to the ED, ambulance personnel inform the ZOCO about the incoming patient. This communication includes key details such as the patient's vital signs, treatments administered during transport, and the estimated time of arrival. The ZOCO uses this information to prepare for the patient's arrival by allocating resources, identifying an available treatment room, and coordinating with ED staff. At the same time, the ZOCO may consult with the receptionist to ensure that the patient is registered in the system. The receptionist plays a role by entering patient details into the hospital information system. This ensures that the patient's data is recorded and readily available for the ED care team.

When a patient is referred to the ED by a GP or GP-Ooh service, the GP may communicate directly with an ED physician before the referral. This consultation is used in complex or unclear cases, allowing the ED physician to assess whether the patient requires urgent care at the ED, should be referred directly to a specialist, or does not require hospital care. Additionally, the GP or GP-OoH can contact a specialist for further information before making a referral, ensuring that the patient is directed to the appropriate level of care.

The ZOCO, as the central coordinator within the ED, communicates closely with nurses to assign patients to treatment rooms and ensure proper staffing. Based on the patient's condition and urgency, the ZOCO informs the nurse about the incoming patient, enabling the nurse to prepare the necessary equipment and resources. The nurse is then ready to provide immediate care and assessment upon the patient's arrival.

When necessary, the ED physician consults with a specialist to discuss advanced diagnostics, treatment plans, or the possibility of bypassing the ED for direct admission to a specialized department. The specialist provides expertise on specific medical concerns and advises on the course of action, which may involve further diagnostics or specialized treatment.

D

Actors involved in IDEF0 processes

D.1. Actors involved

All of the idef0 model's actors of influence are listed below by activity.

D.1.1. Actors A1 & A2: Referring patient

The Ambulance Dispatch Center receives emergency calls made to 112 and assesses whether deploying an ambulance is necessary. It coordinates the dispatch and ensures rapid deployment of the ambulance. This actor initiates the process in emergency cases. **The Ambulance Personnel** provides first aid at the patient's location, stabilizes the patient if required, and transports them to the emergency department (ED). Upon arrival, they ensure a smooth transfer of the patient by handing over critical medical information to the ED staff. They play a crucial role in urgent cases and emergency transports.

The **Receptionist** plays an essential administrative role upon the patient's arrival at the Emergency Department. They are responsible for verifying and recording the patient's personal information and reason for visit in the hospital information system.

The **ZOCO** oversees patient flow and resource allocation within the ED. They are tasked with assigning patients to available nurses and treatment rooms based on the urgency of their condition. The ZOCO also manages incoming patient notifications from ambulance personnel. By monitoring overall patient throughput, the ZOCO ensures that the ED operates efficiently, coordinating with nurses and physicians to address capacity challenges and prioritize care delivery.

General Practitioners (GPs) assess patient complaints and determine whether referral to the ED is necessary. They may also consult with ED physicians or specialists for advice on complex cases. GPs initiate referrals in non-urgent cases or when medical issues are complex and beyond their scope. **The Out-of-Hours GP Service** functions similarly to general practitioners but operates outside regular office hours. They assess patient complaints and refer patients to the ED if needed. The GP0Ooh is particularly important for patients during evenings, nights, and weekends when primary GPs are closed.

Emergency Department Physicians receive patient information from GPs / GP-Ooh. They are involved in deciding whether a patient should be admitted to the ED and are consulted in complex situations. They also determine the patient's treatment path and may coordinate with hospital specialists for advice on specific complaints or follow-up care.

The Emergency Department Nurses are critical in providing immediate care and assessing patient needs upon arrival. They conduct initial examinations, record vital signs, and administer preliminary treatments. ED nurses document all findings and assist the ED physician by gathering diagnostic data, preparing the patient for further treatment, and ensuring continuous patient monitoring.

Hospital **Specialists** are occasionally consulted by GPs or the GP-Ooh to determine whether a patient should bypass the ED and be referred directly to a specific specialty. These specialists provide advice on immediate care for specific complaints and help guide the referral process. They are also engaged by ED physicians for further diagnosis or when specialized care is needed.

D.1.2. Actors A3: Regristration patient

The **ambulance personnel** act as the first line of care providers and are responsible for gathering initial patient information. During transport, they collect vital medical data such as the patient's vital

signs, any treatments already administered, and an assessment of the urgency of the situation. This information is then communicated digitally or verbally to the Emergency Department upon the patient's arrival.

GP or GP-Ooh as the primary referrers for patients entering the Emergency Department through non-urgent pathways. They evaluate the patient's condition and determine whether referral to the ED is necessary. As part of the referral process, they share key medical information with the ED, including the reason for the referral and the nature of the patient's complaints, enabling a seamless transition of care.

The receptionist is the first point of contact when a patient arrives at the Emergency Department and plays a crucial administrative role. They are responsible for verifying and processing the patient's personal details and medical information provided by the referrer. This data is entered into the hospital's information system.

The ED Coordinator, or ZOCO, manages the flow of patients within the department and coordinates the preparation for further steps. They assess the urgency of each case and allocate resources, such as treatment rooms and nursing support, based on priority.

D.1.3. Actors A4: Enrolling and allocating patient

The receptionist is responsible for registering and verifying the patient's details and additional information in the hospital information system. Their role involves processing administrative tasks efficiently and ensuring the accurate entry of data.

The ZOCO plays a central role in the allocation of patients to available treatment rooms and nursing staff. They assess the urgency of the patient's condition, check the availability of resources such as rooms and personnel, and ensure that patients are directed to the appropriate team for care.

D.1.4. Actors A5: Getting additional information and conducting preliminary investigations

ED Nurses are responsible for performing (re)triage and act as the primary point of contact for initial diagnostics. Their tasks include assessing patient complaints, determining the urgency of their condition, and conducting basic medical examinations. These may involve blood and urine tests, measuring vital signs such as temperature, blood pressure, and heart rate, and initiating additional diagnostic procedures, such as X-rays. All findings and actions are meticulously documented in the patient's medical record, ensuring a comprehensive overview of the patient's condition.

D.1.5. Actors A6: Diagnose treat, care for patient

The Emergency Department physician serves as the primary contact for medical diagnostics and treatment. Their responsibilities include conducting physical examinations, making an initial diagnosis, and determining the treatment strategy. They decide whether medication should be administered and coordinate the patient's overall care, including consultations with specialists. Additionally, they make critical decisions regarding the patient's next steps, such as discharge and referral to a specialist.

The Emergency Department nurse provides essential support to the medical staff and is responsible for conducting initial patient assessments and observations. They perform tasks such as measuring vital signs, drawing blood, and completing other basic diagnostic tests. All findings are documented in the patient's medical record and shared with the Emergency Department physician to facilitate further treatment.

Specialists serve as advisors and experts in specific medical areas. Their role includes offering telephonic advice to the Emergency Department physician for complex cases, as well as physically assessing patients in the Emergency Department when necessary. They also provide critical input on the patient's follow-up treatment plan. They provide advice remotely or conduct physical consultations in the Emergency Department. These specialists work collaboratively with the Emergency Department physician to determine the best treatment approach and any required follow-up actions.

D.1.6. Actors A7: Referring patient to specialist

The ZOCO is responsible for the physical and administrative transfer of patients to a nursing ward or specialist. Their tasks include accompanying the patient to the nursing ward or assisting with the handover to the nurses on that ward. The ED nurse ensures that all relevant medical information and test results are thoroughly documented in the patient's medical file. Additionally, they assist in preparing the patient for transport or discharge, which may involve connecting intravenous lines or arranging transport services.

The ED physician coordinates the medical handover of the patient and makes decisions regarding referral to a specialist or admission to a nursing ward. Their responsibilities include discussing the patient's medical condition with the specialist and jointly deciding on admission or further treatment. They document the diagnosis, performed treatments, and the treatment plan in the patient's medical record. The ED physician also provides instructions to nursing staff regarding the subsequent steps in the patient's care process.

Specialists take over patients for further diagnosis and treatment within a specialized team. Together with the Emergency Department physician, they decide on the need for admission or specific follow-up investigations. Once the patient is formally accepted into their specialty, the specialist plans the subsequent treatment trajectory and performs necessary diagnostic or therapeutic procedures as required.

Nursing ward staff are responsible for receiving patients and managing their care following admission. Their tasks include collecting patients from the Emergency Department and ensuring a warm handover. They perform initial assessments and document the patient's status upon arrival at the nursing ward. The nursing staff also prepare patients for further treatment or investigations that will be conducted within the ward.

D.1.7. Actors A8: Discharge of patient

The Emergency Department Nurse plays a vital role in ensuring a smooth discharge process for patients or, in cases of death, handling the logistical and administrative procedures. Their responsibilities include providing aftercare instructions to discharged patients, such as medication details or guidelines for ongoing care. The ED Nurse ensures that all medical records are accurately updated in the patient's file and, when necessary, prepares for the handover of care to general practitioners or specialists. In cases of death, the nurse coordinates closely with other involved parties to manage the situation appropriately.

The ED Physician is responsible for making the medical decisions regarding discharge or follow-up care. This involves confirming whether the patient is stable enough to be discharged and approving their release. The physician also determines whether further referrals to general practitioners or specialists are needed and formulates a treatment plan for any ongoing care.

The General Practitioner becomes involved post-discharge when follow-up care is deemed necessary. The general practitioner receives the patient after their discharge from the ED and continues their treatment or monitoring based on the instructions provided by the ED. Additionally, the general practitioner offers advice to the patient regarding any further steps required in their recovery process.

A Specialist provides continued care for patients who have been referred to an outpatient clinic after discharge from the ED. Specialists are responsible for taking over the patient's care, conducting additional diagnostic tests, or initiating treatment plans as needed, based on the referral from the ED. Their expertise ensures that patients receive the appropriate follow-up care for their specific conditions.

D.1.8. Summarize actors organisational involved in ED

Table D.1: Overview of actors in organisation of acute care

Actor	Falls under	Type of Actor	Relationship with Government
Ministry of Health, Welfare and Sport (VWS)	N/A	Policy maker and regulator	Responsible for national healthcare policy, legislation, and regulation.
Health and Youth Care Inspectorate (IGJ)	Falls under VWS	Healthcare quality inspector	Executive body of VWS. Monitors compliance with healthcare legislation and quality standards.
Dutch Healthcare Authority (NZa)	Falls under VWS	Healthcare cost regulator	Independent regulator under VWS. Oversees accessibility, affordability, and healthcare tariffs.
National Health Care Institute (ZiNL)	Falls under VWS	Quality institute and policy advisor	Advises VWS and develops quality frameworks, such as the Acute Care Quality Framework.
National Institute for Public Health and the Environment (RIVM)	Falls under VWS	National public health institute	Research and knowledge institute under VWS. Conduct monitoring, reporting, and crisis management.
National Network for Acute Care (LNAZ)	Independent, supported by VWS	National coordination body for acute care	Functions as a national coordinator for acute care. Supported by VWS and collaborates with ZiNL and ROAZ networks.
Dutch Society of Emergency Physicians (NVSHA)	Independent	Professional association for emergency physicians	Independent professional association. Collaborates with policymakers but is not directly under VWS.
Dutch Federation of University Medical Centers (NFU)	Independent	Federation of university medical centers	Independent organization, collaborates with VWS and ZiNL on quality improvement and research in academic hospitals.
Federation of Medical Specialists (FMS)	Independent	Professional organization for medical specialists	Independent organization. Receives indirect support through collaborations with VWS and ZiNL.
Regional Consultations on Acute Care (ROAZ)	Coordinated by LNAZ	Regional consultation body	Functions at the regional level under the coordination of LNAZ. Collaborates with hospitals, GP out-of-hours services, ambulance services, and VWS.

Continued on next page

Table D.1 – continued from previous page

Actor	Falls under	Type of Actor	Relationship with Government
Acute Care Network Zwolle Region	Falls under ROAZ	Regional care network	Functions as part of the ROAZ in the Zwolle region. Collaborates with regional hospitals and primary care.

Table D.2: Organisational stakeholders in the ED and their responsibilities

Stakeholder	Role and Responsibilities
Operational Manager	Responsible for the operational management of the team, including staff deployment, efficient resource allocation, and adherence to procedures and protocols.
Supervisory Board	Oversees policies and overall hospital operations, including ED performance and compliance with healthcare standards.
Executive Board	Consists of the Patient Council (PAR), Works Council (OR), and Nursing Advisory Council (VAR), which respectively represent the interests of patients, employees, and nurses in policy decisions.
Ministry of Health, Welfare, and Sport (VWS)	Establishes national healthcare frameworks and monitors the accessibility, quality, and affordability of care, including emergency care in the ED.
Dutch Association of Emergency Physicians (NVSHA)	Represents ED physicians and develops clinical guidelines and protocols to promote safe and standardized care.
Health Insurers	Responsible for financing and reimbursing ED treatments to ensure affordable and accessible care for patients.
Regional Consultation for Acute Care (ROAZ)	Coordinates acute care within the region by facilitating collaboration between EDs, GP out-of-hours services, and ambulance services.
Health and Youth Care Inspectorate (IGJ)	Supervises the quality, safety, and accessibility of healthcare, ensuring compliance with standards and procedures within the ED.

E

Data analyses current situation

This appendix illustrates the snapshot week times for each patient group and the logistical regression results. In addition, it shows the dummy variable for the complaints of the the possible patients that can be redirected.

E.1. Time ED

Below, the graphs for each patient category are presented.

Time of patient on ED

Figure E.1 shows the average length of stay per day in the Emergency Department for 2025, with fluctuations throughout the week. The length of stay is highest on Monday, Wednesday, and Friday, while it is significantly lower on Saturday and Sunday, with an overall average of 149.53 minutes marked by the red dashed line.

Figure E.1: Average time of patient on ED during snapshot week

Figure E.2 displays the average length of stay per day for patients who should not have been seen in the ED in 2025, with an overall average of 125.66 minutes marked by the red dashed line. The length of stay is highest on Wednesday, while it is significantly lower on Thursday, with a gradual increase towards the weekend.

Figure E.2: Time of patient in ED of patients who could have possibly been redirected

Figure E.3 shows the average length of stay per day for patients who definitely required emergency care in 2025, with an overall average of 150.68 minutes marked by the red dashed line. The length of stay is highest on Monday, gradually decreases towards Thursday, peaks again on Friday, and reaches the lowest point on Sunday.

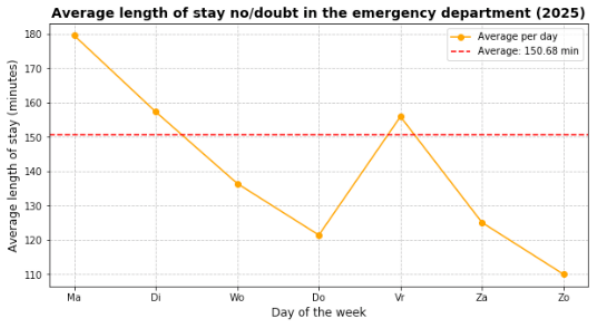

Figure E.3: Time of patient in ED of patients who could have possibly been redirected with the doubt cases

Time till patients are seen by physician

Figure E.4 shows the average time until a patient is seen by an emergency room physician per day in 2025, with an overall average of 33.76 minutes marked by the red dashed line. The wait time is highest on Friday, while Thursday has the shortest wait time, and other days fluctuate around the average.

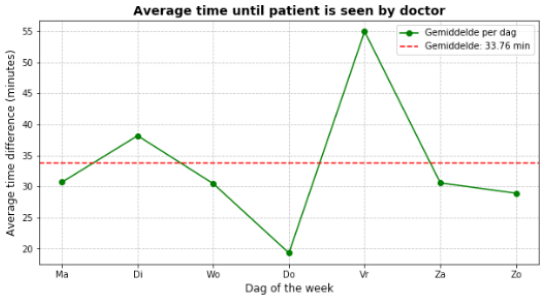

Figure E.4: Average time until patient seen by emergency room physician

Figure E.5 shows the average time until a patient is seen by an emergency room physician per day in 2025, with an overall average of 46.60 minutes marked by the red dashed line. The wait time is significantly higher on Thursday, while other days fluctuate around the average, with Sunday showing a lower wait time.

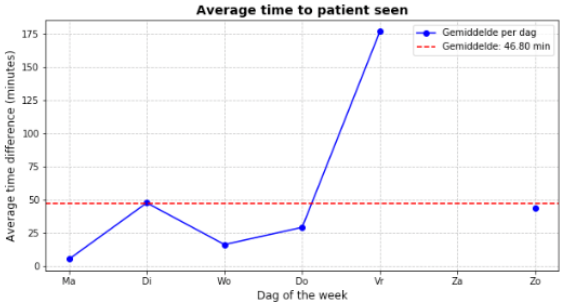

Figure E.5: Average time until (no) patient seen by emergency room physician

Figure E.6 shows the average time until ”no and doubt” patients are seen by an emergency room physician per day in 2025, with an overall average of 34.29 minutes marked by the red dashed line.

The wait time is highest on Monday, Tuesday, and Friday, while it is lowest on Sunday, with fluctuations on other days.

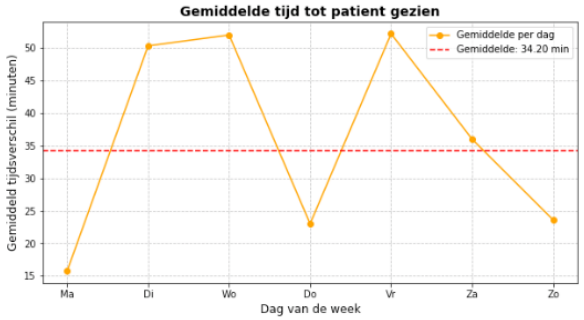

Figure E.6: Average time until (no and doubt) patient seen by emergency room physician

E.2. Logistic regression results

Despite these refinements, a reassessment of the model indicated that statistical significance remained limited. This suggests that, within the scope of this analysis, the selected patient characteristics did not provide strong predictive value in distinguishing between patients who required treatment in the ED and those who could have been redirected to an alternative healthcare facility. Figure Figure E.7 shows the remaining variables after excluding those with the least statistical contribution.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Vervoerder			,107	2	,948	
	Vervoerder(1)	19,238	17974,842	,000	1	,999	226455853,08
	Vervoerder(2)	,152	,465	,107	1	,744	1,164
	Seh_bestemming_omschrijving			,959	5	,966	
	Seh_bestemming_omschrijving(1)	-19,806	28411,320	,000	1	,999	,000
	Seh_bestemming_omschrijving(2)	-19,168	28411,320	,000	1	,999	,000
	Seh_bestemming_omschrijving(3)	,070	40186,322	,000	1	1,000	1,072
	Seh_bestemming_omschrijving(4)	-17,488	28411,320	,000	1	1,000	,000
	Seh_bestemming_omschrijving(5)	,070	49220,706	,000	1	1,000	1,072
	Opname_indicator	-,008	2,108	,000	1	,997	,992
	Constant	21,133	28411,320	,000	1	,999	1506330024,7

a. Variable(s) entered on step 1: Vervoerder, Seh_bestemming_omschrijving, Opname_indicator.

Figure E.7: Logistical regression results

Figure E.7 presents the results of a logistic regression analysis, incorporating mode of transportation, ED destination, and admission indicator as predictive variables. The coefficient estimates (B) and their standard errors (S.E.) indicate that none of the variables is statistically significant ($p>0.05$), suggesting that these characteristics do not provide strong predictive value in determining whether a patient should have been treated in the ED or could have been redirected to an alternative care setting. The relatively high standard errors observed for some variables may indicate limited variation in the dataset or low representation of certain categories, which could affect the stability of the estimates. This indicates that

additional refinement of the model, including reevaluating variable selection or augmenting the dataset, may be essential for achieving a more accurate evaluation of the factors affecting patient redirection.

E.2.1. Recoding variables

One of the main challenges identified was the large number of dummy variables, particularly for patient complaints, which initially resulted in 164 separate dummy variables. This increased the model complexity without contributing to statistically meaningful results, potentially obscuring broader trends within the dataset.

The classification of patient complaints was amended following an analysis performed in conjunction with an expert. This analysis indicated that certain types of complaints were more frequently observed, indicating a notable pattern (see E.3). As a result, three overarching, clinically relevant categories were established: (1) fractures and bone injuries, (2) postoperative complications, and (3) wound-related conditions. This restructuring aimed to reduce redundancy while preserving meaningful distinctions between patient groups. A fourth group, consisting of all other complaints, was initially defined; however, this residual category was excluded from the final analysis as it did not yield statistically significant results in the logistic regression.

Furthermore, to strengthen the analysis, the classification of non-suitable patients was modified by including those previously classified as uncertain. By merging this category with the existing non-suitable classification, the dataset was expanded. This adjustment was intended to improve the reliability of the analysis by mitigating the risk of small sample sizes within individual categories.

After these enhancements, a new logistic regression analysis was performed, integrating the amended complaint categories and the broadened classification of non-eligible patients. The logistic regression analysis failed to identify statistically significant predictors for ascertaining which patients are inappropriate for the ED, as illustrated in Figure E.8.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Opname_indicator	,891	,324	7,555	1	,006	2,438
	Fractures	,602	,564	1,139	1	,286	1,825
	post	-,951	,657	2,096	1	,148	,386
	Time_Slot=Afternoon	-19,428	7773,700	,000	1	,998	,000
	Time_Slot=Evening	-19,609	7773,700	,000	1	,998	,000
	Time_Slot=Morning	-19,284	7773,700	,000	1	,998	,000
	Constant	20,759	7773,700	,000	1	,998	1036510805,9

a. Variable(s) entered on step 1: Opname_indicator, Fractures, post, Time_Slot=Afternoon, Time_Slot=Evening, Time_Slot=Morning.

Figure E.8: Logistical regression with dummy variables of complaints

Among the included variables, the Admission Indicator was found to have a statistically significant effect ($p = 0.006$), with a B of 0.91. This suggests that patients who were admitted had a higher likelihood of being classified as appropriate for the ED. This finding aligns with the expectation that admitted patients are generally considered more urgent and, therefore, more likely to require emergency care. This is further supported by the observation that approximately 65% of patients who could have been redirected were not admitted, reinforcing the notion that non-admitted patients are more frequently categorized as potentially redirectable.

In contrast, the variables indicating fractures, postoperative complications, and wound-related conditions were not statistically significant, as their p-values exceeded the 0.05 threshold. This indicates that these complaint categories did not provide a strong predictive value in determining whether a patient should be classified as appropriate for the ED. Although the B value for post (-0.951) suggests a slightly increased likelihood of admission, this effect was not statistically significant. The time slot variables for

morning, afternoon, and evening displayed exceedingly high p-values of 0.998, signifying that these time categories had no substantial impact on patient classification.

As no statistically significant predictive patterns were discerned for patients potentially misallocated in the ED, it is unfeasible to assess accurately the annual impact of patient redirection. Nonetheless, considering the significant percentage of patients deemed potentially suitable for redirection, additional investigation into the feasibility and consequences of patient redirection is pertinent.

E.3. Diagnoses from patients who can be diverted and the doubt cases

Below, the diagnoses are shown for patients who did not require Emergency Department care and for those where there was uncertainty about whether the Emergency Department was the appropriate setting. The characteristics of these diagnoses are also mapped out.

E.3.1. Complaints

```
CVA_015                                                  4
algehele malaise_302                                     4
overig traumatisch letsel_208                            3
infectie post OK/ingreep_502                             3
buikpijn_305                                             3
infectie huid / wond / abces_316                         2
dyspneu_309                                              2
longembolie_051                                          2
bloedneus (spontaan)_011                                 2
problemen catheter/shunt/sonde/drain/stoma/PAC_329       2
sinus piloidalis_079                                     2
rectaal bloedverlies_331                                 1
# enkel                                                 1
dehydratie_307                                           1
compressie # L1                                          1
opname /overplaatsing_801                                1
hoofdpijn_313                                            1
infectie teen                                            1
#enkelR                                                  1
pneumonie_067                                            1
DVT_020                                                  1
epileptisch insult_023                                   1
pancreatitis_061                                         1
artritis_007                                             1
Radiuskop# rechts                                        1
Klinische beoordeling re elleboog                        1
avulsie fractuur dig 2                                   1
krachtsverlies_049                                       1
sepsis eci_078                                           1
overige klacht_802                                       1
wond_207                                                 1
nabloeding OK_504                                        1
appendicitis_005                                         1
overige klachten post OK/ingreep_507                     1
bloedverlies                                             1
koorts_321                                               1
aangezichtsletsel                                        1
panaritium/paronychia_060                                1
trauma capitis_127                                       1
polsletsel_121                                           1
nierinsuffici□ntie                                       1
controle infectie / wond / abces_603                     1
Name: Seh_bezoek_klacht, dtype: int64
```

Figure E.9: Diagnoses, no patients and doubt patients

In consultation with experts, three categories have been identified from the data that appear to occur more frequently. These categories, postoperative issues, wound-related complaints, and fractures, are examined to determine their significance in recognizing patterns. Below is a representation of their percentages over the entire measurement week, which will be used to create dummy variables.

E.3.2. Complaints

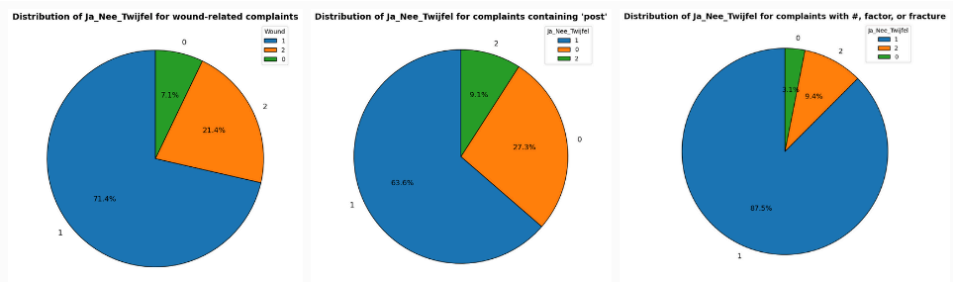

Figure E.10: Percentage wound, post OK and fracture

Figure F.8 presents the distribution of patient classifications for three complaint categories: wound-related complaints, postoperative issues, and fractures. Each pie chart displays the proportion of patients classified as requiring Emergency Department care (1 - blue), those assessed as potentially suitable for redirection to alternative care settings (0 - orange), and cases where there was uncertainty about the appropriate care pathway (2 - green).

For wound-related complaints, 71.6% of patients were classified as requiring ED care, while 27.8% were assessed as potentially redirectable, and 7.2% fell into the uncertain category. In the postoperative complaints category, 63.6% were deemed appropriate for ED care, 27.3% were considered for redirection, and 0.1% were classified as uncertain. For fracture-related complaints, the majority (81.7%) required ED care, 9.9% were identified as potentially redirectable, and 5.9% were categorized as uncertain.

F

Interviews

This chapter presents the structure of the interviews. Additionally, the key quotes used as supporting evidence are listed per interview category.

F.1. Interview setup

The structure of the interviews is outlined below. As all interviewed actors are Dutch, the interview structure is also presented in Dutch.

F.1.1. 1. Introductie

Voor mijn masterthesis in engineering policy analysis voer ik onderzoek uit naar de optimalisatie van de Spoedeisende Hulp (SEH). Ik ga mogelijke interventies onderzoeken die binnen de SEH toegepast kunnen worden en hoe deze eruit moeten zien. Hierbij ben ik vooral geïnteresseerd in de percepties van betrokken actoren over het proces van de patiëntenstroom op de SEH.

Doel van het Interview: Tijdens dit interview wil ik graag inzicht krijgen in de meningen van degenen die betrokken zijn bij de SEH. Het onderzoek richt zich op hoe wordt gedacht over waar patiënten worden gezien en of zij altijd op de juiste plek worden behandeld.

Opbouw van het interview zal er als volgt uitzien.

- Eerst zullen er een aantal algemene vragen worden gesteld waarbij uw mening gevraagd zal worden.
- Daarna zal er wat data worden laten zien, met daar een aantal vragen over.
- En tot slot zal er een hypothese worden geschetst met daar een aantal vragen bij.

F.1.2. 1. Perceptie over patiënten op de SEH

- Denkt u dat patiënten altijd op de juiste plek worden gezien, het gaat hierbij specifiek over patiënten die op de SEH worden gezien?
- Zo ja, kunt u aangeven om welke patiënten het in uw beleving gaat welke type patiënten vallen hieronder?
- Zo ja, waarom komen volgend u deze patiënten op de SEH terecht?
- Wat zou volgens u een oplossing zijn?

F.1.3. 2. Reflectie op data-analyse

Voor het onderzoek is voor een week lang bijgehouden of patiënten volgens de SEH-artsen thuis horen op de SEH of niet. Hier kwam naar voren dat er gemiddeld 15% van de patiënten die binnen komen op een andere plek gezien hadden kunnen worden. Dit gaat om ongeveer 50 patiënten per week. Deze patiënten hadden bijvoorbeeld bij de huisarts gezien kunnen worden, op de poli of op de spoedpoli.

Patiënten die hier onder vallen hebben bijvoorbeeld zelf 112 gebeld, maar hadden ook naar de HAP gekund. Vallen niet onder spoed. Of behoren op de spoedpoli thuis.

- Hoe kijkt u naar deze gegevens? Komt dit overeen met uw verwachting of wijkt het af?
- Waarom denkt u dat in sommige gevallen patienten toch op de SEH terecht komen?

- Wat zou u veranderen om deze patiënten niet op de SEH te laten komen?
- Wie moeten betrokken worden
- Welke Regelgeving moet veranderd worden
- Wat moet er veranderen aan de Communicatie tussen de betrokken actoren
- Wat zijn mogelijke belemmeringen voor deze verandering?
- Hoe denkt u dat andere partijen hier tegen deze aantallen aan kijken?

F.1.4. 3. Hypothese

Stel dat een deel van deze patiënten worden omgeleid en rechtstreeks op de (spoed) poli worden gezien, zonder eerst langs de SEH te gaan. Dit zouden dan ongeveer 2/3 patienten extra op de spoed-poli zijn in de week. Hierdoor zouden de patiënten sneller op de juiste plek zijn waardoor ze niet op plekken hoeven te wachten/ onderzocht hoeven worden waar ze volgens het onderzoek niet thuis zouden horen. Ze hoeven hierdoor niet langs de SEH wat het proces voor de patiënten zou versnellen.

Voor- en nadelen van patiëntomleiding:

- Wat is uw perceptie van deze hypothese
- Wat zou volgens u moeten veranderen aan de regelgeving
- Wat zou volgens u moeten veranderen aan de onderlinge communicatie
- Wat zouden voor u de voordelen zijn van een omleiding van patiënten die niet langs de SEH gaan?
- Wat zouden mogelijke nadelen voor u zijn als de patiënten niet op de SEH worden gezien?
- Zouden er volgens u risico's verbonden zijn aan het omleiden van de patiënten?
- Hoe kunnen we ervoor zorgen dat de voordelen opwegen tegen de nadelen? Welke randvoorwaarden moeten worden gewaarborgd?
-

F.1.5. Afsluiting

- Zijn er nog andere opmerkingen of inzichten die u wilt delen?