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**Emergency department flow —
patterns, predictors and patient outcomes**

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Abstract

Background: Emergency departments (EDs) must balance timely care, safety, and resource utilization. Emergency department length of stay (EDLOS) is widely used as a proxy for ED performance, yet it primarily reflects elapsed time whose clinical meaningfulness depends on patient case-mix and context. **Aim:** The overall aim was to develop a deeper understanding of patient flow in Swedish EDs, with particular focus on process determinants of EDLOS and on patient groups at greatest risk of poor outcomes. **Methods:** Four studies were undertaken. Study I was a concept analysis of “long EDLOS”. Study II was a retrospective observational study of 222,047 ED visits from two hospitals, estimating the impact of input-, throughput and output factors on EDLOS. Study III examined high-frequency ED users (HEDU) at a university hospital (121,403 visits), assessing prevalence, costs, and process outcomes. Study IV linked national registries across 5,049,641 ED visits from 15 sites (2015–2023) to analyse associations between EDLOS and adverse outcomes. **Results:** Long EDLOS is often used as a proxy for other phenomena. Throughput processes were the dominant factors impacting EDLOS. HEDU comprised 6.1% of patients but accounted for 22.4% of visits and a disproportionate share of costs. In Study IV, absolute EDLOS displayed a non-linear association with mortality, with elevated risk at very short stays. Patients with non-specific complaints were vulnerable to extended EDLOS. **Conclusions:** EDLOS is a useful metric, but when dichotomized, blunt and imprecise. Patient flow in the ED is not necessarily a reflection of levels of crowding and access block. Deviations from the expected EDLOS — whether longer or shorter — better predict adverse outcomes than absolute duration, highlighting the need for contextualised patient-centred performance metrics.

Keywords: emergency department; patient flow; ED length of stay (EDLOS); frequent users; mortality; unplanned revisits; registry linkage

“The two most powerful warriors are patience and time”

Leo Tolstoy

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List of papers

This thesis is based on the following studies, referred to in the text by their Roman numerals.

- I. Long emergency department length of stay: A concept analysis. Andersson J, Nordgren L, Cheng I, Nilsson U & Kurland L. *Int Emerg Nurs*. 2020 Nov;53:100930.
- II. Length of stay in the emergency department and its associated input-, throughput-, and output factors at two hospitals in Sweden. Andersson J, Kurland L, Nordgren L, Gusdal AK & Cheng I. *BMC Emerg Med*. 2025 Jul 15;25(1):120.
- III. An observational pilot study: Prevalence and cost of high frequency emergency department users at Örebro University Hospital, Sweden. Cheng, I, Andersson, J, Lundqvist, C & Kurland, L. *PLoS One*. 2022 Sep 15;17(9)
- IV. Emergency department length of stay and adverse outcomes before, during and after the Covid-19 pandemic – associations tested using register linkage. Andersson J, Nyberg F, Huiqi L, Cheng I., Gusdal AK & Kurland L. In manuscript.

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Introduction

The emergency department (ED) is sometimes portrayed as a dangerous place. One that should be avoided at all costs and if unavoidable, time spent there should be minimized. This view is reinforced by media reporting anecdotal patient experiences of overcrowded waiting rooms. It is reinforced by public service announcements from healthcare professionals trying hard to clarify the cases where you shouldn't utilize the ED. It is also reinforced by an overwhelming body of scientific evidence highlighting the burden of increasing ED attendance and the consequences of ED crowding.

However, the ED is also a place where lives are saved, pain and suffering are alleviated, and comfort and reassurance are given. For many patients, it represents the only point of access to urgent care, regardless of time of day or ability to pay. It is where critical interventions occur, where uncertainty is managed, and where the healthcare system demonstrates its capacity to respond to acute need. Still, discussions about the ED often reduce it to a bottleneck, or just a barrier between the patient and definitive treatment. This perspective overlooks its essential role as a dynamic, adaptive environment — staffed by highly skilled healthcare professionals — who deliver life-saving care under pressure.

To improve emergency care, we must move beyond this narrow view and embrace a narrative that recognizes the ED not merely as a point of delay, but as a cornerstone of modern healthcare systems. Personally, I believe this can only be done if we as healthcare professionals and researchers turn the lens inward. We must be willing to critically examine our workflow practices, acknowledge that we do not always get it right, and commit to doing better where we can. This openness is essential if we are to deliver care that meets both clinical and human needs.

1 Background

An emergency department (ED) is a specialized hospital unit designed to provide immediate assessment, stabilization, and treatment for patients with acute illness or injury (1). Ideally, it operates 24 hours a day as the primary point of access for urgent and unscheduled care, serving individuals across all age groups and clinical presentations, from minor injuries to life-threatening emergencies (2). The ED functions as a critical interface between community care and inpatient services, combining rapid diagnostics, multidisciplinary expertise, and time-sensitive interventions in an environment characterized by unpredictability and high patient turnover (3). Its purpose is not only to deliver emergency treatment but also to manage uncertainty, prioritize care based on acuity, and ensure safe transitions within the broader healthcare system (4).

1.1 Emergency Care in Sweden

Sweden provides emergency care within a tax-funded universal healthcare system, which guarantees access to emergency services for all residents at low out-of-pocket cost (5). Compared to most OECD countries, Sweden has one of the lowest numbers of hospital beds per capita, a trend that has persisted for decades (6). Emergency medicine is a relatively young specialty in Sweden, formally recognized as a primary medical specialty in 2012 (7), and many EDs still operate under hybrid staffing models where rotating physicians from various specialties provide care alongside a limited number of emergency medicine consultants (8). Emergency nursing is also a young specialization, only gaining partial formal recognition in 2013, through the addition of the “certain other orientation” to the list of recognized nursing specialist degrees (9). To this day, a substantial part of the nursing staff at Swedish EDs are Registered Nurses, without formal education in emergency care.

Although Sweden has national laws and regulations governing healthcare delivery (10, 11), there are no national guidelines specifying how emergency department services should be organised. As a result, organisational structures and resource allocation vary across

regions, influenced by local policies, population needs, and hospital capacity. Urban regions typically have higher patient volumes and more specialized services, while smaller regions may experience different patterns of ED patient flow (8).

In Swedish emergency care, certain patient groups are routinely redirected from the ED based on their presenting complaint. Patients presenting with conditions assessed as psychiatric are, to a large extent, managed at dedicated psychiatric EDs, which operate 24 hours a day, seven days a week. Other categories, such as gynaecology, ear-nose-throat, and paediatrics, may be redirected during specific hours or days, but are commonly managed in the ED outside regular office hours. These practices influence the overall case-mix and should be taken into consideration when interpreting the study findings and assessing their generalizability.

1.2 Quality of Emergency Care

The World Health Organization (WHO) defines quality of care as the degree to which health services increase the likelihood of desired health outcomes and are consistent with evidence-based professional knowledge. According to WHO, quality health services should be effective, safe, people-centered, timely, equitable, integrated, and efficient (12). Sweden spends approximately 60,000 SEK per capita annually on healthcare, 11% of GDP, placing it among the top five OECD countries in health expenditure (13). With 86% of costs financed through regional and municipal taxes, monitoring efficiency and quality is essential (14). Among the many indicators of ED performance, one stands out: ED length of stay (EDLOS), the interval between arrival and departure (15). On the surface, EDLOS appears to reflect only the timeliness dimension of quality, but extensive research shows it is also linked to safety and efficiency (16-18). By virtue of its simplicity and availability, this makes EDLOS a powerful proxy for overall quality of care. EDLOS is not just an isolated metric of duration: it reflects the tempo of patient flow through the emergency department — an important but sometimes vilified aspect of ED operations (19).

1.3 Patient Flow

Patient flow ultimately unfolds as time: every interaction, delay, and intervention is experienced and recorded in minutes and hours. To understand flow, this fundamental dimension must be explored — not only as an objective measure, but as something perceived and felt by patients and clinicians alike.

1.3.1 Time

Time is often treated as an objective, measurable entity: seconds, minutes, and hours ticking away at a constant pace. From a physical perspective, this uniformity is foundational to how we structure processes and measure efficiency. A minute is sixty seconds, neither more nor less. However, human experience reveals a different truth: time is profoundly relative. Psychological research shows that our perception of time is shaped by attention, emotion, and context; moments of engagement or comfort can feel fleeting, while states of uncertainty or discomfort make even minutes seem like an eternity (20). This subjective relativity becomes especially relevant in healthcare settings, where episodes of pain or severe illness can make time feel as though it slows down or even stands still. The perceived acuity and demands of a health condition, can exacerbate consciousness of the passage of time (21). In the ED, patients rarely perceive time as neutral; instead, they experience waiting in sterile examination rooms as isolating and timeless. The lack of sensory stimulation and uncertainty about when care will resume can heighten feelings of abandonment and anxiety, and the absence of information amplifies frustration and distress (22).

1.3.2 Waiting

Waiting can be defined as a stationary, and unspecified time frame phenomenon, characterized by an uncertainty regarding personal outcomes, but for the definite purpose of something expected (23). This expectation gives waiting its purpose, yet also its tension: the individual is suspended between the present and an uncertain future. Unlike active engagement, waiting often involves diminished agency, where control over timing or outcome lies elsewhere. It is a state characterized by vulnerability, shaped by context and perception rather than

by the actual passage of clock time (24). The experience of waiting can therefore vary dramatically; what is objectively brief may feel never-ending when coupled with anxiety or discomfort. Understanding waiting as both a temporal and experiential phenomenon is essential before considering its specific manifestations in healthcare settings such as the ED (25).

Even though time spent in the ED can be filled with active treatment and care, the full passage of time between arrival and departure has often been referred to as ‘waiting’. This has been done both by media and in scientific research (26-28). However, in most of the recent scientific publications there is a tendency to use more specific time intervals in reference to waiting, such as door-to-provider: reflecting the time between patient arrival and the first assessment by a physician, or disposition-to-departure: measuring the interval between disposition decision and when the patient physically leaves the ED (29).

Regardless of definition, the concept of waiting inevitably accompanies ED length of stay — and the inherent passiveness and uncertainty that waiting implies, makes increased EDLOS a convenient proxy for inefficiency and reduced quality of care. Research suggests that prolonged EDLOS can negatively influence patient satisfaction, not only because of the physical discomfort associated with extended stays but also due to the psychological burden of uncertainty and perceived neglect (17, 22, 30). Patients frequently interpret longer stays as a sign of systemic inefficiency or low prioritization, which can erode trust in the healthcare system. Conversely, shorter EDLOS is generally associated with higher satisfaction scores, which can be clearly visible by comparing publicly reported data on EDLOS and wait times (31) to patient satisfaction surveys performed at the same sites (32) (Figure 1). While patient satisfaction is not necessarily the most comprehensive indicator of quality of care, it has been shown to correlate closely with other established measures of quality and safety (33).

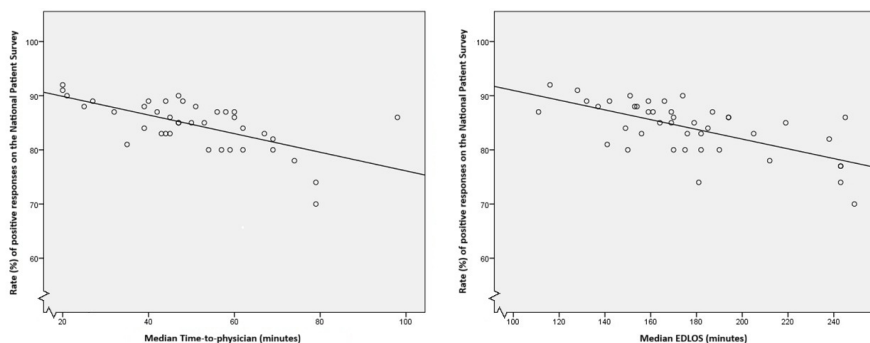


Figure 1 — Each dot on the graphs represents an individual Swedish ED, its respective median waiting time on the x-axis and the rate of positive responses according to the National Patient Satisfaction Survey on the y-axis.

1.3.3 Crowding

ED crowding is a pervasive and complex issue that significantly impacts patient flow and the overall quality of care. It occurs when the demand for ED services exceeds the department's capacity to provide timely care (34), leading to increased waiting, prolonged patient stays, and compromised patient outcomes, such as increased morbidity and mortality (35). Crowding is often the result of various factors, including surges in patient volumes, a shortage of available treatment spaces, and challenges in discharging admitted patients to inpatient units. This phenomenon not only poses risks to patient safety but also strains healthcare resources and staff, potentially affecting the ED's ability to respond efficiently to emergencies (36).

In multiple systematic reviews, EDLOS was found to be one of the most utilized measures of crowding, due to its availability and its potential to be generalized across different sites. It was also concluded to be a useful measure, due to the close relationship between patient flow and crowding (37, 38). A series of studies conducted in Sweden recently found that ED crowding was associated with increased mortality, when adjusted for baseline co-morbidity (39). The association was more prominent in sub-group analysis of admitted patients in counties with high average hospital bed occupancy (40).

1.4 Patient Flow Dichotomized

Efficiency and timeliness are critical factors in emergency care, where swift interventions can significantly impact patient outcomes (17). With the aim to ensure that patients receive timely care, many EDs globally have implemented time-targets (41). These time-targets are specific benchmarks or goals that healthcare providers strive to achieve at various stages of the patient journey within the ED. Time-targets in the ED are designed to optimize patient flow, improve resource allocation, and enhance the overall quality of care (42-44).

Since the earliest implementations of time-targets in the UK in 2001 (42), they have been both questioned and praised, and in a recent systematic review it was concluded that they had both negative and positive effects on the timeliness and quality of emergency care (45). In Sweden, a national time target for EDLOS has never been implemented. However, the Swedish National Board of Health and Welfare used the 4-hour benchmark, reported as proportion of visits with an EDLOS below 4 hours, from the beginning of EDLOS monitoring in 2010 through 2015 (46, 47). The Swedish Association of Local Authorities and Regions (SKR) still use this benchmark today (48).

While dichotomizing continuous measures is often criticized for discarding information and increasing error rates (49), there are pragmatic reasons to use clear cut-offs in emergency care. Thresholds can accelerate risk stratification, support standardized protocols and eligibility decisions, and simplify interpretation when rapid action is required. This is especially relevant when the cut-point corresponds to a biologically or clinically meaningful threshold (50, 51). At the same time, methodological cautions are well documented: outcome-based “optimal” cut-points can inflate type I error, overstate effect sizes, reduce statistical power, and fail to replicate across settings (49, 52). Taken together, these arguments justify the practical use of dichotomization in time-critical contexts while underscoring the need for transparent justification of thresholds and complementary analyses that consider the full continuous distribution. The unresolved question, however, is whether EDLOS: an aggregate of active care and waiting, shaped by clinical complexity and organisational processes, truly lends itself to a single universal cut-off; evidence to date is

mixed, indicating a knowledge gap about when, and for whom, dichotomizing EDLOS is clinically relevant.

1.5 Patient Flow Conceptualized

Although EDLOS has often been employed as a proxy for various aspects of emergency care — such as waiting, crowding, and just quality in general — it is, in its most literal sense, simply a time interval. Conceptually, however, EDLOS may be most accurately understood as an indirect measure of patient flow, reflecting one of two key components of ED flow, i.e. the dynamics of throughput and system performance within the emergency care system. The other key component being ED attendance (53-55) (Figure 2). This interpretation of EDLOS as a reflection of patient flow aligns closely with the conceptual framework proposed by Asplin et al., who describe emergency department operations through the interconnected domains of input, throughput, and output (56).

The “Input-Throughput-Output”-model is a foundational theoretical framework widely utilized in ED research, particularly in the study of ED crowding. This model provides a comprehensive lens through which one can examine and understand the intricate dynamics of patient flow within EDs. In essence, the "Input-throughput-output" model serves as a valuable tool for both researchers and healthcare practitioners engaged in the study and management of patient flow in the ED. Its structured approach enables a more comprehensive assessment of ED operations and facilitates evidence-based decision-making to enhance the overall quality of care provided in this critical healthcare setting (57).

1.5.1 Input

The input component represents the entry point of patients into the ED. It encompasses various factors, including the number and acuity of incoming patients, their demographics, the nature of their medical conditions, and the timing of their arrivals. Understanding the input is essential because it sets the stage for the entire patient flow process within the ED (56). In Sweden, overall ED attendance has remained stable or even declined in recent years, while average EDLOS has

gradually increased (58) (Figure 2). This development suggests that changes in patient characteristics — such as an ageing population and a higher prevalence of multimorbidity and frailty — may influence the complexity of care required (59). A further temporary but pronounced shift occurred during the COVID-19 pandemic, when ED attendance dropped sharply (Figure 2) and case-mix changed abruptly, with fewer low-acuity presentations and a higher proportion of severely ill patients (60). Such shifts in case mix can affect diagnostic and treatment processes, even when the total number of arrivals does not rise (61, 62).

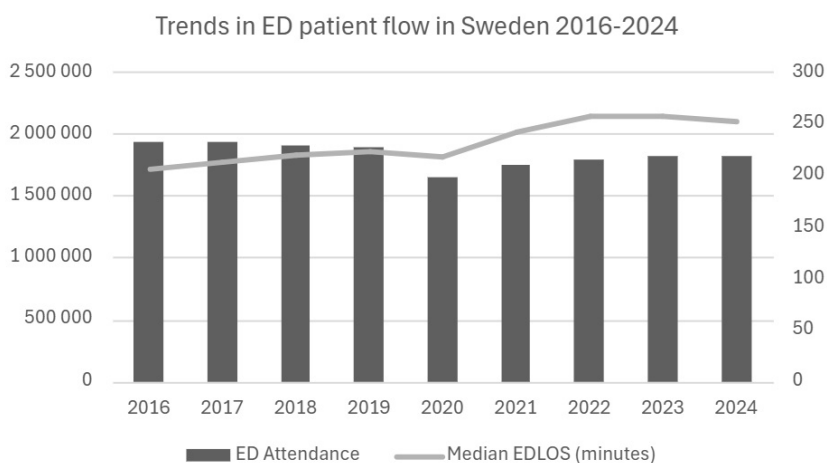


Figure 2 — Statistics from the Swedish National Board of Health and Welfare (58) on yearly attendance (excluding patients aged 18 and younger) and median EDLOS.

Another possible explanation for prolonged EDLOS is the assumption that an increasing proportion of patients attending EDs have non-urgent or even inappropriate conditions, meaning their medical needs are not severe enough to require emergency care (63, 64). Reasons for seeking ED care for non-urgent issues vary and may include convenience, perceived urgency, fear of serious symptoms, or limited access to primary healthcare (65). Non-urgent patients often experience lower quality of care (66) and some develop persistent patterns

of healthcare-seeking behaviour, classifying them as high-frequency ED users (67). Numerous interventions aimed at reducing non-urgent ED visits over the past decades have largely proven ineffective (68). However, experiences during the COVID-19 pandemic have demonstrated promising potential for reducing avoidable ED attendance (69).

International evidence suggests that high-frequency ED users (HEDU) account for a disproportionate share of visits and costs (67, 70), yet Swedish research on this topic has been scarce. Previous studies were limited to a few older investigations (71, 72) and one focusing exclusively on older adults (73), leaving a gap in understanding the characteristics, resource use, and potential impact of HEDU on patient flow and EDLOS in contemporary Swedish settings. Intervention studies internationally have largely converged on three approaches: case management, individualized care plans, and information-sharing systems. Of these three approaches, case management — utilizing patient centred solutions focusing on integrating primary care and community services — has shown the most consistent, though still modest, evidence base (74).

1.5.2 Throughput

The throughput component of the model represents the processes and activities that occur within the ED to assess, diagnose, treat, and disposition patients. It includes clinical assessments, diagnostic testing, treatment interventions, and the coordination of care (75).

One fundamental aspect of managing patient flow within the ED is the process of triage. Triage, derived from the French word "trier" meaning to sort, is a crucial initial step in assessing and prioritizing patients based on the severity of their conditions (76). Triage nurses and other healthcare professionals use standardized assessment tools, such as the Emergency Severity Index (ESI) (77), the Manchester Triage System (MTS) (78) or the Rapid Emergency Triage and Treatment System (RETTTS) (79), to quickly evaluate patients' vital signs, symptoms, and medical histories. This central process aims to ensure that the most critically ill or injured patients are promptly seen by

healthcare providers, while those with less severe conditions may experience longer wait times (80).

In the Swedish ED setting RETTS is widely used. It is a five-level acuity scale, originally inspired by the MTS, that in addition to prioritizing patients, also offer guidance on patient flow logistics (81). RETTS offers structured guidance for immediate clinical actions and provides recommendations that support the organisation of care processes and patient flow (82). For example, certain chief complaints trigger predefined sets of laboratory analyses, which can be initiated early in the ED process. This structured approach aims to standardize care and expedite decision-making, but it also means that triage decisions directly shape resource allocation and throughput dynamics within the ED. As a result, concerns have been raised about potential unintended consequences. The American Academy of Emergency Medicine has cautioned that triage-triggered test orders may contribute to an overall increase in laboratory utilization (83). In addition, simulation modelling has identified over-testing as a potential unintended consequence of triage standing-order protocols (84), and organisations such as the Choosing Wisely initiative have highlighted the associated risks of patient harm and the cost-driving effects of routine laboratory testing (85).

Beyond triage, throughput encompasses the full spectrum of processes that occur within the ED to assess, diagnose, and treat patients before disposition. Among these, diagnostic testing and imaging are consistently identified as major determinants of EDLOS in international research. Studies from North America and Australasia have shown that laboratory panels and radiologic investigations, particularly computed tomography and ultrasound, add substantial time to ED encounters (86-88). While point-of-care testing can mitigate some delays, its adoption remains uneven, and evidence suggests that sequencing and prioritization of diagnostics may be as critical as their availability (89, 90). Few studies have quantified the relative contribution of diagnostic processes to EDLOS in Sweden. Existing literature has largely focused on patient characteristics and disposition status as explanatory factors of prolonged stays (91).

1.5.3 Output

The output component of the model reflects the outcomes of the ED visit, including patient dispositions such as admission to inpatient units, discharge, or transfer to other facilities. The factors studied during the output phase include access block, transfers to other facilities and other potential obstacles to the outflow of patients from the ED (56).

Access block, a significant challenge within the healthcare system, has a profound impact on the flow of patients within an ED. This phenomenon occurs when patients who are medically ready for admission to inpatient units cannot be transferred due to a shortage of available beds (92), causing a bottleneck within the ED. Access block serves as a critical determinant of ED patient flow and efficiency, influencing nearly every aspect of the patient journey (93). Boarding is another term for the same phenomenon, more commonly used in the United States (34).

Access block affects patient flow by creating a series of cascading delays and challenges within the ED. When admitted patients occupy ED treatment spaces for extended periods due to the unavailability of inpatient beds, it limits the capacity to accommodate incoming patients efficiently. As a result, incoming patients may experience prolonged wait times for initial assessments, diagnostic tests, and treatment, disrupting the flow of care (94, 95). Access block is, of course, also a concern for the patients waiting for a hospital bed. Several studies have been able to demonstrate the association between delayed access to in-hospital care and poor outcomes (96, 97).

A lack of in-hospital beds has been proposed as the main explanation for both ED crowding and prolonged EDLOS by several systematic reviews (36, 98), as well as two separate studies conducted in Sweden (59, 91). However, there are many processes within the ED settings that likely contribute to extended EDLOS for patients subsequently admitted to in-hospital care (87), but these processes have not been thoroughly explored in the Swedish ED setting.

1.5.4 Beyond the Linear Model of ED Flow

The input-throughput-output model has been instrumental in structuring operational interventions and performance metrics. However, its linear logic assumes relatively stable relationships between stages, which may not reflect the adaptive, non-linear reality of ED patient flow, where balance between clinical quality and organisational efficiency is delicate (99). Recent work has highlighted that modern emergency care increasingly departs from this linear sequencing, shifting toward more flexible, overlapping, and parallel processes (100). The Emergency Department Benchmarking Alliance (EDBA) describes this as a movement from traditional step-wise care toward a model in which evaluation, testing, and treatment may begin simultaneously or out of the expected order, reflecting innovations such as provider-in-triage (101) and triage-initiated protocols (102). This evolution underscores that contemporary ED operations behave less like a pipeline and more like a dynamic, adaptive workflow (34). The difference between traditional ED care and the new paradigm is depicted in Figure 3.

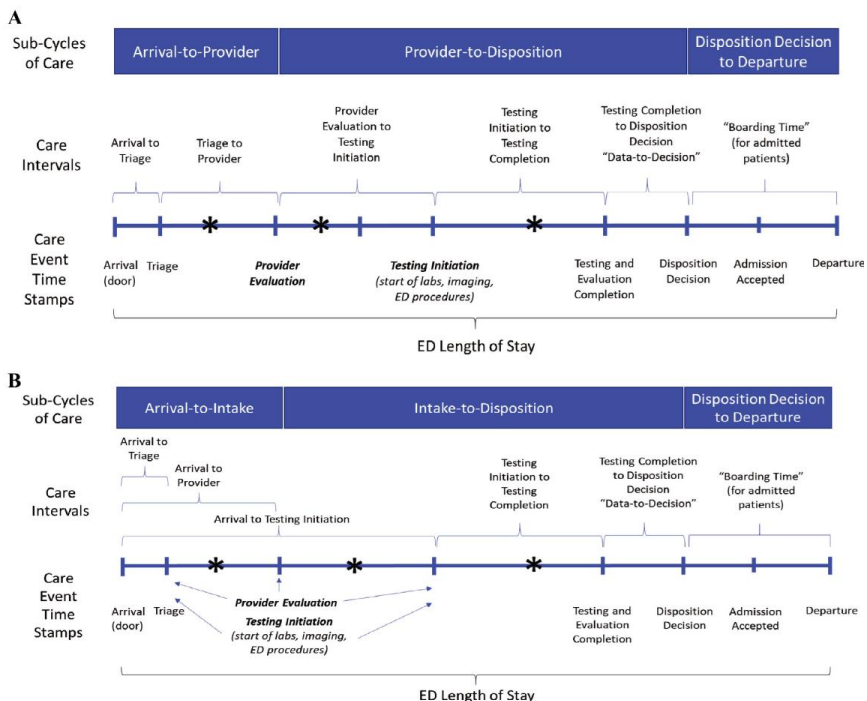


Figure 3 — (A) Traditional ED care: sequential events. (B) New paradigm: parallel processing and overlapping sub-cycles. Model developed by ED BA (34) and used with their permission.

Another way of conceptualizing the ED flow, is by applying complex adaptive system (CAS) theory (103). Seen through this lens, patient trajectories emerge from interactions among clinicians, technologies, and organisational structures. CAS theory frames the ED as a network of agents operating under conditions of uncertainty, with adaptive behaviours and feedback loops shaping outcomes. Rather than viewing integration as a linear “continuity of care” problem, CAS emphasizes porous boundaries, negotiation, and emergent order. This perspective accounts for why interventions based on linear models often fail to scale: they overlook the self-organising, dynamic nature of ED ecosystems (104).

Rationale

Emergency medicine and emergency care is evolving. An increasingly complex patient population and a healthcare system with finite resources requires purposeful management of the patient flow within the emergency department. All patients deserve safe and timely care and tax-paying citizens deserve cost-efficient resource utilization. To achieve this, however, has proven difficult in many healthcare systems, and over many years of research and development. Every healthcare system has their unique features. The solution proposed in one setting, is not necessarily the most appropriate for another setting.

There is uncertainty regarding the usefulness of time-based benchmarking. There is also uncertainty regarding the nature of the problem that faster flow through the emergency department is supposed to solve. Furthermore, the factors that shape EDLOS — spanning from input factors such as case-mix and acuity, throughput processes including triage and diagnostics, as well as output constraints driven by access to inpatient beds — all interact in complex ways that remain underexplored in the Swedish context.

Finally, there is a need for studies that better characterise how recurrent and complex patterns of emergency department use shape resource demand and patient flow in the Swedish context, and, in parallel, for research that clarifies the consequences of prolonged EDLOS, particularly for those vulnerable patient groups most at risk of adverse outcomes.

2 Aim

The overall aim of this thesis was to develop a deeper understanding of patient flow in Swedish emergency departments, with particular focus on process determinants of EDLOS and on patient groups at greatest risk of poor outcomes.

2.1 Specific Objectives

For the individual studies, the specific objectives were:

- I to analyse different uses in the literature of the concept ‘long EDLOS’ in order to clarify its meaning.
- II to determine the input-, throughput- and output factors associated with EDLOS, at two urban EDs in Sweden.
- III to determine the prevalence and costs of high-frequency ED users (HEDU) (>4 visits/year) compared to non-HEDU and to determine the factors and outcomes associated with being a HEDU using the electronic health record.
- IV to investigate the association between EDLOS and poor outcomes, identify vulnerable sub-populations and examine the impact of EDLOS on mortality before, during, and after the COVID-19 pandemic.

3 Materials and Methods

This thesis comprises four studies that together address the overarching aim of improving the understanding of patient flow in Swedish emergency departments. The four studies differ in design but complement each other methodologically. An overview of designs and methods are presented in Table 1. Study I differs fundamentally from the other studies as it is a literature-based concept analysis, while studies II-IV are quantitative observational studies. Therefore, its methods are described separately in section 3.1, followed by a description of the methods and materials used in studies II-IV, highlighting their similarities and differences.

Table 1. Overview of the thesis.

Study #	Design	Materials	Analysis
I	Qualitative Concept analysis	17 scientific articles + grey literature	8-step approach by Walker & Avant (105)
II	Retrospective observational study	Electronic health record data from 222,047 ED visits	Multivariable linear regression
III	Retrospective observational study	Electronic health record data from 121,403 ED visits and regional cost ledger data	Descriptive statistics, multivariable logistic regression and case costing
IV	Population epidemiology approach using registry linkage	Registry data from 5,049,641 ED visits, connecting 15 EDs	Predictive modelling and linear regression

3.1 Study I

The concept analysis was conducted using the eight-step approach described by Walker and Avant (105). The first two steps: (1) selecting the concept and (2) determining the aim of the analysis, are similar to any approach to a scientific query, regardless of method. Step three (3): identifying all uses of the concept, involved an extensive literature

review which is described in section 3.1.1. Step four (4): determining the defining attributes, considered by Walker and Avant as the “heart of concept analysis,” (105, p. 162) required analysing the descriptions of identified uses to extract recurring characteristics. Steps five and six included constructing and presenting cases to illustrate the concept. A model case was developed to demonstrate all defining attributes, and a borderline case was included to clarify what the concept is not. Step seven (7): identifying antecedents and consequences, described the conditions necessary for the concept to occur and the outcomes associated with its presence. Finally, step eight (8): defining empirical referents, aimed to specify how the concept could be measured in practice, particularly when defining attributes are abstract.

3.1.1 Literature Review

A comprehensive literature search was conducted in the PubMed and CINAHL databases to identify all uses of the concept “long emergency department length of stay (EDLOS)”. Synonyms for long (prolonged, extended, protracted) and alternative terms for the setting (emergency department, emergency room) were included. Reference lists of relevant articles were screened for additional studies, reports and other types of grey literature. Dictionaries were consulted to clarify the meaning of the term ‘long’. No restrictions were applied regarding publication date; however, the search was limited to English and Swedish language publications. A research librarian supported the literature search to ensure methodological rigor.

The aim of the literature review was not only to identify explicit definitions of “long emergency department length of stay (EDLOS)” but also to capture implicit uses of the concept in broader contexts. This included studies where “long EDLOS” appeared as a proxy or secondary measure for other phenomena — such as crowding, boarding, or quality of care — even when the authors did not consciously define or analyse the concept itself. This approach reflects Walker and Avant’s recommendation to identify **all** uses of the concept, ensuring that the analysis considers both deliberate and incidental applications in the literature. Although this was not a systematic review, the literature search and selection process were documented and presented

using PRISMA principles to enhance transparency and reproducibility (see Figure 4).

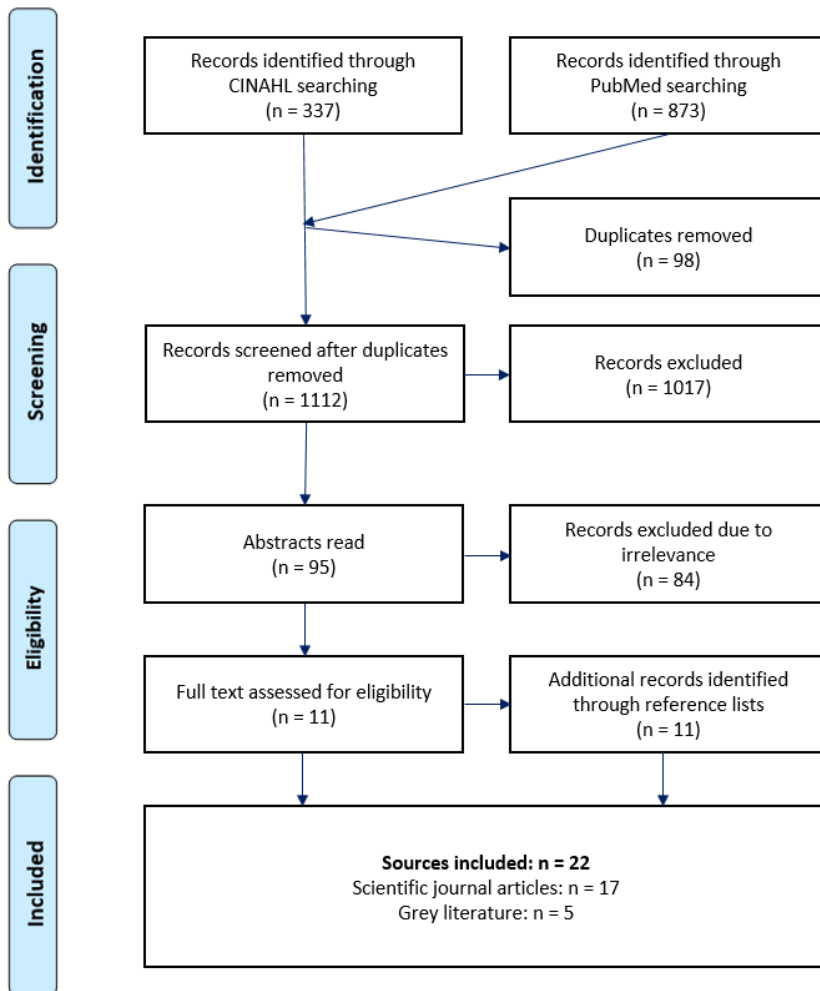


Figure 4 — PRISMA flow chart, describing the literature review and inclusion of data process.

3.2 Studies II through IV

While the specific research questions differed — ranging from determinants of EDLOS (Study II) to characteristics and costs of high-frequency ED users (Study III) and associations between EDLOS and patient outcomes (Study IV) — Studies II through IV share common methodological principles. To avoid redundancy and to highlight these shared foundations, the methodology for Studies II–IV is presented together below, using a consistent set of subheadings.

3.2.1 Design

Studies II–IV employed retrospective observational designs enabling analysis of operational factors and patient outcomes under real-world conditions using routinely collected ED data, without introducing experimental interventions. Retrospective observational studies are well suited for health services research because they allow inclusion of large, unselected populations, supporting external validity and reflecting the complexity of emergency care systems (106).

Study II examined determinants of emergency department length of stay (EDLOS) by applying the input–throughput–output framework to two hospitals in central Sweden. All adult and paediatric ED visits during a two-year period (January 1, 2018–December 31, 2019) were included, except those with incomplete records or patients who left without being seen. The rationale for this design was to identify factors influencing EDLOS across the entire patient flow, using operational and clinical data routinely documented in electronic health records.

Study III focused on high-frequency ED users (HEDU) at a single university hospital during the same two-year period (January 1, 2018–December 31, 2019). The study aimed to determine the prevalence, costs, and characteristics of patients with repeated ED visits, defined as ≥ 4 visits within the preceding 12 months. To apply this definition accurately, each patient required a full 365-day retrospective assessment. For example, to classify a patient as a HEDU on January 1, 2019, it was necessary to verify all ED visits during the previous year. Therefore, a two-year data collection period was essential to ensure

complete look-back coverage for every patient while also capturing seasonal variations in ED utilization.

Study IV investigated associations between EDLOS and patient outcomes across multiple hospitals and administrative regions in Sweden. This study utilized all available data from the Swedish National Emergency Registry (SVAR) for the period 2015–2023, encompassing millions of ED visits. The extended timeframe was necessary to achieve sufficient statistical power for rare outcomes such as short-term mortality and to enable sub-group analysis, but also to analyse the possible effect of the COVID-19 pandemic on the relationship between EDLOS and patient outcomes. The registry-based design enabled linkage to national mortality data and allowed for adjustment of patient-level and hospital-level confounders.

3.2.2 Setting

Study II was conducted in two EDs located in central Sweden: Örebro University Hospital (OUH) and Mälarsjukhuset Eskilstuna (MSE). OUH is a tertiary care university hospital and level 1 trauma centre with approximately 402 inpatient beds and an annual ED volume exceeding 60,000 visits. It serves a catchment area of roughly 300,000 inhabitants and provides comprehensive emergency services, including trauma, stroke, and interventional cardiology care. MSE is the largest hospital in its administrative region, with approximately 240 inpatient beds and an annual ED volume of 50,000–65,000 visits. At the time of data collection for both studies II and III, both hospitals used the Rapid Emergency Triage and Treatment System (RETTs), a five-level acuity scale widely implemented in Swedish EDs. Patients presenting with psychiatric, gynaecological, or certain minor orthopaedic complaints are redirected to specialty-specific units outside the ED.

Study III was restricted to OUH, which was selected for its high patient volume and availability of detailed administrative and cost data, enabling robust analysis of high-frequency ED users.

Study IV included all hospitals participating in the Swedish Emergency Registry (SVAR) from January 2015 to May 2023. SVAR is a

national quality registry that collects standardized data on ED visits across multiple administrative regions, including patient demographics, triage priority, chief complaint, and timestamps for arrival and discharge. The registry covers a mix of university hospitals, regional hospitals, and smaller community EDs, providing a heterogeneous sample representative of Swedish emergency care (107). This multi-centre design allowed for the examination of ED patient flow and outcomes across diverse organisational contexts and a wide array of patient subpopulations.

3.2.3 Study Population

Study II examined visits to two urban EDs in central Sweden, representing different organisational structures but similar patient flow models. All registered visits during the study period were included, except those where patients left without being seen. Transfers between specialty zones were merged into single encounters to reflect continuous ED stays. The population encompassed all age groups and a broad case-mix.

Study III focused on high-frequency ED users (HEDU) at a single academic hospital. All ED visits over two years were considered, with exclusions for duplicate records, incomplete cost data, and non-index registrations generated by intra-ED zone transfers. Patients were categorized by visit frequency into predefined groups of Repeat (4-7 visits), High (8-18 visits) and Super (19 or more visits).

Study IV utilized a national emergency care registry linked to multiple Swedish healthcare registries, covering ED visits across 15 separate hospitals before, during, and after the COVID-19 pandemic. Patients who left before disposition and implausible EDLOS outliers were excluded. Subgroup analyses were based on age, disposition, and chief complaint categories.

Common principles across studies II-IV included consecutive inclusion of eligible visits, exclusion of patients having left without being seen, and removal of implausible EDLOS values. All studies used RETTS for triage and captured specialty zoning and time markers from ED registries.

3.2.4 Data Sources

Data for studies II-IV were obtained from routinely collected electronic health records and administrative registries, supplemented by relevant national datasets. For Studies II and III, information was extracted from local ED registries at the participating hospitals, including demographic details, triage assessments, timestamps, and disposition data. Laboratory and imaging records were retrieved from hospital department databases and linked to ED encounters using unique patient identifiers. Cost data for Study III were obtained from the regional healthcare costing ledger, which applies standardized national methods for calculating patient-level costs.

Study IV utilized the Swedish National Emergency Registry (SVAR), which automatically captures ED visit data from electronic health records at participating hospitals (107). SVAR was linked to multiple national registries to obtain mortality outcomes, comorbidity profiles, and hospital length of stay. The Swedish Population Registry provided date of death, while the National Patient Registry (NPR) supplied diagnostic codes for calculating comorbidity index. All linkages were performed using the unique personal identification number assigned to all residents in Sweden, ensuring comprehensive coverage and accurate matching across data sources.

Across all studies, registry linkage and hospital-level data integration enabled robust ascertainment of exposures, covariates, and outcomes. Data quality was assessed prior to analysis, and exclusions were applied where reporting was incomplete or implausible values were identified.

3.2.5 Variables and Measures

Variables were selected to reflect patient characteristics, clinical processes, and outcomes relevant to ED operations and patient flow (II and III) as well as patient safety and quality of care (study IV). Definitions and categorizations were aligned with established standards and adapted to the context of Swedish ED care.

Study II examined factors associated with ED length of stay (EDLOS) using the input–throughput–output conceptual model. Input

variables included demographic characteristics (age, sex), referral status, mode and time of arrival. Age was categorized into clinically meaningful groups, and arrival time was grouped according to staffing shifts. Throughput variables encompassed triage level, time-to-physician, diagnostic testing, imaging, and intra-ED zone transfers. Output variables included patient disposition and hospital bed occupancy, categorized into predefined levels. The primary outcome was EDLOS, measured in minutes from arrival to departure.

Study III focused on high-frequency ED use. The primary exposure was visit frequency, categorized into HEDU and non-HEDU, with subgroups defined by increasing visit counts. Additional variables included demographic characteristics, triage level (RETTS), referral source, arrival mode and time, presenting complaint, assigned ED zone, zone transfers, radiology use, and disposition. Cost measures were derived from standardized regional costing systems and reported at both visit and patient level. Three separate analyses were conducted, the first using mean cost per patient as primary outcome, the second using HEDU category as outcome measure. The third and final analysis used a selection of patient outcomes, primarily adherence to the 4-hour target for EDLOS.

Study IV investigated associations between EDLOS and adverse outcomes across different phases of the COVID-19 pandemic. The primary exposure was EDLOS, analysed both as absolute time and as deviation from expected values predicted from triage level and chief complaint. Outcomes included short-term (0-48 hours) and long-term (30 days) mortality, unplanned return visits within 72 hours, and hospital length of stay. Subgroup analyses were conducted by age, disposition, and chief complaint categories. Comorbidity burden was quantified using the Charlson Comorbidity Index, calculated from national inpatient and outpatient records prior to the index ED visit.

Across all studies, variable definitions were standardized where possible, using the European Society for Emergency Medicine's Template for uniform reporting of emergency department measures (15). Where necessary, categorical groupings were based on clinical relevance and prior literature.

3.2.6 Statistical Analysis

Study II applied multivariable linear regression to examine associations between explanatory variables and EDLOS. The model was constructed using a stepwise backward elimination procedure to remove non-significant covariates. Assumptions of linear regression were assessed through residual diagnostics, and multicollinearity was evaluated using variance inflation factors. Statistical significance was defined as a p-value threshold of less than 0.01, and 95% confidence intervals were reported for all estimates.

Study III employed descriptive statistics to analyse cost and resource utilization, followed by multivariable logistic regression to estimate adjusted odds ratios for factors associated with high-frequency ED use and also to estimate odds ratios for the association between different HEDU categories and different patient outcome measures. Separate models were fitted for predefined subgroups of frequent users. Cost analyses were conducted from a healthcare payer perspective, with costs aggregated at both visit and patient level. Due to the short time interval, no inflation calculations were required.

Study IV utilized logistic regression to assess associations between EDLOS and binary outcomes, including short-term and long-term mortality and unplanned return visits. For continuous outcomes such as hospital length of stay, linear regression was applied. EDLOS was analysed both as an absolute measure and as deviation from expected values predicted from triage level and chief complaint. Subgroup analyses were conducted by age, disposition, chief complaint, and pandemic period. Adjustment for comorbidity was achieved using the Charlson Comorbidity Index. Sensitivity analyses were performed on complete cases to evaluate the robustness of findings.

Across all studies, analyses were conducted using Stata statistical software. Results were reported as effect estimates with corresponding confidence intervals, and statistical significance was determined using conventional thresholds.

3.3 Ethical Considerations

Study I was a literature-based concept analysis using exclusively previously published data. Studies II–IV were observational studies based on routinely collected health data, primarily intended for clinical care but also used for research and quality improvement.

For Study I, issues of plagiarism and correct citation were addressed by ensuring that all data were obtained from original sources and that credit was given to the original authors. Presentation of results was carefully managed to avoid misrepresentation or manipulation of published findings.

Studies II and III used hospital-level data containing information classified as sensitive under the General Data Protection Regulation (GDPR) (108), which has been incorporated into Swedish law since 2018 (109). All data were stored on secure servers in accordance with the Örebro University policy on information security. After merging data from different sources, pseudonymization was applied to protect individual identities.

Study IV utilized national registry data within the SCIFI-PEARL framework, which links multiple Swedish health registries for epidemiological research. This approach required strict adherence to GDPR and Swedish legislation governing personal data. Registry linkage was performed using encrypted identifiers, and all analyses were conducted on pseudonymized datasets. In Studies II–IV, all analyses were conducted at group level on large population-based samples, which made re-identification of individual persons highly unlikely.

The Declaration of Helsinki (110) served as the cornerstone for guiding ethical principles in research involving human subjects. In the context of these studies, the primary ethical concern was safeguarding personal information and ensuring confidentiality. Obtaining informed consent from all individuals was deemed impossible or highly impractical due to the retrospective design and the large, heterogeneous study populations. To mitigate these challenges, rigorous measures were implemented to protect data integrity and confidentiality, including pseudonymization and secure data handling protocols.

In accordance with the GDPR (108), all processing of personal data must rest on a lawful basis. The lawful basis for studies II-IV was performance of a task carried out in the public interest, which was confirmed by the Swedish Ethical Review Authority under the following reference numbers:

- Study II: Dnr 2020-01614
- Study III: Dnr 2020-01614
- Study IV: Dnr 2020-01800

The research was conducted in accordance with national regulations and international ethical standards, balancing individual rights with the societal benefits of improving patient safety and quality of care in emergency departments. The thesis was planned, conceptualized, drafted, revised and edited by the author. Language editing was intermittently supported by a large language model. No data extraction, statistical analysis or source generation was delegated to AI systems; all factual claims and references were verified by the author.

4 Results

The Results section is organised into three parts. First, an overview table summarizes the aims and main results of all four studies included in the thesis (Table 2). Second, the results from each individual study are reported in separate subsections, providing detailed descriptions of study-specific analyses and outcomes. Finally, a synthesized analysis is presented, addressing the overarching aim of the thesis by integrating findings across studies.

Table 2. Overview of the aims and main results from all studies included in the thesis

Study #	Aim	Main results
I	to analyse different uses in the literature of the concept 'long EDLOS' in order to clarify its meaning.	Long EDLOS was primarily used as proxy for other phenomena, e.g. boarding or crowding. The definitions included cut-offs ranging between 4 and 48 h. The attributes defining long EDLOS were waiting, crowding and inefficiency.
II	to determine the input-, throughput- and output factors associated with EDLOS, at two urban EDs in Sweden.	The most influential factors contributing to increased EDLOS were diagnostic imaging, laboratory testing and intra-ED zone transfers. Arriving during crowding or being admitted during high hospital bed occupancy had a relatively small effect on EDLOS.
III	to determine the prevalence and costs of high-frequency ED users (HEDU) compared to non-HEDU and to determine the factors and outcomes associated with being a HEDU	HEDU represent a relatively small proportion of patients but account for a disproportionately large share of ED visits and costs. HEDU are unlikely to undergo radiology and to be discharged within 4 hours.
IV	to further explore the association between EDLOS and patient outcomes, with a focus on mortality and other important endpoints	EDLOS demonstrated a non-linear association with mortality, with peaks at very short stays and weak association to poor outcomes at extended stays. Subgroup analyses revealed that discharged patients and those presenting with non-specific complaints were most vulnerable to deviations from expected EDLOS.

4.1 What is the Meaning of Long EDLOS (Study I)

EDLOS is widely used as a performance indicator in emergency care research and policy. However, the concept of “long EDLOS” has historically lacked a consistent definition. The concept analysis (Study I) revealed that the term is often applied as a proxy for other phenomena — such as crowding, boarding, or inefficiency — rather than as a standalone construct.

“Emergency department (ED) crowding is common and associated with increased costs and negative patient outcomes. The aim of this study was to conduct an in-depth analysis to identify the root causes of an ED length of stay (ED-LOS) of more than six hours” Driesen et al. (111), problematizing ED Crowding – but investigating long EDLOS.

The concept analysis indicated that two conditions must be present for an ED stay to be regarded as “long.” First, there needs to be an expectation: either from the patient or the healthcare system, that care will be delivered within a certain timeframe. Second, a defined time limit must exist, such as a national or local target for EDLOS. Without these elements, the notion of “long EDLOS” becomes meaningless, as the duration of stay cannot be evaluated against any benchmark.

The concept analysis showed that published thresholds for defining “long EDLOS” varied in a wide range, from 4 to 48 hours. Most cut-offs originated from national or regional time-targets rather than empirical evidence. No single threshold emerged as superior to others in terms of clinical justification or outcome prediction. This wide variation underscores the arbitrary nature of existing definitions and supports the decision to avoid adopting a universal cut-off in this thesis.

“6 h is a reasonable amount of time - long enough for good clinical care but not unjustifiably long” New Zealand Ministry of health (43), justifying the choice of the 6 h cut-off.

Defining attributes. The analysis identified three core attributes that characterize long EDLOS:

- **Waiting:** Non-value-adding time during the ED stay, often linked to delays in diagnostics or disposition.

- Crowded ED environment: A mismatch between patient demand and available resources, contributing to long ED stays.
- Inefficient organisation: Structural or process-related bottlenecks, such as boarding or delayed imaging.

These attributes underscore that long EDLOS is not merely a matter of elapsed time but reflects system- and operational factors.

Consequences associated with prolonged EDLOS include decreased patient satisfaction, increased risk of adverse events, and, in specific subgroups, higher mortality. However, the concept analysis did not identify a single point in time at which EDLOS could reliably be considered “long”. In line with Walker and Avant’s terminology, an empirical referent for “long EDLOS” would require determining the duration at which patient safety and satisfaction begin to deteriorate. This threshold is likely to vary across settings and patient subgroups, suggesting that any suggested universal time limit might be arbitrary and potentially misleading.

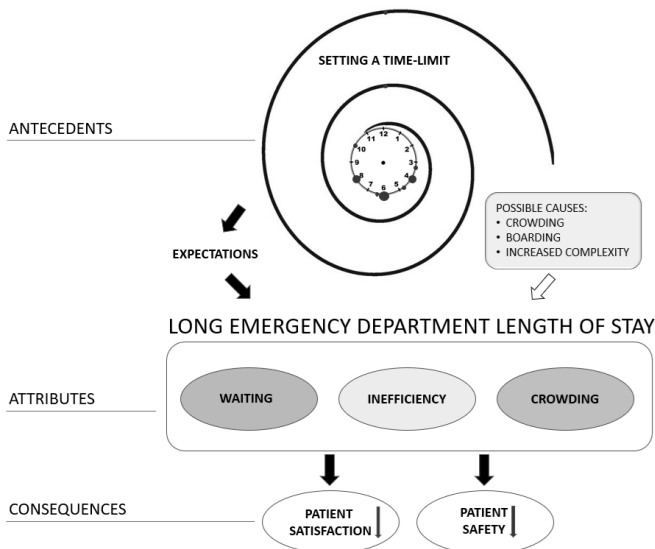


Figure 5 — Illustration of the results derived from the concept analysis.

4.2 From Arrival to Departure: Key Predictors of EDLOS (Study II)

After excluding duplicates, non-index registrations and patients who left without being seen by a provider (LWBS), 222,047 patient visits were included. The mean age was 43.5 years, and 110,728 (49.9%) patients were female. 43,995 patients (19.8%) arrived by ambulance and 58,080 (26.2%) were admitted to in-hospital treatment. For OUH and MSE, the median EDLOS was 190 and 203 minutes respectively.

The multivariable linear regression models (Tables 3-5) demonstrated strong overall fit, with R^2 values of 0.60 for OUH and 0.55 for MSE ($p < 0.01$ for both sites). At OUH, all included variables showed statistically significant associations with EDLOS in minutes. At MSE, there were nonsignificant associations for arrival day of week, referral by general practitioner and for being admitted during low hospital occupancy compared to being discharged home.

The regression analysis identified significant contributors to EDLOS at both study sites, with patterns broadly consistent across hospitals. Among input factors, patient characteristics such as age and arrival mode influenced EDLOS, with ambulance arrivals and older age groups associated with longer stays. Throughput factors were the dominant drivers of EDLOS, particularly diagnostic imaging and laboratory testing, which added substantial time compared to patients without these interventions. Intra-ED zone transfers also contributed markedly to prolonged stays, while crowding had only a modest effect. Output factors, including admission status and hospital bed occupancy, were associated with smaller increases in EDLOS relative to throughput-related delays. Full estimates for all predictors are presented in Tables 3-5, grouped by input, throughput, and output categories.

While most patterns were similar across OUH and MSE, some notable differences emerged. Paediatric patients (<18 years) were dispositioned more quickly than adults at MSE, whereas at OUH they experienced slightly longer stays compared to adults. Intra-ED zone transfers also had a disproportionate impact at OUH, adding roughly twice as much time as at MSE. Both discrepancies suggest organisational or workflow differences between the two hospitals.

Table 3. Linear regression analysis of input factors associated with EDLOS (minutes). Estimated coefficients and 95% confidence intervals (CIs). *= $p < 0.01$. Table adapted from publication of Study II (112)

Independent variable	Coefficient (95% CI) OUH	Coefficient (95% CI) MSE
Age 0-17	11.8 (10.6 – 13.0) *	-8.3 (-10.1 – -6.6) *
18-64 (reference)	0	0
65-79	7.6 (6.3 – 9.0) *	10.3 (8.6 – 12.1) *
80+	14.7 (13.1 – 16.4) *	11.3 (9.2 – 13.5) *
Sex, female	3.0 (2.1 – 3.9) *	2.7 (1.4 – 3.9) *
Arrival day, Monday	11.8 (10.6 – 13.0) *	-8.3 (-10.1 – -6.6) *
Tuesday-Friday (ref.)	0	0
Weekend	-5.2 (-6.3 – -4.2) *	0.8 (-0.6 – 2.3)
Time of day, 8 AM – 4:59 PM (ref.)	0	0
5 PM-9:59 PM	-12.6 (-13.7 – -11.5) *	-6.8 (-8.3 – -5.3) *
10 PM-7:59 AM	-13.8 (-15.1 – -12.6) *	-10.2 (-11.9 – -8.5) *
Arrival by ambulance	19.3 (17.9 – 20.7) *	19.8 (18.0 – 21.6) *
Referral	2.9 (1.1 – 4.6) *	5.7 (1.3 – 10.1)

Table 4. Linear regression analysis of throughput factors associated with EDLOS (minutes). Estimated coefficients and 95% confidence intervals (CIs). *= $p < 0.01$, POC = Point of care. Table adapted from publication of Study II (112)

Independent variable	Coefficient (95% CI) OUH	Coefficient (95% CI) MSE
Crowding, low 0-75% (ref.)	0	0
Moderate 76-94%	5.4 (4.2 – 6.6) *	9.6 (8.0 – 11.1) *
High 95-100%	9.8 (7.6 – 11.9) *	11.5 (8.8 – 14.3) *
Triage level, Red (ref.)	0	0
Orange	52.1 (49.6 – 54.7) *	64.2 (60.0 – 68.4) *
Yellow	38.6 (36.1 – 41.2) *	65.8 (61.5 – 70.0) *
Green	30.0 (27.2 – 32.7) *	57.7 (53.3 – 62.2) *
Blue	19.0 (16.0 – 22.1) *	52.6 (47.8 – 57.3) *
Time-to-Physician (minutes)	0.9 (0.9, 0.9) *	0.9 (0.9, 0.9) *

Laboratory analysis, no labs (ref.)	0	0
excluding Trop-I and D-dimer	61.1 (59.9 – 62.4) *	59.6 (58.0 – 61.3) *
incl. Troponins not D-dimer	52.8 (51.3 – 54.4) *	61.8 (59.2 – 64.5) *
incl. D-Dimer not Troponins	83.3 (76.9 – 89.7) *	68.3 (62.7 – 74.0) *
incl. Troponins & D-Dimer	98.3 (93.5 – 103.1) *	98.7 (92.8 – 104.6) *
POC analysis only	38.8 (36.5 – 41.1) *	26.0 (23.3 – 28.8) *
Diagnostic imaging, no radiology (ref.)	0	0
X-ray	67.7 (66.0 – 69.4) *	63.8 (62.1 – 65.5) *
Ultrasound	148.5 (145.0 – 152.0) *	121.2 (117.4 – 125.1) *
Computed tomography	131.7 (130.3 – 133.1) *	125.3 (123.5 – 127.1) *
Other examination	143.1 (132.8 – 153.4) *	-
Intra-ED zone transfer	93.5 (90.9 – 96.1) *	46.4 (43.0 – 49.8) *

Table 5. Linear regression analysis of output factors associated with EDLOS (minutes). Estimated coefficients and 95% confidence intervals (CIs). *= $p < 0.01$. Table adapted from publication of Study II (112)

Independent variable	Coefficient (95% CI) OUH	Coefficient (95% CI) MSE
Disposition, discharged (ref.)	0	0
Admitted, <85% occupancy	3.5 (1.5 – 5.6) *	0.7 (-3.4 – 4.7)
Admitted, 85-95% occupancy	8.0 (6.5 – 9.4) *	4.5 (2.4 – 6.7) *
Admitted, >95% occupancy	7.4 (5.2 – 9.7) *	16.5 (14.3 – 18.8) *

4.3 Input Flow Amplification: Prevalence and Characteristics of High-frequency ED Users (Study III)

Between January 1, 2018, and December 31, 2019, a total of 132,191 ED visits were recorded at OUH. After excluding non-index registrations (4.4%), duplicate entries (1.9%), and visits with missing cost data (2.0%), 121,403 index ED visits remained, representing 69,984 unique patients. The mean age was 41.4 years, and 50.9% of patients were female. Overall, 21.5% of visits were triaged as high acuity (RETTS 1–2), 19.0% involved arrival by ambulance, and 26.5% resulted in admission to in-hospital care. Median EDLOS was 3.1 hours.

High-frequency ED use accounted for a small proportion of patients but a substantial share of visits. Among 69,984 unique patients, 4,242 (6.1%) met the definition of high-frequency use (≥ 4 visits per year), representing 22.4% of all ED visits during the study period. Within this group, most were classified as Repeat users (4–7 visits, 5.3%), while smaller proportions fell into the High (8–18 visits, 0.7%) and Super (≥ 19 visits, 0.1%) categories. These findings indicate that a relatively small patient segment contributes disproportionately to overall ED utilization.

High-frequency users differed from the general ED population in several respects. Compared to non-HEDU patients, they were more likely to be male, present with abdominal pain, and arrive during evening or night hours. They were also more likely to arrive by ambulance and less likely to arrive on referral from a general practitioner, compared to non-HEDU. High-frequency users were also to a higher degree residents of Örebro municipality compared to the general ED population.

High-frequency users demonstrated distinct patterns in resource utilization and process outcomes. Compared to non-HEDU visits, they were less likely to undergo radiologic imaging and less likely to meet the four-hour EDLOS target. They were also more likely to leave the ED without being seen by a physician (LWBS). In terms of cost, descriptive analysis indicated that the mean cost per visit was slightly lower, 3,583.19 SEK for HEDU compared to 3,662.94 SEK for non-HEDU, while the cumulative cost per patient increased substantially with visit frequency, reaching the highest levels among Super HEDU patients.

4.4 Understanding Flow Vulnerabilities: EDLOS and Adverse Outcomes (Study IV)

A total of 5,049,641 ED visits from 15 Swedish EDs were included in the analysis, covering the period January 2015 to May 2023. The study population was distributed across the three time periods: pre-pandemic (55.4%), pandemic (23.6%), and post-pandemic (21.1%). The mean ED length of stay (EDLOS) was 276 minutes (median 221

minutes), with a slight decrease during the pandemic and an increase post-pandemic.

4.4.1 Association Between EDLOS and Mortality

Both short-term (0–48 hours) and long-term (within 30 days) mortality demonstrated a non-linear association with absolute EDLOS. Mortality peaked for very short visits in the 30–90-minute range, then declined toward the reference category (3–4 hours). Beyond this point, long-term mortality showed a modest upward trend, whereas short-term mortality continued to decline (Figures 6–7).

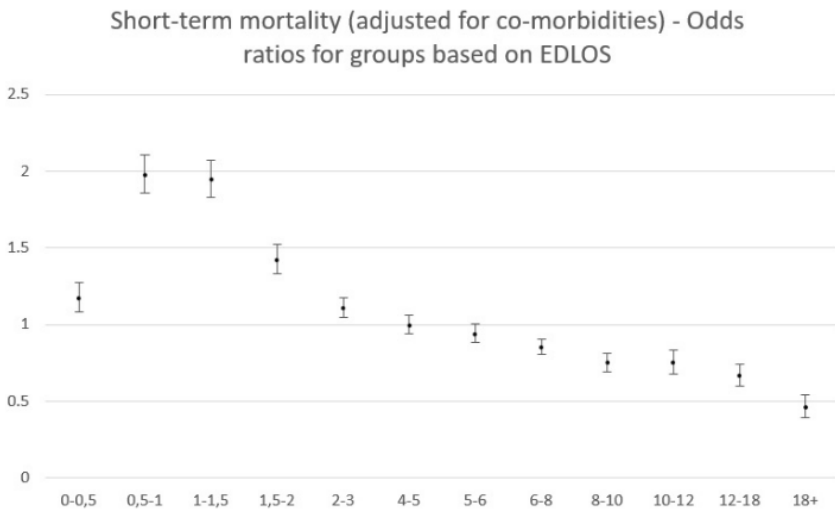


Figure 6 — Adjusted OR for short-term mortality across EDLOS-categories (EDLOS in hours)

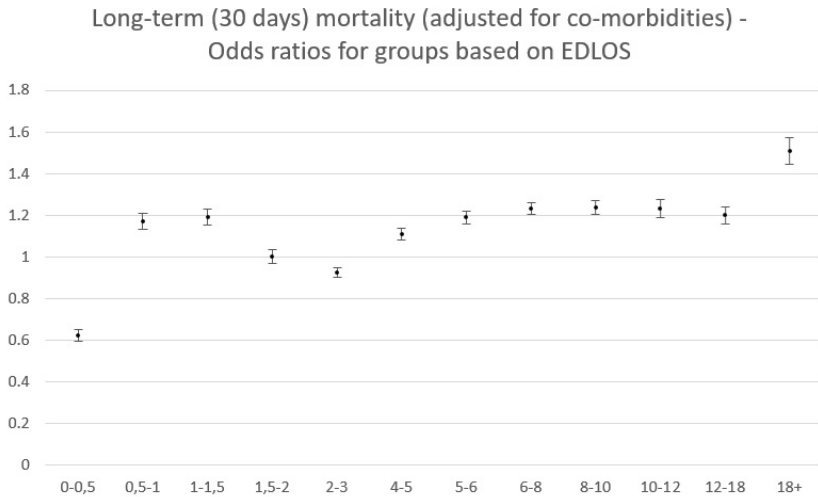


Figure 7 — Adjusted OR for long-term mortality across EDLOS-categories (EDLOS in hours)

When EDLOS was modelled as deviation from expected duration (based on triage level and chief complaint), the most favourable outcomes occurred when observed EDLOS remained within $\pm 25\%$ of expected values. Spending substantially less time than expected ($<50\%$) was associated with increased short-term mortality (adjusted OR 1.59, 95% CI 1.51–1.66), while prolonged stays ($>200\%$) also carried elevated risk (adjusted OR 1.69, 95% CI 1.62–1.76). For long-term mortality, shorter-than-expected EDLOS was generally protective, whereas longer-than-expected stays were associated with increased risk.

4.4.2 Unplanned Revisits and Hospital Length of Stay

Very short ED visits (<30 minutes) were linked to higher odds of unplanned 72-hour revisits and longer hospital stays among admitted patients (figures 8–9). Patients discharged after shorter-than-expected EDLOS had a modest but significant increase in revisit risk, particularly post-pandemic (OR 1.25, 95% CI 1.22–1.29). Longer-than-expected EDLOS did not consistently affect revisit risk, but was associated with slightly reduced hospital LOS during the pandemic.

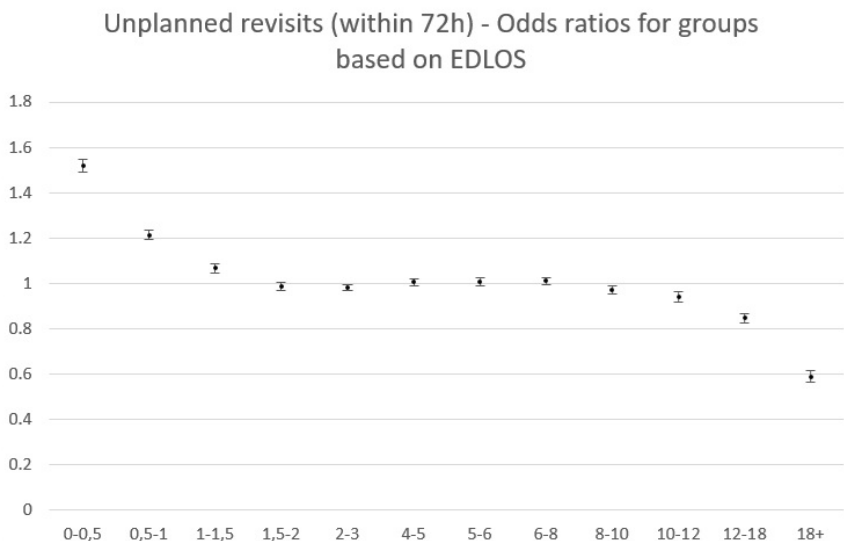


Figure 8 — Association between EDLOS and unplanned return visit within 72 hours. EDLOS (in hours) on the x-axis and OR (95% CI) on the y-axis.

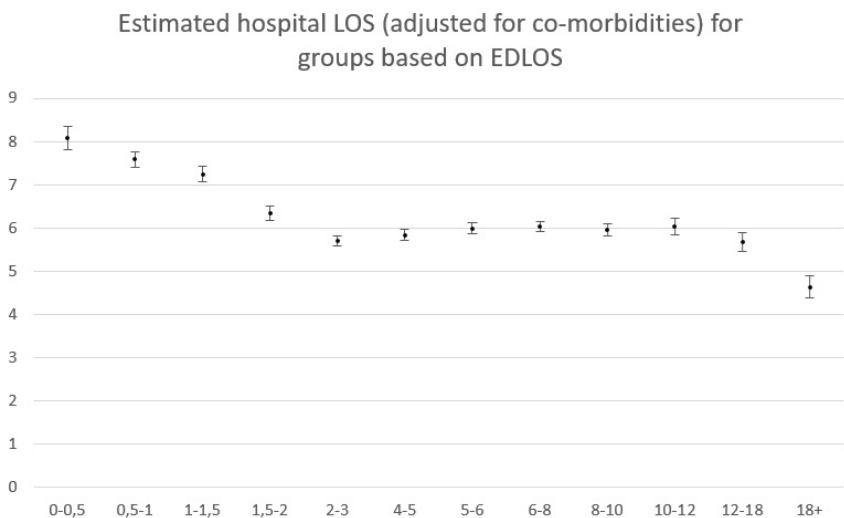


Figure 9 — Association between EDLOS and hospital length of stay. EDLOS (in hours) on the x-axis and hospital LOS (in days, with 95% CI) on the y-axis.

4.4.3 Subgroup Analyses

The subgroup analyses showed variation in associations between deviation from expected EDLOS and outcomes across different patient groups. Among discharged patients, both shorter-than-expected and longer-than-expected EDLOS were associated with increased odds of short-term mortality, while admitted patients exhibited higher odds of short-term mortality for shorter-than-expected EDLOS and lower odds of short-term mortality when EDLOS was longer-than-expected. For long-term mortality, discharged patients had increased odds at both extremes of EDLOS deviation, whereas admitted patients had lower odds for longer-than-expected EDLOS.

Chief complaint categories demonstrated distinct patterns. Patients presenting with non-specific complaints had a positive linear association between deviation from expected EDLOS and both short-term and long-term mortality. Chest pain showed a similar association for long-term mortality. Other complaint categories, including abdominal pain and shortness of breath, displayed mixed associations across deviation categories.

Age-based analyses indicated that deviations from expected EDLOS were associated with increased odds of mortality in all age groups, with the highest odds observed in older adults (>65 years) for both short-term and long-term mortality. Associations for unplanned 72-hour revisits and hospital length of stay varied across subgroups but were generally less pronounced.

4.5 Integrating Observations on ED Time and Patient Flow: a Synthesized Summary of Results

The combined findings from the four studies provide an overall view of ED flow and ED utilization patterns — as well as a detailed picture of EDLOS, its determinants, associated outcomes — in Swedish emergency care. Across all datasets, the ED population was characterized by broad age distributions and diverse presenting complaints. A consistent organisational feature was the routine re-direction of certain patient groups, such as psychiatric presentations at all hours and, variably, gynaecology, ENT, and paediatrics during off-office periods.

These practices shaped the case-mix and should be considered when interpreting the results and their generalizability.

Analyses of factors influencing EDLOS demonstrated that throughput-related processes were the most significant contributors to prolonged stays. Diagnostic imaging, particularly computed tomography and non-bedside ultrasound, was associated with the largest absolute increases in EDLOS. Central laboratory testing also added substantial time, especially when panels included D-dimer and troponins, whereas point-of-care testing was linked to smaller increments. These patterns were consistent across sites and remained robust in complete-case sensitivity analyses. In addition to diagnostic processes, intra-ED zone transfers — reflecting reassignment of medical responsibility within hybrid organisational models — were independently associated with marked increases in EDLOS, although the magnitude varied between hospitals.

Input factors such as age, sex, arrival mode, arrival time, and referral status showed statistically significant associations with EDLOS, but their absolute effects were smaller than those observed for diagnostic testing and imaging. Output-related factors, including admission during periods of varying hospital bed occupancy, also had modest absolute impacts compared to throughput processes. Measures of ED crowding were associated with longer EDLOS; however, for most patients, the absolute increments were small, and clinically meaningful effects were observed only at the highest crowding levels.

High-frequency ED users (HEDU), defined as patients with four or more visits per year, represented a small proportion of the population but accounted for a disproportionately large share of visits and total ED-related costs. HEDU visits were less likely to involve radiology and less likely to meet the four-hour EDLOS target, and they more often ended in leaving without being seen. These utilization features — many brief, repeated encounters with limited imaging — suggest a pattern that can amplify input pressure and contribute to operational volatility, even if individual visits did not always entail prolonged EDLOS. From a flow perspective, HEDU represent a concentrated source

of demand whose cumulative impact makes them a substantial component of the overall patient inflow.

The national registry analysis revealed important associations between EDLOS and adverse outcomes across pre-pandemic, pandemic, and post-pandemic periods. Both short-term and long-term mortality showed non-linear relationships with absolute EDLOS, with elevated risk at very short stays and lower risk among patients whose EDLOS was close to the median. When EDLOS was modelled as deviation from expected values — predicted from triage level and chief complaint — outcomes were most favourable within $\pm 25\%$ of expected EDLOS. Deviations, shorter or longer than expected, were associated with increased mortality risk. Shorter-than-expected EDLOS was also linked to higher odds of unplanned 72-hour revisits, an association that became more pronounced in the post-pandemic period. Among admitted patients, shorter-than-expected EDLOS was associated with longer inpatient length of stay, while associations for longer-than-expected EDLOS varied by time-period and subgroup. Subgroup analyses indicated that discharged patients and those presenting with non-specific complaints were most sensitive to exceeding the expected EDLOS, showing positive linear associations with mortality. Patients presenting with shortness of breath and visits ending in admission demonstrated reversed patterns for short-term mortality, consistent with expedited disposition to inpatient care for clinically severe cases.

Across all studies, data underwent rigorous quality checks, and findings regarding the dominance of throughput factors, the limited absolute effect of crowding at the patient level, the disproportionate utilization by high-frequency users, and the predictive value of deviation-based EDLOS were consistent across sensitivity analyses. Taken together, these results highlight that diagnostic processes and organisational flow exert the largest measurable effects on EDLOS; while crowding and access block contribute less at the individual level. High-frequency use concentrates visits and costs among a small subset of patients with distinctive utilization patterns, and modelling EDLOS relative to clinically expected duration provides clearer associations with mortality, revisits, and inpatient length of stay, particularly for vulnerable subgroups.

5 Discussion

The overall aim of this thesis was to develop a deeper understanding of patient flow in Swedish EDs, with particular focus on process determinants of EDLOS and on patient groups at greatest risk of poor outcomes. To address this aim, the problem was approached from multiple perspectives and using complementary methods. Study I provided a conceptual lens by clarifying how “long EDLOS” has been defined and interpreted in the literature, revealing its role as a proxy for waiting, crowding, and inefficiency. Studies II and III shifted the focus to operational and behavioural dimensions, quantifying the determinants of EDLOS and exploring the characteristics of high-frequency ED users as amplifiers of input pressure. Finally, Study IV examined the clinical consequences of EDLOS across millions of visits, applying predictive modelling to uncover non-linear associations with mortality and other adverse outcomes.

5.1 What is the Nature of ED Flow?

Across this thesis, ED flow appears as the ordered progression of assessment, investigation, consultation, decision-making and transfer that a patient experiences from ED arrival to departure. Study I shows that the literature often uses “long EDLOS” as shorthand for waiting, crowding, and organisational inefficiency — i.e., the convenient time-based patient flow measure that is EDLOS, was used to represent a comprehensive statement about quality or safety. Even if empirical evidence sometimes is provided to support this use (113, 114), it leads to a problematic conclusion: less time equals better quality. The extreme interpretation of this conclusion would be that the best outcomes for acutely ill patients would arise from not spending any time in the ED at all. Furthermore, in Study I it was impossible to identify a cut-off in the other end of the EDLOS spectrum: a duration limit to separate safe EDLOS from harmful EDLOS. The range of different cut-offs used indicates that the distinction between safe and unsafe EDLOS is highly context dependent. This aligns with recent reviews urging caution about absolute cut-offs (45) and recommending that ED performance be judged by a broader set of outcomes rather than a single time standard (115, 116). Methodologically, it is well

established that dichotomizing continuous variables should be avoided whenever possible, even though clinical practice sometimes requires threshold-based decisions (49). However, Study I demonstrated that, in the context of emergency care, it is difficult to identify practical or clinically meaningful justification for dichotomizing EDLOS.

Previous research tends to emphasize the adverse effects of longer EDLOS, implying that the flow of patients should be as fast as possible to avoid poor outcomes (16-18). In Study IV, modelling EDLOS relative to clinical expectation (conditioned on triage and chief complaint) revealed that adverse outcomes were lowest within $\pm 25\%$ of expected EDLOS, whereas both shorter-than-expected and longer-than-expected durations carried increased risk when viewing the entire ED population. This pattern is in agreement with a prior study conducted in Sweden, where both short and prolonged EDLOS was found associated with higher mortality, depending on triage category (117). This challenges the assumption of linear association between EDLOS and adverse outcomes.

Our findings show that EDLOS is highly predictable when modelled against patient and process variables. In Study II, multivariable regression analyses explained a substantial proportion of EDLOS variation, and nearly all included factors were statistically significant. This indicates that ED flow follows a structured logic rather than a random pattern. Comparable results have been reported in large-scale analyses: for example, a national study using data from over 1,000 emergency departments in the United States found that regression models explained two thirds of the variation in EDLOS for admitted patients and more than half of the variation for discharged patients (86).

At the same time, ED flow is influenceable because the largest increments of added time arise from throughput factors — laboratory testing, imaging, and intra-ED transfers, i.e. processes that, to a certain degree can be controllable on a clinician level — rather than processes that require system-level changes to be affected, like primary healthcare or hospital bed availability. These throughput factors are workflow elements: they can be redesigned, sequenced differently, or supported by technology and staffing strategies. Evidence from

interventional studies demonstrates that such changes produce measurable effects. For example, fast-track pathways can be implemented both for low-acuity patients (118) as well as time-sensitive conditions such as stroke (119). Alternatives to diagnostic investigations such as point-of-care testing (89) and ultrasound (90, 120) can be considered. Furthermore, several studies have been able to show that a substantial amount of diagnostic imaging is deemed inappropriate (121-123). Taken together, this makes a case for critically evaluating the necessity and timing of certain diagnostic investigations: considering whether they should be deferred, omitted, or performed outside the boundaries of the ED visit when clinically appropriate.

Our results show that ED flow cannot be reduced to a linear sequence of tasks; it behaves as a complex adaptive system (CAS): a dynamic network in which individuals and teams perceive, act, react, communicate, adapt, learn, and self-organise over time. Actions are interconnected so that one component's behaviour changes the context for others, and the system's performance is influenced by signals from surrounding systems such as inpatient capacity, radiology, and laboratory services (124, 125). Resilience is critical in such settings. Defined as the ability to adjust functioning before, during, and after disturbances to maintain performance under expected and unexpected conditions, resilience is not static but shaped by local context (124). In Study II, the minimal effect of crowding on EDLOS can be interpreted through this lens. Our crowding measure was designed to capture genuine high-pressure conditions, yet throughput times remained largely stable. This suggests that the ED system may have absorbed the disturbance by redistributing tasks, reprioritizing resources, and adapting workflows in real time: hallmarks of resilient performance.

The same adaptive capacity was evident during the COVID-19 pandemic, when the healthcare system faced unprecedented operational stressors that demanded dynamic capabilities at the organisational level (126). During this time, all EDs experienced a surge in high-acuity presentations and were required to implement extensive infection-control measures, including isolation protocols and personal protective equipment, while simultaneously managing a

fundamentally altered case-mix (60). Within this context, Study IV found that the relationship between EDLOS and adverse outcomes remained remarkably stable across pre-, pandemic, and post-pandemic periods. The protective window around expected EDLOS ($\pm 25\%$) persisted, and deviations from expected time continued to predict risk in similar ways. In other words, the pandemic did not appear to alter the association between EDLOS and adverse outcomes. This resilience reflects the EDs' ability to reconfigure processes under systemic pressure, while preserving core performance patterns. It underscores that emergency departments are not passive victims of external strain, but dynamic systems capable of maintaining tempo and safety through adaptive strategies — even under conditions that radically reshape the healthcare environment.

Overall, the results of this thesis demonstrate that small, local process disturbances (diagnostics, transfers) and heterogeneous demand (frequent users, non-specific complaints) interacted to produce non-linear outcomes. This fits the CAS view of EDs: a network of agents (nurses, physicians, radiology, laboratory, transport) operating under uncertainty, with feedback and interdependencies shaping emergent behaviour (127).

In summary, ED flow is predictable and influenceable, but fundamentally complex. It emerges from the interaction of multiple agents and subsystems, shaped by feedback loops and contextual constraints rather than linear cause–effect chains. This complexity means that managing flow is not a matter of applying isolated fixes; it requires continuous sense-making, coordination, and adaptive capacity from clinicians and leaders. The task of managing ED flow is cognitively demanding and operationally intricate, as interventions in one area can ripple across the system, producing trade-offs and emergent effects.

5.2 How do Patterns of ED Flow Arise?

The patterns that define the nature of ED flow — predictability yet variability, influenceability yet complexity — do not occur by chance. They arise from the interaction of structural design, clinical processes, and adaptive behaviours within a system that is both highly organised

and inherently dynamic. In the preceding section, ED flow was characterised as a sequence of interdependent tasks shaped by diagnostic work, organisational rules, and real-time prioritisation, but also as a complex adaptive system where feedback loops and contextual constraints govern performance. Understanding how these patterns emerge requires examining how performance indicators, patient flow bottlenecks, organisational structures, heterogeneous demand, and clinical uncertainty combine to produce the observed configurations of time, risk, and resource use.

One mechanism behind the patterns observed in this thesis, is the way EDLOS is used as a performance proxy. When time is treated as an absolute benchmark, it compresses diverse processes — waiting, crowding, diagnostic work — into a single metric. This framing of EDLOS drives uniform expectations even though clinical needs vary. In Study I, the defining attributes of “long EDLOS” emerged alongside an antecedent that is often overlooked: a predefined limit or implicit promise about how long care ought to take — whether codified by formal time-targets or communicated informally. Without such a frame of reference, “long” has no meaning; with it, every minute is judged against an expected tempo. However, eliminating expectations does not solve the issues of extended waiting. Dahlén et al. (24) described the experience of low-priority patients waiting in Swedish EDs as one of diminished agency and uncertain temporality — a “being put on hold”, where information is sparse and the grounds for prioritisation are opaque. In such circumstances, expectations are unanchored, and time expands subjectively: patients report feelings of abandonment even when the objective waiting time is not extreme (24). Swancutt et al. (25) showed that not all waits are equal: patients traversing different pathways interpret similar durations differently depending on communication, milestones, and visible progress (e.g., bloods drawn, imaging requested). Where there are clear markers of forward motion, patients “lend” more time to the system; where markers are absent, the same time feels like neglect (21). The implication is that expectation-management, informational signalling, and pathway transparency are primary determinants of how ED time is perceived and tolerated. These practices should therefore receive

increased focus within emergency care delivery and professional development.

The results from study II show that diagnostic imaging and laboratory testing exert the largest absolute influence on EDLOS — adding increments measured in hours — while output factors such as hospital bed occupancy contribute only modestly. This contrasts sharply with the prevailing assumption, reinforced by multiple studies, that access block and admission delays are the primary drivers of prolonged ED stays (91, 128, 129). The difference is partly methodological: Study II explicitly included diagnostic imaging and testing as explanatory variables, whereas many earlier studies did not. For example, Perdahl et al. (91) concluded that older patients and patients admitted to in-hospital care were more likely to experience long EDLOS, but did not examine whether these groups underwent more extensive diagnostics compared to discharged patients: a plausible mechanism behind their observed association. By incorporating throughput processes, our models explained a substantial proportion of EDLOS variation, similar to Canellas et al. (86) and far exceeding the explanatory power reported by Wu et al. (130) and Sompie et al. (131), whose models omitted imaging and achieved markedly lower R^2 values. These comparisons suggest that an accurate explanation of ED flow is incomplete without accounting for diagnostic workup: what appears as an age or disposition effect may, in reality, be a proxy for the frequency and complexity of investigations. Recognising this, can shift the focus from bed availability alone to the design and prioritisation of diagnostic pathways as a central lever for improving ED flow.

Study III revealed that high-frequency ED users (HEDU), patients with four or more visits per year, constitute only a small fraction of the ED population yet account for almost a fourth of all visits and roughly the same proportion of ED-related costs. Our findings align with international evidence showing that frequent ED use is a global phenomenon, with approximately 5 % of patients typically accounting for 21–28% of all visits (67). A contributing factor may be patient convenience. Geographical proximity as a driving force for increased ED attendance has been identified in several studies (132, 133). Study III revealed that a disproportionately high share of HEDU resided in

Örebro municipality, suggesting that convenient distance to the ED may reinforce patterns of repeated use for issues that could otherwise be managed in other parts of the healthcare system.

While our analysis could not fully determine the underlying drivers of these repeated visits, international evidence suggests that frequent ED use often reflects chronic illness, mental health needs, and social vulnerability (67, 134) — domains poorly served by episodic, fragmented care. In Sweden, the ED is not structurally optimized for such cases: rotating physicians, limited integration with primary care, and absence of embedded case management create a continuity gap that forces patients to re-enter the ED for issues that might otherwise be managed longitudinally (8, 74). This mismatch between patient trajectory and ED design suggests that certain competencies are absent in the current emergency care system, which may explain why HEDU exert disproportionate pressure on ED flow and why interventions focused solely on reducing EDLOS will fail to address the systemic challenge.

5.3 Why Does ED Flow Matter?

The consequences of a disrupted ED flow — or more specifically, long EDLOS — known prior to this thesis work, were underscored in Study I. The concept analysis identified several potential outcomes associated with long EDLOS: decreased patient satisfaction and decreased patient safety, including increased mortality, higher risk of adverse events, and poor adherence to clinical guidelines. These consequences position EDLOS not merely as an operational metric but as a proxy for quality and safety. They also frame the rationale for subsequent analyses in this thesis: if extended EDLOS signal vulnerability, then understanding the mechanisms behind EDLOS and its relationship to outcomes becomes essential for improving emergency care.

Study III showed that 6% of patients generated over one-fifth of ED visits and costs at OUH, with “Super” users accruing per-patient expenditures up to 27 times higher than non-HEDU. Redirecting a substantial share of these encounters to coordinated, continuity-based pathways — either within the ED through embedded case

management (135) or outside the ED via primary care linkage or community services (136, 137) — is not only more cost-effective but also better for patients (138). However, strategies that simply redirect high-frequency users away from the ED risk being superficial. While transferring these patients to other services may reduce ED visit counts in the short term, it often fails to address the underlying drivers of repeated attendance — such as unmet medical, psychosocial, or continuity needs. Evidence from systematic reviews suggests that interventions focused solely on diversion or referral have limited effectiveness and may lead to fragmented care (68, 139). Study III did not permit evaluation of the clinical appropriateness of ED visits among high-frequency users. However, a study from the same region of Sweden, conducted in the years directly following our study period, observed that frequent users of the ambulance services were more likely to be transported to the ED, whereas non-conveyance was more common among the general population (140). This indicates that frequent emergency care use in our setting was not predominantly driven by clearly non-urgent needs.

Study IV used several approaches to examine the impact of deviations in ED flow patterns on patient outcomes. Across absolute EDLOS categories, the associations with short-term mortality, 72-hour revisits, and inpatient length of stay (IPLOS) were predominantly negative — meaning that as EDLOS increased, risks for these outcomes generally decreased. These results remained stable even when the risk of both mortality and IPLOS was studied using models adjusted to co-morbidities. To contextualise the strength of this evidence, it is important to consider the scale of the available literature: a 2022 systematic review included 2,308,840 ED visits (16), and a meta-analysis published the same year included 1,718,518 (141). By contrast, Study IV analysed 5,049,641 ED visits with linked EDLOS and outcome data — making it, to our knowledge, the largest investigation of these associations to date.

Evaluating the association between EDLOS and mortality is inherently challenging because study designs vary widely in both exposure and outcome definitions. Many investigations dichotomize EDLOS using different thresholds, ranging from 3 hours to 24 hours or more

— while follow-up windows for mortality span from “in-hospital” to 30-day or even longer — making direct comparisons problematic. The systematic review by Burgess (16) characterized the evidence as “variable”, noting that some studies reported prolonged EDLOS as harmful, others found no association, and yet others observed an inverse relationship. Similarly, the meta-analysis by Lauque (141) tested a broad range of EDLOS cut-offs without identifying consistent evidence of harm; however, two exceptions emerged: patients admitted to ICU with EDLOS > 24 hours had significantly higher odds of in-hospital mortality, and non-ICU patients with EDLOS < 3 hours also showed increased mortality risk.

This complexity is further illustrated by Wessman et al. (117), whose Swedish cohort analysis revealed a pattern strikingly similar to the findings in Study IV when admitted and discharged patients were examined separately. For admitted patients, shorter EDLOS was associated with worse outcomes, whereas for discharged patients, the association was reversed - longer EDLOS predicted higher short-term mortality. This suggests that Swedish EDs are generally effective at rapidly identifying patients at greatest risk of dying and prioritizing them for inpatient care, resulting in very short ED stays for the sickest individuals. Conversely, uncomplicated patients who are treated quickly and discharged home from the ED typically have an extremely low risk of death, so prolonged EDLOS in this group may signal diagnostic complexity rather than causal association with mortality.

Interestingly, another Swedish study by af Ugglas et al. (39), using the same national registry as Study IV, reported partly conflicting findings when admitted patients were analysed separately. In their work, the effect of ED crowding on mortality was more pronounced among admitted patients, and this association strengthened in counties with high average inpatient bed occupancy. This suggests that crowding — but not prolonged EDLOS — was the key contributor to mortality in that context. It also underscores an important methodological point: boarding time and EDLOS for admitted patients are not interchangeable exposures. While EDLOS captures total time in the ED, boarding time specifically reflects delays after the decision to admit, which may

be more sensitive to bed availability and system strain. Taken together, the observations made throughout this thesis highlight the need for future research to disentangle crowding- and boarding components from EDLOS — and to consider system-level factors when interpreting EDLOS–outcome relationships.

The role of crowding versus EDLOS in driving mortality has been debated. Gabayan et al. (113) tested a wide array of crowding indicators — including occupancy, waiting times, and boarding — but found that none were associated with 7-day or in-hospital mortality except total EDLOS. This contrasts sharply with both Study IV and af Ugglas (39), where the crowding measures — but not EDLOS — predicted mortality. From a causal perspective, it is more plausible that an imbalance between demand and available resources (crowding), rather than the mere time spent in the ED, contributes to excess mortality. This suggests that the crowding metric used by af Ugglas (39, 40) and later in Study II: captures the true system-level risk more effectively than the proxies tested by Gabayan (113). It also reinforces the need to distinguish boarding time and crowding pressure from overall EDLOS when evaluating quality and safety.

Study IV also revealed that long-term mortality correlated with deviation from expected EDLOS, following a pattern where shorter-than-expected stays were associated with better outcomes and longer-than-expected stays with worse outcomes. Interestingly, this effect did not appear in the subgroups where one might anticipate it: such as older patients or those admitted to hospital. Instead, it was partly explained by chief complaint-level analyses. Patients presenting with chest pain and those with non-specific complaints exhibited the same directional pattern. In Sweden, ambulances equipped with pre-hospital electrocardiography (ECG) can diagnose many cases of myocardial infarctions in the field, allowing paramedics to bypass the ED and transport patients directly to primary percutaneous coronary intervention (PCI) (142). This means that patients presenting to the ED with chest pain many times lack signs of acute coronary syndrome. Even though Study IV identified an increased risk of death in relation to time spent in the ED; it also estimated a very low base odds of mortality in this

sub-population: about half the base odds compared to the general population.

Patients presenting with a non-specific chief complaint, meaning they underwent triage without being able to articulate a clear main symptom, constituted a sizeable subgroup of almost 300,000 individuals. They had more than twice the baseline odds of mortality compared to the general ED population and showed a more pronounced association with prolonged EDLOS than patients presenting with chest pain. The vulnerability of this sub-population has been identified in many other studies, both internationally (143, 144) and in the Swedish setting (145, 146) and a systematic review described these patients as mostly older, often triaged as less urgent and with a significantly increased risk of mortality, compared to patients with specific presenting complaints (147). It has been argued that the term non-specific functions as a residual category that clinicians use in ED practice when a case does not clearly fit specific categories — a practice that constitutes a patient safety concern (148). The results of study IV provide further evidence in support of prioritizing this sub-population, either by improved communication between patient and clinician or by refined triage and diagnostic protocols.

5.4 Methodological Considerations

This chapter critically examines the strengths and limitations inherent in the designs, data sources, and analytic strategies applied across the four studies. Each study employed approaches suited to its specific aims — ranging from a qualitative concept analysis to large-scale registry-based regression analysis — yet all were subject to constraints typical of observational research and administrative data.

5.4.1 Concept Analysis of “Long EDLOS”

Study I employed Walker and Avant’s (105) eight-step concept analysis to clarify the meaning and empirical referents of long EDLOS. This approach was appropriate given the widespread but inconsistent use of the term in research and policy. However, critique has been raised against concept analysis as a method. Draper (149) argues that concept analysis can lack philosophical rigor and practical utility,

often producing definitions detached from empirical application. These concerns are relevant, but in this context, the method served a necessary role: it exposed the arbitrary nature of time thresholds and identified core attributes — waiting, crowding, and organisational inefficiency — that underpin the construct.

Limitations include the use of a purposeful literature review rather than a systematic review, which may have introduced selection bias and omitted relevant sources. The reliance on textual interpretation rather than quantitative synthesis also restricts reproducibility. Furthermore, the absence of empirical testing means that proposed attributes and referents remain theoretical. Despite these limitations, the analysis provided a conceptual foundation for subsequent empirical studies, informing the decision to move beyond arbitrary time cut-offs toward continuous and context specific measures.

5.4.2 Determinants of EDLOS: Input, Throughput, and Output Factors

The second study analysed EDLOS determinants using retrospective data from two Swedish hospitals. Strengths include large sample size, integration of multiple data sources, and the use of reliable timestamps for precise measurement of EDLOS as well as other automatically collected clinical data.

Several limitations must be acknowledged. First, the observational design precludes causal inference; associations may reflect underlying patient complexity rather than process inefficiency. Second, residual confounding is likely, as clinical severity beyond triage and diagnostic orders was not fully captured. Third, the choice of OLS regression, while justified for interpretability, assumes linearity and normality despite EDLOS being right-skewed. Although post-estimation diagnostics supported model adequacy, alternative approaches such as generalized linear models could have strengthened robustness. Missing data for key variables (time-to-physician, triage level) required imputation, introducing potential bias if missingness was not random. However, a sensitivity analysis was performed without revealing any signs of systematic patterns in cases with missing data — nor any signs of selection bias in the complete cases analysis.

Although Study II was technically a multi-centre analysis, the two participating emergency departments were similar in size and operational structure, each reporting a median EDLOS of approximately three hours. This throughput pace is somewhat faster than the national average for Swedish EDs and markedly faster than median EDLOS observed in more densely populated regions (58). These contextual factors limit external validity. International generalization should be approached with caution, not only because of the relatively rapid patient flow but also due to organisational characteristics such as hybrid authority models and specialty-based zoning, which differ substantially from configurations common in other healthcare systems. These features may influence both process efficiency and resource allocation, making direct extrapolation of effect sizes or intervention implications problematic.

5.4.3 High-Frequency ED Users and Cost Analysis

Study III combined descriptive statistics with regression modelling to characterize high-frequency ED users. While the adjusted analyses confirmed and sharpened some patterns, such as the distinct profile of “Super” HEDU, they added little explanatory depth beyond what was evident in the descriptive results. The models were cross-sectional, based on administrative data, and lacked key covariates such as mental health and social determinants, limiting their ability to identify mechanisms or actionable predictors. Consequently, the regression served primarily as a confirmatory tool rather than advancing causal understanding or informing intervention design.

Study III quantified the costs associated with high-frequency ED users but did not incorporate a formal health economic evaluation framework. This limits the ability to assess whether interventions targeting this population would be cost-effective. The analysis was restricted to descriptive costing, omitting patient-centred outcomes such as health-related quality of life, thus failing to calculate incremental cost-effectiveness ratios (ICERs). Without linking costs to outcomes, the findings cannot inform resource allocation decisions or policy regarding intervention implementation. Additionally, the single-site design and exclusion of certain cost components — such as ambulance services

— further constrain the comprehensiveness of the economic perspective. However, the scope of the study design was that of a pilot study; its purpose was to provide an initial overview and to direct future research rather than to achieve large-scale clinical implications.

5.4.4 Evaluating EDLOS and Patient Outcomes Using Registry Linkage

Study IV utilized the combined power of several national patient and quality registries to examine associations between EDLOS and adverse outcomes before, during, and after the COVID-19 pandemic. Large-scale data and robust linkage across SVAR, NPR, and the Swedish Population Registry enhanced statistical power and completeness. In addition to using absolute EDLOS as the exposure, Study IV modelled deviation from an expected EDLOS: predicted from triage level and chief complaint. This approach is unproven and should therefore be interpreted cautiously, but it is logically defensible. Absolute time in the ED does not always signal inefficiency. As shown in Study II, diagnostic testing and imaging were major drivers of EDLOS — and these processes are often clinically necessary for safe care. By benchmarking EDLOS against what is expected for a given presentation, the deviation-based metric aims to distinguish appropriate time use from potential delays. This reduces indication bias and provides a context-sensitive measure that better reflects operational performance.

Despite these strengths, several limitations warrant discussion. First, the observational design limits causal interpretation; deviations from expected EDLOS may reflect unmeasured severity or operational decisions rather than inefficiency or premature discharge. Second, rare outcomes such as short-term mortality pose methodological challenges. Low base rates increase susceptibility to random error and amplify the impact of coding inconsistencies. The choice of follow-up windows — 1 calendar day (0-48 hours) for short-term mortality and 30 days for long-term mortality — balances clinical relevance with statistical feasibility, but influences interpretation. The decision to use a 1 calendar-day window for short-term mortality introduces important methodological considerations. First, mortality data were only available with date-level resolution, meaning the exact time of

death within the day was unknown. When follow-up windows are very short, this lack of precision amplifies starting-time bias, as the unknown interval constitutes a larger proportion of the observation period. This can distort risk estimates and reduce interpretability for outcomes intended to reflect immediate ED-related effects.

Second, and more critically, confounding by resuscitation may occur. In emergency care, patients with severe acute illness are often treated aggressively at presentation to allow clinicians time to gather diagnostic information and evaluate treatment response. Decisions to continue or withdraw life-sustaining measures are frequently made within the first 24-48 hours, once prognostic clarity emerges. Consequently, deaths occurring after initial stabilization may reflect these complex clinical judgments rather than the quality or timeliness of ED processes. This dynamic introduces competing risks: patients who survive the first hours may later die following a deliberate transition to palliative care, which is not attributable to ED inefficiency.

Taken together, these factors suggest that extremely short windows (e.g., <24 hours) may overemphasize timing artifacts and ethical decision-making rather than operational performance. Longer windows, such as 3-day mortality, as argued by Malmer (150), can mitigate these biases by reducing the proportional impact of unknown time intervals and capturing the period during which critical decisions about ongoing care are made. However, longer windows also risk diluting ED-specific effects by incorporating outcomes influenced by inpatient care. Sensitivity analyses across multiple horizons (e.g. 1 and 3 days) and explicit reporting of absolute risks alongside adjusted estimates can therefore strengthen validity and interpretability.

Outcome selection in emergency care is inherently complex. A recent systematic review by Toukola et al. (115) demonstrates the lack of consensus on which outcome metrics adequately represent overall ED performance and shows wide heterogeneity in indicator sets across jurisdictions and study aims. The outcome metrics used commonly cluster into five dimensions: reattendances, mortality, diagnostic/procedural errors and complications, diagnosis-specific survival, and patient experience (115). Notably, many frameworks conflate process

measures (e.g., EDLOS or disposition) with outcomes, complicating benchmarking and interpretation. In studies relying on administrative data, this distinction is crucial: process indicators are often easier to capture but do not, by themselves, reflect clinical benefit or harm. Austin et al. (116), in their scoping review of strategies to measure and improve ED performance, revealed that while time-based measures such as EDLOS and waiting times are commonly reported — clinical outcomes and revisit rates are often neglected, despite their importance for evaluating patient safety and quality of care. The authors conclude that the complexity of ED performance measurement necessitates a multidimensional approach; relying on a single metric risks an incomplete understanding of ED performance and intervention effectiveness. In line with these findings, Study IV adopted multiple outcome measures — short- and long-term mortality, 72-hour unplanned revisit, and hospital length of stay — to capture the potential impact of EDLOS on both short-term and longer-term patient outcomes. This comprehensive approach aligns with best practice recommendations for robust performance evaluation in complex healthcare systems.

Restricted by the retrospective design, Study IV failed to capture two of the five dimensions described by Toukola et al. (115): *diagnostic/procedural errors and complications* and, perhaps even more importantly, *patient experience*. Patient-reported outcome measures (PROMs) are increasingly recognized as central to evaluating patient-centred benefits of care (symptoms, function, quality-of-life), complementing traditional administrative outcomes (151). However, ED use of PROMs is constrained by measurement and operational barriers: many instruments are designed for chronic outpatient care with recall periods (7–14 days) misaligned with the minutes-to-hours timescale of ED encounters; instruments are frequently unidimensional and increase respondent burden when multiple domains matter; and few PROMs are validated in ED populations with diverse literacy, language, and technology access (152, 153).

Reliable outcome assessment depends on standardized operational definitions and time stamps. Throughout this thesis, definitions and measurement guidance from the Emergency Department

Benchmarking Alliance (EDBA) were used to structure exposures and outcomes, including EDLOS, time-to-physician and categories for incomplete encounters (LWBS) (34). These measures were applied when available and appropriate to ensure consistency and to enhance generalizability. In addition, context-sensitive metrics of crowding (40) and a relative EDLOS construct inspired by classical epidemiological approaches were incorporated where the relation between the observed and the expected values were used to capture system-level performance.

5.5 Clinical and Policy Implications

In two average-sized Swedish EDs, throughput factors, particularly diagnostic testing, imaging, and intra-department transfers, had the largest impact on EDLOS. In similar settings, interventions to improve ED flow should therefore target internal organisational processes and the sequencing of diagnostics rather than external factors alone. In other contexts, these determinants should be measured and evaluated comprehensively before implementing change, as local drivers of EDLOS may differ. Arbitrary time-targets applied to the general ED population should be avoided; they risk oversimplifying performance and may incentivize unsafe shortcuts. Instead, real-time patient-level EDLOS prognostics could be integrated into existing workflow systems to manage patient expectations and support timely clinical decision-making. From a safety perspective, deviation from expected EDLOS was associated with increased risk, particularly among discharged patients and those presenting with non-specific complaints. This underscores the need for safety-net checklists before discharge home when EDLOS is markedly longer than expected, and for structured pathways for non-specific complaints including senior review and targeted assessment.

5.6 Future Research

Several areas warrant further investigation. First, outcome assessment should move beyond time-based metrics to include measures that better reflect patient safety and quality, such as functional outcomes, patient-reported experience, and long-term morbidity. Second, high-

frequency ED users require deeper study to understand drivers of repeated attendance and to evaluate targeted interventions that integrate medical, mental health, and social care. Third, the health economic impact of diagnostic imaging availability should be examined, including cost-effectiveness analyses of point-of-care testing and prioritized imaging pathways in relation to EDLOS and downstream resource use. Finally, patients presenting with non-specific complaints remain a high-risk group; future work should explore structured assessment bundles, senior review strategies, and post-discharge follow-up models to reduce missed pathology and improve outcomes. This also includes refining triage instruments to better identify underlying problems in patients currently classified as “non-specific,” ensuring that risk stratification and diagnostic prioritization are more accurate and responsive.

6 Conclusions

The combined findings from Studies I–IV provide a nuanced understanding of the nature of ED patient flow. Rather than viewing EDLOS solely as a time-based measure or a direct indicator of quality, the results suggest that EDLOS often functions as a proxy for multiple operational and clinical processes. Attempts to define the concept revealed that long EDLOS may reflect diverse phenomena — such as diagnostic complexity, organisational structure, and resource utilization — rather than a single dimension of performance. This underscores the need to consider supplementary operational metrics that capture these underlying factors more directly. In this sense, EDLOS is best understood as a measurement of the flow’s tempo rather than its essence.

Analyses of the determinants of EDLOS demonstrated that throughput-related processes, particularly diagnostic imaging and laboratory testing, exert a far greater influence on EDLOS than input or output factors. These findings challenge the prevailing assumption that access block is the primary driver of prolonged EDLOS and problematize the use of EDLOS as a proxy for crowding. While crowding was associated with EDLOS at extreme levels, its effect on individual patient stays was modest and unlikely to be clinically meaningful for most encounters.

Further, the thesis brought attention to patient groups whose care trajectories are shaped by organisational and flow-management practices, both at system- and department level. High-frequency ED users and patients presenting with non-specific complaints both underscore how structural factors can influence both health-economic outcomes and patient safety. Finally, modelling EDLOS relative to expected values revealed that both shorter- and longer-than-expected stays — rather than absolute duration — provides greater explanatory power for adverse outcomes, reinforcing the importance of contextualised performance metrics and a patient centred view on EDLOS.

Svensk sammanfattning

Bakgrund: Akutmottagningen är en central del av hälso- och sjukvården där patientflöden och tidsaspekter påverkar både säkerhet, upplevelse och resursutnyttjande. Total vistelsetid används ofta som indikator för generell kvalitet men fångar i grunden ett tidsintervall vars betydelse varierar med kontext och patientgrupp.

Syfte: Det övergripande syftet med avhandlingen var att bidra till fördjupad förståelse för patientflöden på svenska akutmottagningar, med särskilt fokus på processdeterminanter för vistelsetid och patientgrupper med högst risk för ogynnsamma utfall.

Material och metoder: Avhandlingen omfattar fyra delstudier. Studie I är en begreppsanalys av "lång vistelsetid på akutmottagning". Studie II är en retrospektiv observationsstudie med 222 047 akutbesök från två sjukhus, där inflödes-, genomflödes- och utflödesfaktorer modelleras mot vistelsetid. Studie III analyserar mångbesökare på akutmottagningen vid ett universitetssjukhus (121 403 besök) avseende prevalens, kostnader och utfall. Studie IV är en multicenterstudie som, med hjälp av registerlänkning inkluderar 5 049 641 patientbesök från 15 akutmottagningar (2015–2023) och analyserar samband mellan vistelsetid (absolut och relativt förväntad tid) och mortalitet, oplanerade återbesök samt sjukhusvårdtid.

Resultat: Lång vistelsetid används ofta som surrogatmått för väntetid, överbelastning och ineffektivitet. Genomflödesprocesser, såsom radiologi, laboratorieanalyser och interna kliniköverflyttningar bidrog starkast till förlängd vistelsetid. Överbelastning på akutmottagningen och hög belägningsgrad på sjukhusens vårdavdelningar hade mindre effekt. Mångbesökare utgjorde 6,1 % av patienterna men stod för 22,4 % av besöken och en oproportionerlig andel av kostnaderna; deras besök hade lägre sannolikhet för radiologi och ledde oftare till att patienten lämnade akutmottagningen utan läkarbedömning. Studie IV visade ett icke-linjärt samband mellan vistelsetid och mortalitet, med förhöjd risk vid mycket korta vistelser. Lägst risk sågs vid en observerad vistelsetid inom ± 25 % av förväntad vistelsetid; både kortare och längre vistelsetid än förväntat var associerat med ökad risk. Patienter

som inte skrevs in till slutenvård och patienter med ospecifika kontaktorsaker framstod som särskilt sårbara för långa vistelsetider.

Slutsatser: Total vistelsetid är en värdefull kvalitetsindikator på akutmottagningens verksamhet, men när den reduceras till en binär tröskel blir den trubbig och oprecis. Patientflödet formas främst av interna diagnostiska och organisatoriska processer och speglar inte på ett tillförlitligt sätt graden av överbelastning eller vårdplatsbrist. Avvikelse från förväntad vistelsetid — både kortare och längre — förutsäger ogynnsamma utfall bättre än vad total vistelsetid gör, vilket understryker behovet av kontextanpassade och patientcentrerade kvalitetsindikatorer i stället för universella tidsgränser.

Nyckelord: akutmottagning; patientflöden; vistelsetid; EDLOS; mångbesökare; mortalitet; oplanerade återbesök; registerlänkning.

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References

1. World Health Organization (WHO). Health systems: emergency-care systems. 2007. [Available from: https://apps.who.int/gb/ebwha/pdf_files/WHA60/A60_R22-en.pdf]
2. Lecky F, Bengler J, Mason S, Cameron P, Walsh C. The International Federation for Emergency Medicine framework for quality and safety in the emergency department. *Emerg Med J.* 2014;31(11):926–9.
3. Hansen K, Boyle A, Holroyd B, Phillips G, Bengler J, Chartier LB, et al. Updated framework on quality and safety in emergency medicine. *Emerg Med J.* 2020;37(7):437–42.
4. World Health Organization (WHO). Emergency care systems for universal health coverage: ensuring timely care for the acutely ill and injured. 2019.
5. Janlöv N, Merkur S. Sweden: Health System Summary, 2024. Copenhagen: European Observatory on Health Systems and Policies, WHO Regional Office for Europe; 2024. Contract No.: ISBN: 9789289059923.
6. Organisation for Economic Co-operation and Development (OECD). Health at a Glance 2025: OECD Indicators. Paris: OECD Publishing; 2025. Contract No.: ISBN 978-92-64-45888-8.
7. Hallas P, Ekelund U, Bjørnsen LP, Brabrand M. Hoping for a domino effect: a new specialty in Sweden is a breath of fresh air for the development of Scandinavian emergency medicine. *Scand J Trauma Resusc Emerg Med.* 2013;21:26.
8. Myndigheten för vård- och omsorgsanalys. En akut bild av Sverige: Kartläggning av akutsjukvårdens organisation och arbetsfördelning. 2018. Report No.: 2018:13.
9. Högskoleförordningen (SFS 1993:100). The Higher Education Ordinance. 1993. [Available from: <https://svensksforfattningssamling.se/>]

10. Hälso- och sjukvårdslagen (SFS 2017:30). Health and Medical Services Act. 2017. [Available from: <https://svenskförfattningssamling.se/>]
11. Patientsäkerhetslag (SFS 2010:659). Patient Safety Act. 2010. [Available from: <https://svenskförfattningssamling.se/>]
12. World Health Organization (WHO). HANDBOOK FOR NATIONAL QUALITY POLICY AND STRATEGY: A practical approach for developing policy and strategy to improve quality of care. Geneva: World Health Organization; 2018. Report No.: ISBN 978-92-4-156556-1.
13. Organisation for Economic Co-operation and Development (OECD). OECD Data Explorer - Health expenditure and financing [Available from: <https://data-explorer.oecd.org>]
14. Socialstyrelsen. Sex frågor om vården - Övergripande indikatorbaserad uppföljning av hälso- och sjukvårdens resultat. 2020. Report No.: 2020-1-6544.
15. Hruska K, Castren M, Banerjee J, Behringer W, Bjornsen LP, Cameron P, et al. Template for uniform reporting of emergency department measures, consensus according to the Utstein method. *Eur J Emerg Med.* 2018.
16. Burgess L, Ray-Barruel G, Kynoch K. Association between emergency department length of stay and patient outcomes: A systematic review. *Res Nurs Health.* 2022;45(1):59–93.
17. Chang AM, Lin A, Fu R, McConnell KJ, Sun B. Associations of Emergency Department Length of Stay With Publicly Reported Quality-of-care Measures. *Acad Emerg Med.* 2017;24(2):246–50.
18. Ackroyd-Stolarz S, Read Guernsey J, Mackinnon NJ, Kovacs G. The association between a prolonged stay in the emergency department and adverse events in older patients admitted to hospital: a retrospective cohort study. *Pediatr Emerg Care.* 2011;27(2):110–5. doi: 10.1097/PEC.0b013e31820943e4.

19. Kirk JW, Nilsen P. Implementing evidence-based practices in an emergency department: contradictions exposed when prioritising a flow culture. *J Clin Nurs*. 2016;25(3-4):555–65.
20. Matthews WJ, Meck WH. Temporal cognition: Connecting subjective time to perception, attention, and memory. *Psychological Bulletin*. 2016;142(8):865–907.
21. Buetow S. Patient experience of time duration: strategies for 'slowing time' and 'accelerating time' in general practices. *J Eval Clin Pract*. 2004;10(1):21–5.
22. Elmqvist C, Fridlund B, Ekebergh M. On a hidden game board: the patient's first encounter with emergency care at the emergency department. *J Clin Nurs*. 2012;21(17-18):2609–16.
23. Irvin SK. Waiting: concept analysis. *Nursing Diagnosis*. 2001;12(4):128–36.
24. Dahlen I, Westin L, Adolfsson A. Experience of being a low priority patient during waiting time at an emergency department. *Psychol Res Behav Manag*. 2012;5:1–9.
25. Swancutt D, Joel-Edgar S, Allen M, Thomas D, Brant H, Bengler J, et al. Not all waits are equal: an exploratory investigation of emergency care patient pathways. *BMC Health Serv Res*. 2017;17(1):436.
26. Guttman A, Schull MJ, Vermeulen MJ, Stukel TA. Association between waiting times and short term mortality and hospital admission after departure from emergency department: population based cohort study from Ontario, Canada. *J Hosp Med*. 2011;6(5):279–84. doi: 10.1002/jhm.866.
27. Vermeulen MJ, Stukel TA, Boozary AS, Guttman A, Schull MJ. The Effect of Pay for Performance in the Emergency Department on Patient Waiting Times and Quality of Care in Ontario, Canada: A Difference-in-Differences Analysis. *Ann Emerg Med*. 2016;67(4):496–505 e7.
28. Eiset AH, Kirkegaard H, Erlandsen M. Crowding in the emergency department in the absence of boarding - a transition

- regression model to predict departures and waiting time. *BMC Med Res Methodol*. 2019;19(1):68.
29. Nyce A, Gandhi S, Freeze B, Bosire J, Ricca T, Kupersmith E, et al. Association of Emergency Department Waiting Times With Patient Experience in Admitted and Discharged Patients. *J Patient Exp*. 2021;8:23743735211011404.
 30. Walsh M, Knott JC. Satisfaction with the emergency department environment decreases with length of stay. *Emergency Medicine Journal*. 2010;27(11):821–8.
 31. Socialstyrelsen. Tillgänglighet i hälso- och sjukvården. 2018. Report No.: 2018-2-16.
 32. Sveriges Regioner i Samverkan. Nationell patientenkät - Akutmottagningar 2016. 2018. [Available from: [https://resultat.patientenkät.se/Akutmottagningar%20\(2016-2024\)/2016#](https://resultat.patientenkät.se/Akutmottagningar%20(2016-2024)/2016#)]
 33. Doyle C, Lennox L, Bell D. A systematic review of evidence on the links between patient experience and clinical safety and effectiveness. *BMJ Open*. 2013;3(1).
 34. Yiadom M, Napoli A, Granovsky M, Parker RB, Pilgrim R, Pines JM, et al. Managing and Measuring Emergency Department Care: Results of the Fourth Emergency Department Benchmarking Definitions Summit. *Acad Emerg Med*. 2020;27(7):600–11.
 35. McKenna P, Heslin SM, Viccellio P, Mallon WK, Hernandez C, Morley EJ. Emergency department and hospital crowding: causes, consequences, and cures. *Clin Exp Emerg Med*. 2019;6(3):189–95.
 36. Morley C, Unwin M, Peterson GM, Stankovich J, Kinsman L. Emergency department crowding: A systematic review of causes, consequences and solutions. *PLoS One*. 2018;13(8):e0203316.
 37. Hwang U, McCarthy ML, Aronsky D, Asplin B, Crane PW, Craven CK, et al. Measures of crowding in the emergency

- department: a systematic review. *Acad Emerg Med.* 2011;18(5):527–38.
38. Badr S, Nyce A, Awan T, Cortes D, Mowdawalla C, Rachoin JS. Measures of Emergency Department Crowding, a Systematic Review. How to Make Sense of a Long List. *Open Access Emerg Med.* 2022;14:5–14.
 39. af Ugglas B, Lindmarker P, Ekelund U, Djärv T, Holzmann MJ. Emergency department crowding and mortality in 14 Swedish emergency departments, a cohort study leveraging the Swedish Emergency Registry (SVAR). *PLoS One.* 2021;16(3):e0247881.
 40. af Ugglas B, Djärv T, Ljungman PLS, Holzmann MJ. Emergency department crowding associated with increased 30-day mortality: a cohort study in Stockholm Region, Sweden, 2012 to 2016. *J Am Coll Emerg Physicians Open.* 2020;1(6):1312–9.
 41. Jones P, Wells S, Harper A, Le Fevre J, Stewart J, Curtis E, et al. Impact of a national time target for ED length of stay on patient outcomes. *N Z Med J.* 2017;130(1455):15–34.
 42. Department of Health. *Reforming Emergency Care.* 2001.
 43. New Zealand Ministry of Health. *Targeting emergencies - Shorter stays in emergency departments.* 2011.
 44. Council of Australian Governments. *National partnership agreement on improving public hospital services.* 2011.
 45. Walker K, Honan B, Haustead D, Mountain D, Gangathimmaiah V, Forero R, et al. Review article: Have emergency department time-based targets influenced patient care? A systematic review of qualitative literature. *Emerg Med Australas.* 2021;33(2):202–13.
 46. Socialstyrelsen. *Väntetider vid sjukhusbundna akutmottagningar - Plan för utveckling av system för uppföljning.* 2012. Report No.: 2012-4-17
 47. Socialstyrelsen. *Väntetider och patientflöden på akutmottagningar - Rapport december 2015.* 2015. Report No.: 2015-12-11.

48. Sveriges kommuner och regioner (SKR). Vänstetidsstatistik - Akutmottagning 2025 [Available from: <https://extra.skr.se/vantetiderivarden/vantetidsstatistik/akutmottagning.54391.html>]
49. Altman DG, Royston P. The cost of dichotomising continuous variables. *BMJ*. 2006;332(7549):1080.
50. Sauzet O, Ofuya M, Peacock JL. Dichotomisation using a distributional approach when the outcome is skewed. *BMC Med Res Methodol*. 2015;15:40.
51. Williams BA, Mandrekar JN, Mandrekar SJ, Cha SS, Furth AF. Finding Optimal Cutpoints for Continuous Covariates with Binary and Time-to-Event Outcomes. Rochester, MN: Mayo Clinic; 2006.
52. Grimes DR, Heathers J. "Cake causes herpes?" - promiscuous dichotomisation induces false positives. *BMC Med Res Methodol*. 2025;25(1):255.
53. Kreindler SA. Six ways not to improve patient flow: a qualitative study. *BMJ Qual Saf*. 2017;26(5):388–94.
54. Patey C, Norman P, Araee M, Asghari S, Heeley T, Boyd S, et al. SurgeCon: Priming a Community Emergency Department for Patient Flow Management. *West J Emerg Med*. 2019;20(4):654–65.
55. DeFlitch C, Geeting G, Paz HL. Reinventing Emergency Department Flow via Healthcare Delivery Science. *HERD*. 2015;8(3):105–15.
56. Asplin BR, Magid DJ, Rhodes KV, Solberg LI, Lurie N, Camargo CA, Jr. A conceptual model of emergency department crowding. *Ann Emerg Med*. 2003;42(2):173–80.
57. Kwok ESH, Geymonat C, Peters K, Bickerton K, Mackenzie T, Lamothe R, et al. A Novel Emergency Department Surge Protocol: Implementation of a Targeted Response Plan. *Journal of Clinical Outcomes Management*. 2015;22(11):495–503.

58. Socialstyrelsen. Statistikdatabas för akutmottagningar, väntetider och besök 2025 [Available from: https://sdb.socialstyrelsen.se/if_avt_manad/]
59. Berg LM, Ehrenberg A, Florin J, Östergren J, Göransson KE. Significant changes in emergency department length of stay and case mix over eight years at a large Swedish University Hospital. *Int Emerg Nurs.* 2019;43:50–5.
60. Westman A, Hugelius K, Weinstein E, Kurland L. Facilitators and Barriers for Effective Staff Work in Swedish National Governmental Crisis Response to the COVID-19 Pandemic. *Disaster Med Public Health Prep.* 2022;17:e191.
61. Kurhayati K, Emaliyawati E, Trisyani Y. An Updated Scoping Review of Factors Associated with Length of Stay in Emergency Department. *J Multidiscip Healthc.* 2025;18:3191–203.
62. Kreindler SA, Cui Y, Metge CJ, Raynard M. Patient characteristics associated with longer emergency department stay: a rapid review. *Emerg Med J.* 2016;33(3):194–9.
63. Breen BM, McCann M. Healthcare providers attitudes and perceptions of 'inappropriate attendance' in the Emergency Department. *Int Emerg Nurs.* 2013;21(3):180–5.
64. McHale P, Wood S, Hughes K, Bellis MA, Demnitz U, Wyke S. Who uses emergency departments inappropriately and when - a national cross-sectional study using a monitoring data system. *BMC Med.* 2013;11:258.
65. Shaw EK, Howard J, Clark EC, Etz RS, Arya R, Tallia AF. Decision-making processes of patients who use the emergency department for primary care needs. *J Health Care Poor Underserved.* 2013;24(3):1288–305.
66. Burström L, Starrin B, Engström ML, Thulesius H. Waiting management at the emergency department - a grounded theory study. *BMC Health Serv Res.* 2013;13:95.
67. Soril LJ, Leggett LE, Lorenzetti DL, Noseworthy TW, Clement FM. Characteristics of frequent users of the emergency

department in the general adult population: A systematic review of international healthcare systems. *Health Policy*. 2016;120(5):452–61.

68. Ismail SA, Gibbons DC, Gnani S. Reducing inappropriate accident and emergency department attendances: a systematic review of primary care service interventions. *Br J Gen Pract*. 2013;63(617):e813–20.
69. Cheng L, Ng WM, Lin Z, Law LSC, Yong L, Liew YST, et al. Factors reducing inappropriate attendances to emergency departments before and during the COVID-19 pandemic: A multicentre study. *Ann Acad Med Singap*. 2021;50(11):818–26.
70. Shannon B, Pang R, Jepson M, Williams C, Andrew N, Smith K, et al. What is the prevalence of frequent attendance to emergency departments and what is the impact on emergency department utilisation? A systematic review and meta-analysis. *Intern Emerg Med*. 2020;15(7):1303–16.
71. Hansagi H, Olsson M, Sjöberg S, Tomson Y, Göransson S. Frequent use of the hospital emergency department is indicative of high use of other health care services. *Ann Emerg Med*. 2001;37(6):561–7.
72. Olsson M, Hansagi H. Repeated use of the emergency department: qualitative study of the patient's perspective. *Emerg Med J*. 2001;18(6):430–4.
73. Doheny M, Agerholm J, Orsini N, Schön P, Burström B. Socio-demographic differences in the frequent use of emergency department care by older persons: a population-based study in Stockholm County. *BMC Health Serv Res*. 2019;19(1):202.
74. Soril LJ, Leggett LE, Lorenzetti DL, Noseworthy TW, Clement FM. Reducing frequent visits to the emergency department: a systematic review of interventions. *PLoS One*. 2015;10(4):e0123660.
75. Asplin BR. Measuring crowding: time for a paradigm shift. *Acad Emerg Med*. 2006;13(4):459–61.

76. Göransson KE, Eldh, A. C., Jansson, A. Triage på akutmottagning. Lund: Studentlitteratur; 2008.
77. Gilboy N, Travers D, Wuerz R. Emergency nursing at the millennium. Re-evaluating triage in the new millennium: a comprehensive look at the need for standardization and quality. *Journal of Emergency Nursing*. 1999;25(6):468–73.
78. Mackway-Jones K, Marsden J, Windle J. *Emergency triage*. 2nd ed. Malden, Mass. ; Blackwell Pub.; 2006.
79. Widgren BR, Jourak M. Medical Emergency Triage and Treatment System (METTS): a new protocol in primary triage and secondary priority decision in emergency medicine. *J Emerg Med*. 2011;40(6):623–8.
80. Farrohknia N, Castrén M, Ehrenberg A, Lind L, Oredsson S, Jonsson H, et al. Emergency department triage scales and their components: a systematic review of the scientific evidence. *Scand J Trauma Resusc Emerg Med*. 2011;19:42.
81. Widgren B. Rätt med RETTS beslutstöd - Utmaningar och möjligheter inom akutsjukvård. 2:nd ed. Göteborg: B4PRESS förlag; 2019.
82. TriageIQ. Rapid emergency triage and treatment system (RETTS): A comprehensive guide to the Swedish Triage System. 2025.
83. Gottlieb M, Farcy DA, Moreno LA, Vilke GM, Guittard JA. Triage Nurse-Ordered Testing in the Emergency Department Setting: A Review of the Literature for the Clinician. *J Emerg Med*. 2021;60(4):570–5.
84. Samiedaluie S, Tilson V, Ingolfsson A. Streamlining emergency department workflow: reducing length of stay with congestion-triggered standing orders. *Health Care Manag Sci*. 2025;28(2):143–59.
85. Baird GS. The Choosing Wisely initiative and laboratory test stewardship. *Diagnosis (Berl)*. 2019;6(1):15–23.

86. Canellas M, Michael S, Kotkowski K, Reznick M. Operations Factors Associated with Emergency Department Length of Stay: Analysis of a National Operations Database. *West J Emerg Med.* 2023;24(2):178–84.
87. Grant KL, Bayley CJ, Premji Z, Lang E, Innes G. Throughput interventions to reduce emergency department crowding: A systematic review. *Cjem.* 2020;22(6):864–74.
88. Payne K, Risi D, O'Hare A, Binks S, Curtis K. Factors that contribute to patient length of stay in the emergency department: A time in motion observational study. *Australas Emerg Care.* 2023;26(4):321–5.
89. Hausfater P, Hajage D, Bulsei J, Canavaggio P, Lafourcade A, Paquet AL, et al. Impact of Point-of-care Testing on Length of Stay of Patients in the Emergency Department: A Cluster-randomized Controlled Study. *Acad Emerg Med.* 2020;27(10):974–83.
90. Estrella Y, Bronzo A, Fey L, Ryoo A, Ayala S, Lin M, et al. Point-of-care ultrasound: impact on emergency department length of stay for suspected lower extremity DVT. *Emerg Radiol.* 2023;30(2):203–7.
91. Perdahl T, Axelsson S, Svensson P, Djarv T. Patient and organizational characteristics predict a long length of stay in the emergency department - a Swedish cohort study. *Eur J Emerg Med.* 2017;24(4):284–9.
92. Australasian College for Emergency Medicine (ACEM). Standard terminology. *Emerg Med (Fremantle).* 2002;14(3):337–40.
93. Chan SS, Cheung NK, Graham CA, Rainer TH. Strategies and solutions to alleviate access block and overcrowding in emergency departments. *Hong Kong Med J.* 2015;21(4):345–52.
94. Mohr NM, Wessman BT, Bassin B, Elie-Turenne MC, Ellender T, Emler LL, et al. Boarding of Critically Ill Patients in the Emergency Department. *Crit Care Med.* 2020;48(8):1180–7.

95. He J, Hou XY, Toloo S, Patrick JR, Fitz Gerald G. Demand for hospital emergency departments: a conceptual understanding. *World J Emerg Med.* 2011;2(4):253–61.
96. Boulain T, Malet A, Maitre O. Association between long boarding time in the emergency department and hospital mortality: a single-center propensity score-based analysis. *Intern Emerg Med.* 2020;15(3):479–89.
97. Reznick MA, Upatising B, Kennedy SJ, Durham NT, Forster RM, Michael SS. Mortality Associated With Emergency Department Boarding Exposure: Are There Differences Between Patients Admitted to ICU and Non-ICU Settings? *Med Care.* 2018;56(5):436–40.
98. Hoot NR, Aronsky D. Systematic review of emergency department crowding: causes, effects, and solutions. *Ann Emerg Med.* 2008;52(2):126–36.
99. Nugus P, Braithwaite J. The dynamic interaction of quality and efficiency in the emergency department: Squaring the circle? *Soc Sci Med.* 2010;70(4):511–7.
100. Ward MJ, Ferrand YB, Laker LF, Froehle CM, Vogus TJ, Dittus RS, et al. The nature and necessity of operational flexibility in the emergency department. *Ann Emerg Med.* 2015;65(2):156–61.
101. Abdulwahid MA, Booth A, Kuczawski M, Mason SM. The impact of senior doctor assessment at triage on emergency department performance measures: systematic review and meta-analysis of comparative studies. *Emerg Med J.* 2016;33(7):504–13.
102. Rowe BH, Villa-Roel C, Guo X, Bullard MJ, Ospina M, Vandermeer B, et al. The role of triage nurse ordering on mitigating overcrowding in emergency departments: a systematic review. *Acad Emerg Med.* 2011;18(12):1349–57.
103. Chinnis A, White KR. Challenging the dominant logic of Emergency Departments: guidelines from chaos theory. *J Emerg Med.* 1999;17(6):1049–54.

104. Nugus P, Carroll K, Hewett DG, Short A, Forero R, Braithwaite J. Integrated care in the emergency department: a complex adaptive systems perspective. *Soc Sci Med*. 2010;71(11):1997–2004.
105. Walker LO. *Strategies for theory construction in nursing*. 5. ed.. ed. Avant KC, editor: Upper Saddle River, N.J. Prentice Hall; 2011.
106. Hackshaw A. *A concise guide to observational studies in healthcare*. 1 ed. Chichester: WILEY; 2015.
107. Kurland L, Holmqvist L, Ekelund U. The Swedish National Emergency Registry (SVAR), a modern emergency care registry. *Eur J Emerg Med*. 2025;32(3):216–8.
108. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), OJ L 119/1 (2016).
109. Lag (2018:218) Dataskyddsförordning. General Data Protection Regulation. 2018.
110. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. Declaration of Helsinki. 2013.
111. Driesen B, van Riet BHG, Verkerk L, Bonjer HJ, Merten H, Nanayakkara PWB. Long length of stay at the emergency department is mostly caused by organisational factors outside the influence of the emergency department: A root cause analysis. *PLoS One*. 2018;13(9):e0202751. doi: 10.1371/journal.pone.. eCollection 2018.
112. Andersson J, Kurland L, Nordgren L, Gusdal AK, Cheng I. Length of stay in the emergency department and its associated input-, throughput-, and output factors at two hospitals in Sweden. *BMC Emerg Med*. 2025;25(1):120.

113. Gabayan GZ, Derose SF, Chiu VY, Yiu SC, Sarkisian CA, Jones JP, et al. Emergency Department Crowding and Outcomes After Emergency Department Discharge. *Ann Emerg Med*. 2015;66(5):483–92 e5.
114. Flabouris A, Jeyadoss J, Field J, Soulsby T. Association between emergency department length of stay and outcome of patients admitted either to a ward, intensive care or high dependency unit. *Emerg Med Australas*. 2013;25(1):46–54.
115. Toukola TK, Mertanen RKK, Kaartinen JM, Tuunainen EA, Castrén MK, Torkki PM. Outcome metrics in recommended performance measurement tools for emergency department performance evaluation: a systematic review. *Scand J Trauma Resusc Emerg Med*. 2025;33(1):127.
116. Austin EE, Blakely B, Tufanaru C, Selwood A, Braithwaite J, Clay-Williams R. Strategies to measure and improve emergency department performance: a scoping review. *Scand J Trauma Resusc Emerg Med*. 2020;28(1):55.
117. Wessman T, Ärnlov J, Carlsson AC, Ekelund U, Wändell P, Melander O, et al. The association between length of stay in the emergency department and short-term mortality. *Intern Emerg Med*. 2022;17(1):233–40.
118. Chrusciel J, Fontaine X, Devillard A, Cordonnier A, Kanagaratnam L, Laplanche D, et al. Impact of the implementation of a fast-track on emergency department length of stay and quality of care indicators in the Champagne-Ardenne region: a before-after study. *BMJ Open*. 2019;9(6):e026200.
119. Shen Y, Lao Y, Xu X. Impact of emergency fast track on treatment time and outcomes in acute stroke: a systematic review and meta-analysis. *BMC Emerg Med*. 2025;25(1):186.
120. Popat A, Harikrishnan S, Seby N, Sen U, Patel SK, Mittal L, et al. Utilization of Point-of-Care Ultrasound as an Imaging Modality in the Emergency Department: A Systematic Review and Meta-Analysis. *Cureus*. 2024;16(1):e52371.

121. Alimohammadi H, Zareh Shahamati S, Karkhaneh Yousefi A, Safarpour Lima B. Potentially inappropriate brain CT-scan requesting in the emergency department: A retrospective study in patients with neurologic complaints. *Acta Biomed.* 2021;92(5):e2021302.
122. Ståhlbrandt H, Björnfort I, Cederlund T, Almén A. CT and MRI imaging in Sweden: retrospective appropriateness analysis of large referral samples. *Insights Imaging.* 2023;14(1):134.
123. Novoa Ferro M, Santos Armentia E, Silva Priegue N, Jurado Basildo C, Sepúlveda Villegas CA, Del Campo Estepar S. Brain CT requests from emergency department: Reality. *Radiologia (Engl Ed).* 2022;64(5):422–32.
124. Göransson KE, Drennan J, Mainz H, Fauerholdt Skov N, Amritzer M, Berg LM, et al. The scope of emergency nursing viewed through the lens of complex adaptive systems: A discussion paper. *Int J Nurs Stud Adv.* 2025;8:100270.
125. Martin CM. Complexity in dynamical health systems - transforming science and theory, and knowledge and practice. *J Eval Clin Pract.* 2010;16(1):209–10.
126. Rosenbäck R, Eriksson KM. COVID-19 healthcare success or failure? Crisis management explained by dynamic capabilities. *BMC Health Serv Res.* 2024;24(1):759.
127. Gomersall T. Complex adaptive systems: a new approach for understanding health practices. *Health Psychol Rev.* 2018;12(4):405–18.
128. Wiler JL, Handel DA, Ginde AA, Aronsky D, Genes NG, Hackman JL, et al. Predictors of patient length of stay in 9 emergency departments. *Eur Heart J Acute Cardiovasc Care.* 2012;1(2):99–108. doi: 10.1177/2048872612447049.
129. White BA, Biddinger Pd Fau - Chang Y, Chang Y Fau - Grabowski B, Grabowski B Fau - Carignan S, Carignan S Fau - Brown DFM, Brown DF. Boarding inpatients in the emergency department increases discharged patient length of stay. 2013(0736-4679 (Print)).

130. Wu W, Li M, Jiang H, Sun M, Zhu Y, Zhu G, et al. Development of an emergency department length-of-stay prediction model based on machine learning. *World J Emerg Med.* 2025;16(3):220–4.
131. Sompie LM, Lestari R, Suryanto S. Determinants of Emergency Department Length of Stay Using the Time Frame Emergency Care Model: A Retrospective Study. *Journal of Applied Nursing and Health.* 2025;7(3):820–35.
132. Kelekar U, Das Gupta D, Theis-Mahon N, Fashingbauer E, Huang B. Distances to emergency departments and non-urgent utilization of medical services: a systematic review. *Glob Health Action.* 2024;17(1):2353994.
133. Telagi P, McGurk K. Impact of Proximity and Accessibility of Urgent Care Centers on Emergency Department Utilization for Non-emergent Visits. *Cureus.* 2025;17(4):e82257.
134. Kanzaria HK, Niedzwiecki M, Cawley CL, Chapman C, Sabbagh SH, Riggs E, et al. Frequent Emergency Department Users: Focusing Solely On Medical Utilization Misses The Whole Person. *Health Aff (Millwood).* 2019;38(11):1866–75.
135. Di Mauro R, Di Silvio V, Bosco P, Laquintana D, Galazzi A. Case management programs in emergency department to reduce frequent user visits: a systematic review. *Acta Biomed.* 2019;90(6-s):34–40.
136. Morgan SR, Chang AM, Alqatari M, Pines JM. Non-emergency department interventions to reduce ED utilization: a systematic review. *Acad Emerg Med.* 2013;20(10):969–85.
137. Hansagi H, Olsson M, Hussain A, Ohlén G. Is information sharing between the emergency department and primary care useful to the care of frequent emergency department users? *Eur J Emerg Med.* 2008;15(1):34–9.
138. Wammes JJG, van der Wees PJ, Tanke MAC, Westert GP, Jeurissen PPT. Systematic review of high-cost patients' characteristics and healthcare utilisation. *BMJ Open.* 2018;8(9):e023113.

139. Moe J, Kirkland SW, Rawe E, Ospina MB, Vandermeer B, Campbell S, et al. Effectiveness of Interventions to Decrease Emergency Department Visits by Adult Frequent Users: A Systematic Review. *Acad Emerg Med.* 2017;24(1):40–52.
140. Alm F, Kurland L, Hugelius K. Frequent users of the ambulance service in a Swedish region: a retrospective cohort study. *Scand J Trauma Resusc Emerg Med.* 2026;34(1):16.
141. Lauque D, Khalemsky A, Boudi Z, Östlundh L, Xu C, Alsabri M, et al. Length-of-Stay in the Emergency Department and In-Hospital Mortality: A Systematic Review and Meta-Analysis. *J Clin Med.* 2022;12(1).
142. Postma S, Bergmeijer T, ten Berg J, van 't Hof A. Pre-hospital diagnosis, triage and treatment in patients with ST elevation myocardial infarction. *Heart.* 2012;98(22):1674–8.
143. Wachelder JJH, Stassen PM, Hubens L, Brouns SHA, Lambooi SLE, Dieleman JP, et al. Elderly emergency patients presenting with non-specific complaints: Characteristics and outcomes. *PLoS One.* 2017;12(11):e0188954.
144. Sauter TC, Capaldo G, Hoffmann M, Birrenbach T, Hautz SC, Kämmer JE, et al. Non-specific complaints at emergency department presentation result in unclear diagnoses and lengthened hospitalization: a prospective observational study. *Scand J Trauma Resusc Emerg Med.* 2018;26(1):60.
145. Wallgren UM, Antonsson VE, Castrén MK, Kurland L. Longer time to antibiotics and higher mortality among septic patients with non-specific presentations—a cross sectional study of Emergency Department patients indicating that a screening tool may improve identification. *Scand J Trauma Resusc Emerg Med.* 2016;24:1.
146. Erwander K, Ivarsson K, Olsson ML, Agvall B. Elderly patients with non-specific complaints at the emergency department have a high risk for admission and 30-days mortality. *BMC Geriatr.* 2024;24(1):5.

147. Kemp K, Mertanen R, Lääperi M, Niemi-Murola L, Lehtonen L, Castren M. Nonspecific complaints in the emergency department - a systematic review. *Scand J Trauma Resusc Emerg Med.* 2020;28(1):6.
148. Meier N, Pedersen KZ, Andresen LC, Andersen O. Patients with Non-Specific Complaints in Emergency Departments: A Growing Patient Safety Concern in an Aging Population with Multimorbidity. *Healthcare (Basel).* 2024;12(20).
149. Draper P. A critique of concept analysis. *J Adv Nurs.* 2014;70(6):1207–8.
150. Malmer G. Mortality prediction and equity in emergency care [Doctoral thesis]. Stockholm, Sweden: Karolinska Institutet; 2024.
151. Lin MP, Kligler SK, Friedman BW, Kim H, Rising K, Samuels-Kalow M, et al. Barriers and Best Practices for the Use of Patient-Reported Outcome Measures in Emergency Medicine. *Ann Emerg Med.* 2023;82(1):11–21.
152. Vaillancourt S, Cullen JD, Dainty KN, Inrig T, Laupacis A, Linton D, et al. PROM-ED: Development and Testing of a Patient-Reported Outcome Measure for Emergency Department Patients Who Are Discharged Home. *Ann Emerg Med.* 2020;76(2):219–29.
153. van Oppen JD, Alshibani A, Coats TJ, Graham B, Holch P, Lalseta J, et al. A systematic review and recommendations for PROM instruments for older people with frailty in emergency care. *J Patient Rep Outcomes.* 2022;6(1):30.

