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EMERGENCY DEPARTMENT WAIT TIMES AS A SYSTEM-LEVEL CHALLENGE: DRIVERS, PROCESS INEFFICIENCIES, AND LEAN SIX SIGMA SOLUTIONS

Yetunde Omobowale Adewale*[1], Chioma Ogechukwu Obi[2], Ayomide Bolaji-Fayehun[3], Zainab Feyi Onasanya[4]

[1]School of Nursing, Midwifery and Health, Coventry University, Coventry, England.

[2]Department of Health Sciences, Towson University, Maryland, USA.

[3]Plymouth Business School, University of Plymouth, Plymouth, UK.

[4]Master of Business Administration (Finance), Edge Hill University, UK.

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***Corresponding Author: Yetunde Omobowale Adewale**
School of Nursing, Midwifery and Health, Coventry University, Coventry, England.
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ABSTRACT

Emergency departments (EDs) are often the first point of care for patients in urgent need, yet long waiting time remains a persistent and frustrating problem across many healthcare systems. Patients frequently wait hours before being seen, not always because hospitals lack resources, but because care processes are complex, fragmented, and difficult to manage in real time. These delays worsen clinical outcomes, reduce patient satisfaction, and place serious pressure on both patients and healthcare staff. This study explores key factors driving ED waiting times and evaluates the role of process improvement approaches, particularly Lean and Lean Six Sigma (LSS). Using a critical review with structured narrative synthesis, relevant studies published between 2010 and 2023 were identified across Google Scholar, PubMed, MEDLINE, Embase and PubMed Central (PMC). The findings show that while rising and unpredictable patient demand is an important driver of delays; inefficiencies in how care is organised and delivered such as bottlenecks in triage, delays in diagnostics and admissions, organisational dynamics and poor coordination across hospital units, often play an even bigger role. Process improvement approaches such as LSS are consistently associated with better patient flow and reduced waiting times, but the evidence also shows that their success depends heavily on how well they are implemented and adapted to local conditions. This study concludes that improving waiting times is not just a technical or operational issue. Organisational culture, staff workload, communication, and equity-related factors all shape how patients move through the system. In some cases, efforts to improve efficiency such as strict time targets, can create unintended consequences, including staff burnout or reduced quality of patient interaction. As such, meaningful improvement requires a system-wide approach that combines process redesign, better use of data, stronger coordination, and attention to both staff and patient experience.

KEYWORDS: Wait Times, Emergency Department, Length of Stay, Lean Six Sigma Interventions, Lean Management.

1. INTRODUCTION

Waiting for care is something many patients experience when they visit a hospital, especially in the emergency department (ED). While some waiting is expected, excessively long waiting times have become a serious concern across healthcare systems. They are not just inconvenient, they may delay treatment, worsen health conditions, and leave patients feeling frustrated or neglected (Viberg et al., 2013; Vainieri et al., 2020). In many hospitals, long waiting time is a sign that the system is under strain. This strain often comes from a mix of factors: too many patients arriving at once, limited staff or resources, and inefficient processes that slow things down. For example, when patient demand is higher than what the system can handle, queues naturally form. However, literature suggests that the problem is not always a simple lack of resources, it is often about how those resources are organised and managed. In fact, increasing resources alone does not necessarily reduce waiting time if underlying inefficiencies remain unaddressed (Johannessen & Alexandersen, 2018).

Emergency departments face this challenge more than most areas of the hospital. Patients arrive without appointments, their conditions vary widely in urgency, and care often depends on multiple steps such as triage, diagnosis, consultation, and admission. When even one part of this process is delayed, it can create a ripple effect that slows down the entire system. As a result, overcrowding becomes common, and waiting times, which refers to the time from arrival to first clinical contact, increase (Morley et al., 2018; Salway et al., 2017). The impact of long waiting times goes beyond discomfort. In some cases, delays in treatment can lead to serious complications or even death (Gaughan et al., 2020; Verma et al., 2021). Long waits also affect how patients perceive the quality of care they receive. When people feel ignored or delayed, their satisfaction drops, and trust in the healthcare system can weaken (Abbasi-Moghaddam et al., 2019). For healthcare staff, constant overcrowding and pressure can lead to stress, burnout, and reduced job satisfaction (Pich et al., 2017).

Hence, reducing waiting times has become a priority for healthcare managers and policymakers around the world. Different strategies have been introduced, such as setting time targets and improving patient flow. For example, the introduction of the four-hour ED target in the UK was aimed at improving efficiency and patient throughput, although its implementation has also raised concerns about unintended effects on care quality and staff experience (Gaughan et al., 2020; Vezyridis & Timmons, 2014). One approach that has gained increasing attention is Lean Six Sigma (LSS).

This method focuses on improving processes by removing unnecessary steps, reducing delays, and making better use of available resources. Instead of simply adding more staff or equipment, LSS examines how work is done and identifies ways to make it smoother and more efficient (Improta et al., 2018; Honda et al., 2018). Evidence from different healthcare settings suggests that LSS can significantly reduce waiting times, improve patient flow, and enhance overall service quality (Mandahawi et al., 2017; Sanchez et al., 2018).

Despite ongoing policy efforts, process redesigns, and increased attention to patient flow, many hospitals continue to experience overcrowding, delayed treatment, and inefficiencies in service delivery (Morley et al., 2018; Gaughan et al., 2020). These delays are not merely operational inconveniences, they are associated with adverse clinical outcomes, including increased morbidity and mortality, as well as reduced patient satisfaction and trust in healthcare services (Verma et al., 2021; Abbasi-Moghaddam et al., 2019). Existing literature has identified a wide range of determinants of waiting times, including demand-capacity mismatch, patient complexity, diagnostic delays, staffing constraints, and systemic bottlenecks such as admission block and bed shortages (Salway et al., 2017; Johannessen & Alexandersen,

2018). However, these factors often interact in complex and context-specific ways, making it difficult to isolate their individual effects or develop universally applicable solutions. Moreover, evidence suggests that policy-driven interventions such as time-based performance targets, can improve throughput but may also introduce unintended consequences, including increased pressure on staff and reduced quality of patient-provider interactions (Vezyridis & Timmons, 2014).

Process improvement approaches, particularly Lean Six Sigma (LSS), have been widely promoted as effective tools for reducing inefficiencies and improving patient flow. Empirical studies report significant reductions in waiting times and length of stay following LSS implementation (Mandahawi et al., 2017; Honda et al., 2018). However, much of this evidence is derived from single-site case studies, quasi-experimental designs, or simulation-based models, which may limit the robustness and generalisability of findings. In addition, several studies rely on retrospective data or administrative datasets that may suffer from incomplete reporting, measurement inconsistencies, and limited clinical granularity (Bobrovitz et al., 2017; Hajzargarbashi et al., 2019).

Further methodological limitations persist in the literature. Simulation and optimisation models, while useful for testing hypothetical scenarios, often depend on assumptions or synthetic ("dummy") data that may not accurately reflect real-world complexity (Alhuntushi et al., 2022). Similarly, advanced analytical models such as Markov or discrete event simulations may lack interpretability for healthcare practitioners, thereby reducing their practical applicability in decision-making contexts (Chaou et al., 2020). Additionally, most studies are conducted in specific institutional or national contexts, raising concerns about the transferability of findings across different healthcare systems, particularly in resource-constrained settings.

Another important gap lies in the limited integration of social and behavioural dimensions into operational analyses.

While quantitative studies focus heavily on efficiency metrics, fewer studies examine how organisational culture, staff experience, patient behaviour, and equity issues such as racial disparities in waiting times, shape ED performance (Opoku et al., 2017; Hansen et al., 2022). This creates a fragmented understanding of the problem, where technical solutions are often proposed without fully accounting for human and contextual factors. This study addresses these gaps by providing a systematic review of the literature on ED waiting times, with a particular focus on identifying key determinants and evaluating the effectiveness and limitations of Lean Six Sigma as a process improvement strategy.

Therefore, this study aims to offer a practically relevant foundation for reducing waiting times and improving emergency care delivery.

2. METHODOLOGY

This study adopts a critical review with structured narrative synthesis to examine the determinants of waiting times in emergency departments (EDs) and to assess the role of process improvement approaches, particularly Lean and Lean Six Sigma (LSS). A fully systematic review design was not considered appropriate given the heterogeneity of the literature. Existing studies span multiple disciplines, employ diverse methodologies, and report outcomes using different definitions and measures. These include quantitative analyses, qualitative studies, quasi-experimental designs, and simulation-based models. A critical review approach therefore allows for a more flexible and interpretive synthesis, enabling the integration of varied forms of evidence while maintaining analytical depth.

To develop a focused and relevant evidence base, a structured literature search was conducted across multiple databases, including Google Scholar, PubMed, MEDLINE, Embase, and PubMed Central (PMC). These sources were selected to capture a broad range of studies across healthcare, operations management, and policy research. Search terms were developed around three core domains: emergency care settings, waiting time and patient flow, and process improvement strategies. The core search string combined these domains using Boolean operators, with additional keyword variations applied to reflect differences in terminology across disciplines. The search was limited to studies published between 2010 and 2023, written in English, and focused on hospital-based emergency care contexts. Both empirical studies and relevant review articles were included where they contributed meaningful insight.

The initial search produced a large volume of records. Given the impracticality of screening all results, a structured relevance-based approach was used. Specifically, the top-ranked records, particularly from Google Scholar, were screened based on titles and abstracts. While this approach does not meet the criteria for systematic sampling, it provides a pragmatic way to identify highly relevant and frequently cited studies. Inclusion criteria focused on studies addressing ED waiting times, patient flow, or operational performance, and those examining determinants, consequences, or interventions related to delays. Studies were excluded if they focused on non-ED settings, were not available in full text, lacked substantive analytical contribution, or were not directly related to operational processes.

Data extraction was conducted using a structured template to ensure consistency across studies. Key information included study design, setting, sample characteristics, determinants of waiting time, type of intervention, and reported outcomes. This approach facilitated systematic comparison while preserving contextual detail. Given the diversity of study designs and outcome measures, a statistical meta-analysis was not appropriate. Instead, a structured narrative synthesis was employed. The analysis focused on identifying patterns of convergence and divergence, examining how demand, capacity, and process factors interact, and exploring the conditions under which interventions are effective.

Findings were organised into three core themes: determinants of waiting times, effects of delays, and process improvement strategies. Particular attention was given to distinguishing between within-ED process inefficiencies and broader system-level constraints.

In line with the critical review design, evidence quality was appraised narratively rather than through a formal scoring system. Across the literature, several recurring limitations were identified. Many studies relied on single-site data, limiting generalisability. Administrative datasets often lacked behavioural and experiential variables, constraining interpretation. Simulation and optimisation studies depended on simplifying assumptions that may not reflect real-world complexity, and in some cases relied on synthetic or incomplete data. In addition, findings were frequently context-specific, shaped by institutional and system-level factors. These limitations were explicitly considered during analysis. Evidence from studies with stronger methodological transparency and clearer real-world applicability was given greater interpretive weight, while findings from more constrained designs were treated with caution. As a result, strong or universal claims were avoided, particularly where the underlying evidence base was limited or inconsistent.

However, the relevance-based screening approach introduces potential selection bias and limits reproducibility.

Restricting the search to English-language publications may exclude relevant international studies, and the exclusion of grey literature may omit practical insights from healthcare organisations. Thus, the aim of this study is not exhaustive

coverage, but a clear, balanced, and practically grounded synthesis of the most relevant evidence. As such, the review provides a nuanced understanding of ED waiting times and the conditions under which process improvement strategies such as LSS may be effective.

3. LITERATURE REVIEW

This study develops a conceptual framework to explain the determinants of waiting times in emergency departments (EDs) and how process improvement interventions, particularly Lean Six Sigma (LSS), can help reduce these delays.

The framework draws on insights from operations management, healthcare systems theory, and empirical evidence from the reviewed literature. At its core, it conceptualises ED waiting time as the outcome of interactions between demand-side pressures, supply-side constraints, and process inefficiencies, all of which are influenced by organisational and behavioural factors (Morley et al., 2018; Salway et al., 2017).

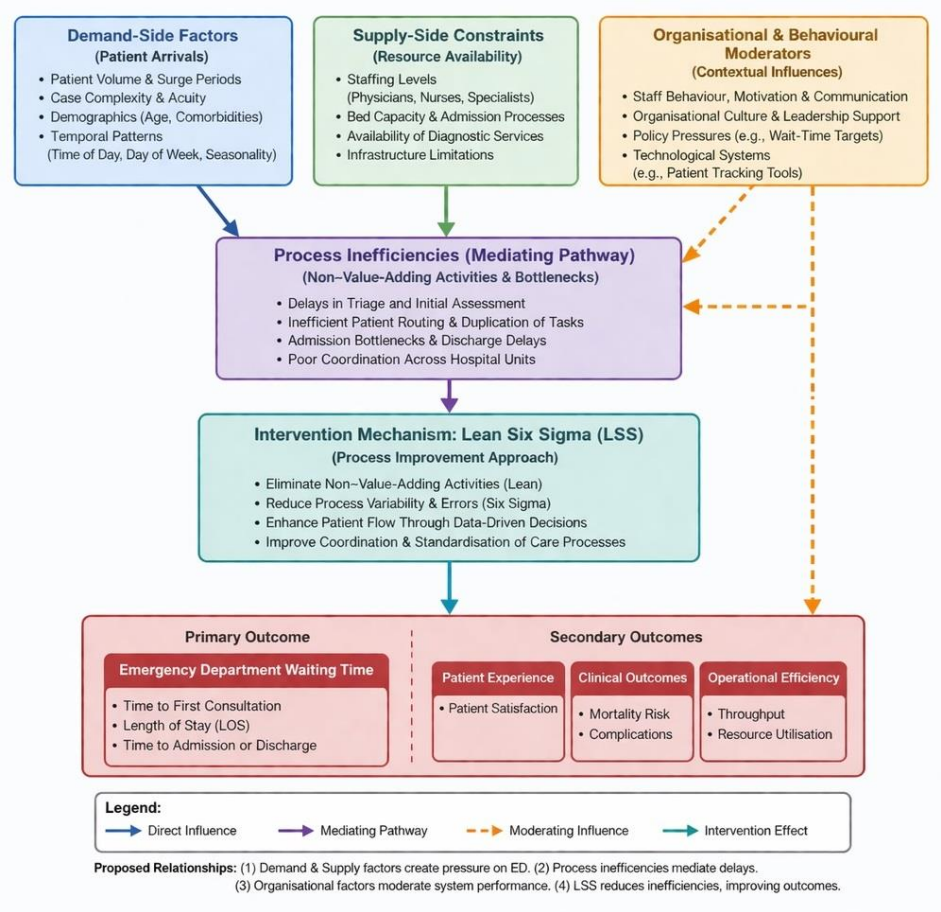

Fig. 1: Determinants of ED Waiting Time and the Role Lean Six Sigma (LSS).

Demand-side factors relate to the volume, timing, and characteristics of patient arrivals into the ED. Evidence shows that fluctuations in patient volume, especially during peak periods, significantly affect waiting times (Bobrovitz et al., 2017; Janke et al., 2023). In addition, differences in case complexity and acuity levels influence how quickly patients can be assessed and treated, with more complex cases requiring longer processing times (Chaou et al., 2020; Hajzargarbashi et al., 2019). Demographic characteristics, such as age and the presence of comorbidities, further contribute to variation in waiting times, as older patients tend to require more diagnostic procedures and longer care pathways (Bobrovitz et al., 2017; Verma et al., 2021). Temporal patterns, including time of day, day of the week, and

seasonal variation, also introduce unpredictability into ED utilisation, often leading to congestion during peak demand periods (Bobrovitz et al., 2017).

Supply-side constraints capture the availability and allocation of healthcare resources required to meet patient demand. These include staffing levels, such as the number of physicians, nurses, and specialists, as well as the availability of hospital beds and the efficiency of admission processes (Bahari & Asadi, 2020; Shen & Lee, 2019). Access to diagnostic services and infrastructure capacity also influence patient throughput and waiting times (Luo et al., 2018).

When demand exceeds available capacity, delays become unavoidable, resulting in prolonged waiting times and overcrowding (Johannessen & Alexandersen, 2018; Salway et al., 2017).

Process inefficiencies represent delays and non-value-adding activities within the patient care pathway. These include bottlenecks in triage and initial assessment, duplication of tasks, inefficient patient routing, and delays in admission or discharge (Shen & Lee, 2019; Rehman et al., 2023). Poor coordination across hospital units further exacerbates these inefficiencies, often creating system-wide congestion (Morley et al., 2018). Evidence suggests that such inefficiencies amplify the impact of demand-supply imbalance, making waiting times longer than expected even in resource-adequate settings (Johannessen & Alexandersen, 2018).

In addition to these structural and operational factors, the framework recognises the role of organisational and behavioural moderators. ED performance is shaped by staff behaviour, communication, and motivation, as well as organisational culture and leadership support (Vezyridis & Timmons, 2014). Policy pressures, such as wait-time targets, can influence how care is delivered, sometimes improving efficiency but also introducing unintended consequences for staff and patient experience (Gaughan et al., 2020; Vezyridis & Timmons, 2014). Technological systems, including patient tracking tools and information systems, also play a critical role in improving coordination and real-time decision-making (Vezyridis & Timmons, 2014; Ehrler et al., 2022).

Lean Six Sigma (LSS) is introduced in the framework as a key intervention mechanism that directly targets process inefficiencies. LSS helps eliminate non-value-adding activities, reduce process variability, streamline workflows and improve patient flow (Improta et al., 2018; Honda et al., 2018). It also promotes data-driven decision-making and standardisation of care processes, leading to improved coordination and reduced delays (Mandahawi et al., 2017; Sanchez et al., 2018). Empirical evidence suggests that LSS significantly reduces waiting times, length of stay, and operational inefficiencies in ED settings (Tejedor-Panchón et al., 2014; Honda et al., 2018).

Outcome Variables

The primary outcome of interest in this framework is emergency department waiting time, which is typically measured using indicators such as time to first consultation, total length of stay (LOS), and time to admission or discharge (Verma et al., 2021). In addition to these primary measures, the framework also considers secondary outcomes, including patient satisfaction, clinical outcomes such as mortality risk and complications, and operational efficiency indicators like throughput and resource utilisation (Abbasi-Moghaddam et al., 2019; Morley et al., 2018). These outcomes reflect both the quality and efficiency of ED performance.

The framework proposes that demand-side pressures and supply-side constraints jointly determine the level of congestion within the ED (Salway et al., 2017). Process inefficiencies act as a key pathway through which this

imbalance translates into prolonged waiting times (Rehman et al., 2023). Organisational and behavioural factors influence how effectively processes operate, either mitigating or exacerbating delays (Vezyridis & Timmons, 2014).

Lean Six Sigma interventions reduce process inefficiencies, thereby improving patient flow and reducing waiting times (Mandahawi et al., 2017). As processes become more efficient, waiting times decrease, leading to improved patient outcomes and better overall system performance (Honda et al., 2018).

Related Studies

Across the literature on emergency department (ED) waiting times, there is broad agreement that inefficiencies in patient flow, variability in demand, and constraints in resource allocation are central drivers of delays (Morley et al., 2018; Bobrovitz et al., 2017). However, the evidence diverges regarding the effectiveness and sustainability of proposed interventions. Importantly, much of the literature is shaped by methodological constraints. Differences in study design, ranging from retrospective observational analyses to simulation-based modelling and qualitative inquiry, produce varying interpretations of the same problem. As a result, while individual studies provide valuable insights, their findings are often difficult to synthesise into universally applicable solutions.

A consistent finding across studies is that waiting times are influenced by a combination of patient-level, temporal, and system-level factors. For example, Bobrovitz et al. (2017), using a large retrospective dataset, identify age, time of arrival, referral source, and diagnostic complexity as significant predictors of delays. Similarly, Hajzargarbashi et al. (2019) demonstrate that triage level, work shift, and type of consultation significantly affect waiting times, reinforcing the role of both clinical urgency and organisational processes. While these studies agree on the multifactorial nature of delays, they diverge in emphasis. Bobrovitz et al. (2017) highlight temporal variability, such as higher delays during night shifts and peak periods, whereas Hajzargarbashi et al. (2019) emphasise intra-hospital coordination challenges, particularly delays in specialist consultations. This suggests that waiting times are not driven by isolated factors but emerge from interdependent bottlenecks across the patient pathway.

Further complexity arises from studies examining equity-related determinants. Opoku et al. (2017) and Hansen et al. (2022) identify persistent racial disparities in ED waiting times, even after controlling for observable variables. These findings challenge purely operational explanations and point to deeper systemic issues, including structural inequalities and potential provider bias. However, most quantitative models lack the capacity to fully capture these socio-behavioural dynamics, revealing a key limitation in the literature.

A substantial body of research evaluates the impact of performance targets, particularly the four-hour wait target in the United Kingdom. Evidence suggests that such targets can improve throughput and increase organisational focus on time management. Vezyridis and Timmons (2014), through qualitative analysis, show that the target reshaped clinical workflows, enhanced time awareness, and was supported by real-time tracking systems. However, the literature also reveals important contradictions. While performance targets may improve measurable efficiency, they can generate unintended consequences. Vezyridis and Timmons (2014) report reduced quality of patient-clinician interactions, increased staff pressure, and shifts in professional roles. These findings contrast with quantitative studies that often assume that efficiency gains directly translate into improved care outcomes. This divergence highlights a critical insight: operational improvements may come at the expense of relational and experiential dimensions of care. As such,

policies focused solely on time-based metrics risk overlooking broader aspects of healthcare quality, including patient experience and staff wellbeing.

Evidence from quasi-experimental studies supports the effectiveness of Lean interventions in reducing waiting times.

For instance, Tejedor-Panchón et al. (2014) report significant reductions in waiting time and length of stay following Lean implementation, particularly in lower-complexity patient pathways. These findings align with broader literature suggesting that process redesign and waste elimination can improve patient flow. However, the impact of such interventions is not uniform. Improvements tend to vary across clinical pathways, with less pronounced effects in complex or high-acuity cases. This is consistent with findings by Verma et al. (2021), which show that prolonged ED stays are associated with increased mortality among critically ill patients. Together, these studies suggest that process optimisation alone may be insufficient for managing high-risk patient groups.

Digital and informational interventions produce more mixed results. McDougal et al. (2017) find that publicly posting ED wait times is associated with improved throughput efficiency, likely by influencing patient behaviour. Similarly, Ehrler et al. (2022) show that SMS-based systems can enhance patient satisfaction by reducing perceived waiting burden. However, these interventions often do not significantly reduce actual waiting times. Instead, they reshape the patient experience of waiting. This distinction between operational efficiency and perceived efficiency is important but often underexplored in the literature.

Simulation-based studies consistently highlight the importance of resource allocation in reducing waiting times. For example, Luo et al. (2018) demonstrate that capacity reservation policies can significantly reduce delays, while Bahari and Asadi (2020) show that optimised staffing and resource configurations can improve both efficiency and cost outcomes. Similarly, Rehman et al. (2023) report reductions in waiting times and patient abandonment through optimisation modelling. Despite these promising findings, significant limitations remain. Many simulation studies rely on simplified assumptions, static conditions, or synthetic datasets (Alhuntushi et al., 2022), which may not accurately reflect real-world complexity. Additionally, their outputs are often difficult to translate into practical decision-making, limiting their applicability in clinical settings.

A growing body of evidence highlights that ED waiting times are shaped by system-wide dynamics rather than isolated departmental issues. Shen and Lee (2019) demonstrate that delays in bed allocation and ward acceptance significantly contribute to prolonged ED stays, emphasising the role of downstream bottlenecks. Similarly, Sorić et al. (2022) show that the introduction of emergency medicine specialists improves patient throughput, underscoring the importance of staff expertise and coordination. These findings reinforce a key point of agreement across the literature: ED congestion is fundamentally a system-level problem. Effective solutions therefore require integrated approaches that address both upstream demand pressures and downstream capacity constraints.

4. DISCUSSION

This study brings together evidence on what drives waiting times in emergency departments (EDs) and how process improvement approaches, especially Lean Six Sigma (LSS), can help address them. One clear message runs through the findings: long waiting times are not caused by a single issue. Instead, they emerge from a combination of pressures, patient demand, available resources, process design, and organisational dynamics (Morley et al., 2018; Salway et al., 2017). These elements are closely connected, and when one part of the system struggles, the effects quickly spread. In

this context, LSS is best understood not as a quick fix, but as a structured approach that works best when it addresses these interconnected components (Improta et al., 2018; Honda et al., 2018).

One major driver of delays is the mismatch between patient demand and available capacity. Across the literature, studies consistently show that EDs face fluctuating and often unpredictable demand. Busy periods, night-time arrivals, seasonal variation, and sudden surges during disease outbreaks all place pressure on services (Bobrovitz et al., 2017; Morley et al., 2018). At the same time, patient complexity, particularly among older adults and those with multiple conditions, requires more time and coordination, slowing overall flow (Hajzargarbashi et al., 2019). However, an important insight is that delays are not simply the result of limited resources. Evidence suggests that even well-resourced systems can experience congestion when resources are not aligned with demand patterns (Johannessen & Alexandersen, 2018; Luo et al., 2018). This shifts the focus from resource scarcity to how resources are organised and managed.

Alongside demand pressures, process inefficiencies play a central role. Many delays occur not because care cannot be delivered, but because processes are fragmented or poorly coordinated. Common issues include delays in triage, inefficient diagnostic workflows, and bottlenecks in specialist consultations and admissions (Shen & Lee, 2019; Sorić et al., 2022). What happens outside the ED is equally important. Delays in bed allocation and ward acceptance often mean patients remain in the ED longer than necessary, increasing congestion (Shen & Lee, 2019). These findings reinforce the idea that ED waiting times are not just an ED problem, but reflect wider hospital system performance (Salway et al., 2017).

Another important layer relates to human and organisational factors. Staff workload, communication, and coordination directly affect how efficiently patients move through the system (Pich et al., 2017). Policy tools such as time-based targets can improve throughput and create a sense of urgency, but they may also lead to unintended consequences.

Studies report increased staff pressure, reduced quality of patient-provider interactions, and fragmentation of care processes (Vezyridis & Timmons, 2014; Gaughan et al., 2020). In addition, disparities in waiting times across patient groups persist even after controlling for clinical factors, suggesting the influence of deeper structural and behavioural dynamics (Opoku et al., 2017; Hansen et al., 2022). These findings highlight that improving waiting times is not only about efficiency, but also about equity, staff well-being, and quality of care.

Within this complex system, Lean Six Sigma emerges as a useful, but not universally effective, approach. Many studies report improvements such as reduced waiting times, shorter length of stay, and better patient flow following LSS implementation (Mandahawi et al., 2017; Sanchez et al., 2018). These gains are typically achieved by removing non-value-adding activities, streamlining workflows, and using data to support decision-making (Improta et al., 2018).

However, the strength of this evidence varies. Much of it comes from single-site or quasi-experimental studies, which limits generalisability (Honda et al., 2018). LSS appears most effective when delays are driven by identifiable process inefficiencies and when there is strong organisational support. Its impact is more limited when delays stem from broader system constraints, such as bed shortages or staffing gaps. This suggests that LSS should be viewed as one part of a wider system improvement strategy, rather than a standalone solution.

Technology and data analytics also play an increasingly important role. Tools such as real-time tracking systems, predictive models, and simulation techniques help improve system visibility and support more proactive decision-making (McDougal et al., 2017; Ehrler et al., 2022; Rehman et al., 2023). For example, predictive analytics can help anticipate demand surges, while tracking systems allow better coordination across departments. However, these tools are not without limitations. Some studies highlight concerns about data quality, reliance on simplifying assumptions, and difficulties in translating complex models into practice (Alhuntushi et al., 2022; Chaou et al., 2020). There are also implementation challenges, particularly in resource-constrained settings. As a result, technology is most effective when it complements, rather than replaces, sound process design and organisational coordination.

The literature also reveals important variations and trade-offs. Some interventions produce strong results in certain contexts but limited impact in others. For example, increasing resources improves outcomes in some settings but has little effect where coordination remains weak (Luo et al., 2018). Performance targets can improve efficiency but may affect care quality and staff experience (Vezyridis & Timmons, 2014). Similarly, process improvements may benefit low-complexity cases more than critically ill patients, who require more intensive care (Verma et al., 2021). These differences highlight the importance of context. The effectiveness of any intervention depends on factors such as hospital size, patient population, organisational culture, and the broader healthcare system (Janke et al., 2023).

Bringing these insights together, this study contributes by offering a more integrated understanding of ED waiting times. Rather than treating causes, effects, and solutions separately, it connects them within a single framework. The findings show how demand pressures, resource constraints, and process inefficiencies interact to shape outcomes such as waiting time, patient experience, and clinical risk. Within this system, LSS is positioned not simply as a technical tool, but as a method for improving how these elements work together.

Importantly, the study also extends beyond purely operational explanations by incorporating organisational and human factors. By highlighting the role of staff behaviour, communication, and equity considerations, it provides a more realistic view of how ED systems function in practice (Pich et al., 2017; Hansen et al., 2022). This helps explain why some interventions succeed while others do not, and why improvements are not always sustained.

Overall, the findings suggest that reducing waiting times requires a whole-system approach. It is not enough to fix isolated steps or introduce single interventions. Meaningful improvement depends on aligning demand, resources, processes, and people in a coordinated way. Lean Six Sigma can play a valuable role in this process, but only when applied thoughtfully, supported by data, and adapted to the specific context in which care is delivered.

5. Limitations and Future Directions

While this study provides a comprehensive and integrated review of waiting times in emergency departments (EDs), few limitations should be acknowledged. First, the review is based on secondary data from published studies, many of which have their own methodological constraints. Several included studies rely on retrospective datasets, administrative records, or self-reported measures, which may be affected by missing data, reporting bias, or inconsistencies in measurement across settings. These data quality issues can influence the reliability of the conclusions drawn. Second, a significant portion of the evidence comes from single-site case studies, quasi-experimental designs, and simulation-based models. While these approaches provide useful insights, they often depend on context-specific conditions or simplifying assumptions. As a result, the findings may have limited generalisability to other hospitals, particularly those

operating in different healthcare systems or resource-constrained environments. Finally, although this study attempts to integrate operational and human factors, the available literature remains skewed toward quantitative and efficiency-focused analyses. As a result, important aspects such as organisational culture, staff behaviour, and patient perceptions may not be fully captured or adequately explored.

Building on these limitations, several areas for future research are recommended. First, there is a need for more robust and generalisable empirical studies, including multi-site and cross-country research that can better capture variations across different healthcare systems. Such studies would help determine whether findings from individual settings can be applied more broadly. Second, future research should prioritise the use of high-quality, real-time data. Integrating electronic health records, patient flow data, and operational metrics can improve the accuracy of analyses and support more reliable conclusions. Efforts should also be made to standardise key measures, such as waiting time and length of stay, to enhance comparability across studies.

Third, further research is needed to evaluate the long-term sustainability and cost-effectiveness of interventions, particularly Lean Six Sigma (LSS). Most existing studies focus on short-term improvements, with limited attention to whether these gains are maintained over time or how much they cost to implement and sustain. Finally, there is a need for greater focus on equity and inclusion in ED performance. Future research should explore disparities in waiting times across different population groups and investigate the underlying causes, including potential biases in triage and care processes.

6. Conclusion and Industry Implications

Looking across the evidence, one thing becomes very clear, long waiting times are not caused by a single failure in the system but a result of several pressures happening at the same time including unpredictable patient demand, limited or poorly aligned resources, inefficient processes, and the way people and organisations work together. This means that improving waiting times is not about finding one “perfect solution.” Instead, it requires looking at the system as a whole. When hospitals focus only on one part such as adding more staff or introducing a new policy, the results are often limited or short-lived. What makes a real difference is how well demand, resources, processes, and staff are aligned and coordinated.

Within this broader picture, Lean Six Sigma (LSS) stands out as a useful approach but with an important caveat. It works best when it is used to fix clear process problems, such as unnecessary steps, delays in decision-making, or poor workflow design. It helps teams see where time is being lost and how to improve flow in a practical, structured way.

However, it is not a cure-all. If the main issue is a shortage of beds, staffing gaps, or wider system constraints, then process improvement alone will not be enough. In other words, LSS is most effective when it is part of a wider, system-level effort.

For healthcare managers and policymakers, the implications are quite practical. First, improving ED performance requires a shift from isolated fixes to coordinated, system-wide thinking. Hospitals need to look beyond the ED itself and address bottlenecks across the entire patient journey from arrival to admission or discharge. This includes improving bed management, strengthening coordination between departments, and ensuring that resources are used where and when they are most needed.

Second, there is a strong case for investing in better use of data. Real-time information on patient flow, waiting times, and resource use can help teams make quicker and more informed decisions. When combined with process improvement approaches like LSS, data can turn guesswork into targeted action. However, these tools must be simple enough to use in practice and supported by proper training and infrastructure. Third, the human side of the system cannot be overlooked. Staff are central to how well the ED functions. Supporting them through training, manageable workloads, and clear communication structures is essential for sustaining improvements. At the same time, care must remain patient-centred. Efforts to reduce waiting times should not come at the expense of compassion, communication, or fairness. Addressing disparities in waiting times across different patient groups should also be a priority. Finally, what works in one hospital may not work in another. Differences in size, resources, patient populations, and organisational culture all matter. This means that improvement strategies should be tested, adapted, and refined locally rather than applied as one-size-fits-all solutions.

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