

A Systematic Review of Demand-Based Capacity Planning in the Emergency Department of the Hospital

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ABSTRACT

The emergency department (ED) is an important entry point for healthcare systems that often function under strong pressure due to unpredictable patient volumes. The requested capacity plan is intended to coordinate resources with patient requirements in real time to ensure a timely, safe and effective supply. This review examines demand-based capacity planning from healthcare leaders, managers, and professionals perspective and examines strategies, challenges, tools and future directions for effective resource management in EDs.

The ED is a dynamic and high-stakes environment that operates at the threshold of chaos, demanding continuous adaptability, strategic foresight, and leadership excellence. As healthcare systems confront growing patient volumes, limited resources, and unpredictable case mixes, demand-based capacity planning has emerged as a vital tool to optimize care delivery and ensure operational resilience.

Healthcare managers in the ED serve as key drivers of system performance, balancing clinical urgency with resource allocation. The review highlights how senior ED leadership must engage in continuous planning, simulation, and strategic adjustment to maintain patient flow, mitigate overcrowding, and enhance care quality especially during surges in demand.

Furthermore, this paper explores the intersection of people, systems, and physical environments as critical components in capacity planning. Managers must be agile in change management, aligning operational innovations with team values to embed improvements at all levels. Ultimately, the success of demand-based capacity planning hinges not only on data-driven models but also on the leadership capacity to transform challenges into coordinated responses. The findings underscore that the effectiveness of ED services is inextricably linked to the quality of its leadership and the strength of its organizational framework.

1. INTRODUCTION

The Emergency Department (ED) is a unique operational environment often described as functioning on the edge of chaos [1]. It is designed to deliver rapid, comprehensive emergency care in both anticipated and unforeseen situations. The ED environment is inherently complex and disruptive due to frequent interruptions, multitasking demands, and high decision density [2,3]. The unpredictable nature of patient inflow, varied case acuity, and limited control over throughput processes make capacity management exceptionally challenging for ED staff and administrators [4].

ED practitioners operate at multiple cognitive and organizational levels. At the first level, clinicians engage in direct one-on-one care with patients, progressing sequentially from one case to the next. At the second level, they manage multiple patients simultaneously—requiring multitasking and rapid prioritization to ensure safe, concurrent care delivery across the department [5]. At the third level, advanced practitioners, often emergency physicians, coordinate team-based care, triage urgent needs, and make real-time decisions regarding which protocols can be adapted to meet evolving situational demands [6]. At the fourth level, ED managers and administrators are responsible for maintaining an environment conducive to high-quality care. This includes ensuring that people, systems, and physical infrastructure are aligned to support operational performance and clinical safety [7].

EDs serve as the frontline interface for patients requiring urgent and often life-saving care, typically under high-pressure and unpredictable conditions [8]. The volatile nature of patient demand—shaped by time of day, seasonality, public events, and referral surges—creates persistent misalignments between available resources and actual needs. Traditional capacity

planning approaches, which rely on historical averages and static staffing models, frequently fail to anticipate demand surges. This leads to overcrowding, prolonged wait times, increased risk of medical error, staff fatigue, and suboptimal patient outcomes [9,10].

In response, demand-based capacity planning has emerged as a strategic and data-informed solution. This approach integrates real-time operational data, predictive analytics, and scenario modeling to proactively match ED resources with projected patient demand [11,12]. From a leadership standpoint, such planning enhances both clinical quality and operational efficiency while supporting financial sustainability and workforce well-being [13].

This paper systematically reviews demand-based capacity planning strategies in the Emergency Department . It explores the operational drivers of demand variability, technological enablers such as forecasting tools and digital dashboards, and change management practices critical for successful implementation. By fostering a responsive, data-driven planning culture, healthcare leaders can shift ED operations from reactive crisis management to proactive, resilient care delivery.

2. METHOD

This review article adopts a qualitative, narrative review methodology to explore current practices, strategies, and outcomes associated with demand-based capacity planning in Emergency Departments (EDs). The aim is to synthesize findings from existing literature and identify emerging themes, challenges, and best practices for healthcare leaders.

Literature Search Strategy

A structured search was conducted across multiple electronic databases including PubMed, Scopus, Web of Science, and Google Scholar, covering the period from 2010 to 2025. Keywords and Boolean operators used in the search included:

- "demand-based capacity planning" AND "emergency department"
- "ED overcrowding" AND "predictive analytics"
- "hospital operations" AND "capacity optimization"

Inclusion criteria were:

- Peer-reviewed journal articles
- Systematic reviews, case studies, and theoretical frameworks
- Focus on emergency department operations, capacity management
- English language publications

Exclusion criteria included:

- Articles focused solely on non-acute care settings
- Opinion pieces without empirical or theoretical grounding
- Publications lacking a management component

Data Extraction and Synthesis

Articles meeting inclusion criteria were analyzed for content related to:

- Demand forecasting tools and technologies (e.g., machine learning, simulation modeling)
- Leadership roles and decision-making in ED planning
- Strategic implementation of resource allocation models
- Outcome metrics such as patient wait times, length of stay, and staff workload

Themes were identified through thematic analysis, emphasizing the leadership implications of planning processes and how organizational change is managed in high-demand healthcare settings. Special attention was paid to studies that report quantitative impacts of capacity planning interventions and those that integrate qualitative assessments of leadership practices.

3. LIMITATIONS

This review is limited by its reliance on English-language publications and potential publication bias toward successful implementations. Furthermore, while the focus is on the ED, findings from broader hospital operations were selectively included when directly relevant to emergency care leadership.

4. STUDIES REPORTED VARIOUS OUTCOMES, INCLUDING:

4.1 *Reduction in patient wait times and length of stay.*

Reducing patient wait times and LOS in EDs requires a multifaceted approach, including enhanced triage systems, process improvement methodologies, workflow optimization, and hospital-wide initiatives. Implementing these strategies can lead to more efficient ED operations and improved patient outcomes.

4.1.1. Enhanced Triage and Rapid Assessment Models

Implementing structured triage systems, such as the Canadian Triage and Acuity Scale (CTAS), combined with rapid assessment protocols, can significantly reduce wait times. For instance, a study in a pediatric ED introduced the Pediatric Rapid Assessment and Management (PRAM) model, leading to reduced assessment times and overall LOS.[14-15]

4.1.2 Process Improvement Methodologies

Applying methodologies like Six Sigma has proven effective in streamlining ED operations. A prospective study in China demonstrated that employing the DMAIC (Define, Measure, Analyze, Improve, Control) cycle led to a significant reduction in LOS for both admitted and non-admitted patients. This approach also improved bed utilization rates and patient flow. [16]

4.1.3. Workflow Optimization and Standardization

Standardizing admission processes and modifying consultation workflows can decrease consultation-to-decision times, a major component of ED LOS. A systematic review highlighted that interventions such as direct communication with senior physicians and process standardization effectively reduced these times. [17]

4.1.4. Enhanced Recovery Programs (ERPs)

ERPs, particularly in surgical contexts, focus on optimizing perioperative care to reduce LOS. Evidence suggests that ERPs can reduce hospital stays by 0.5 to 3.5 days compared to conventional care, especially in colorectal surgeries. However, the effectiveness varies across different surgical specialties.

4.1.5. Interdisciplinary Bedside Rounds

Implementing interdisciplinary bedside rounds, where the care team collaborates at the patient's bedside, can enhance communication and coordination. This approach has been associated with improved patient outcomes and reduced LOS.

4.1.6. Hospital-Wide Initiatives

Hospital-wide strategies, such as those implemented in the UK, focus on treating more patients at home or at the scene to alleviate ED congestion. For example, a £450 million overhaul of NHS emergency care services aims to reduce long A&E wait times by enhancing at-home care and establishing new urgent care centers.

4.2 *Improvement in patient throughput and satisfaction.*

Improving patient throughput and satisfaction in Emergency Departments (EDs) is critical for enhancing care quality and operational efficiency. Several strategies have been identified through research and practice that effectively address these challenges.

4.2.1. Implementing Lean-Based Systems Engineering

A study at Massachusetts General Hospital applied Lean principles to reorganize the Fast Track process in the ED. This intervention led to a significant reduction in median length of stay (LOS) by 15 minutes, increased the percentage of patients discharged within one hour by 2.8%, and decreased median exam room time by 34 minutes. These improvements were achieved without additional expenses, demonstrating the efficacy of Lean methodologies in enhancing ED throughput

4.2.2 Adopting Physician at Triage (PAT) Models

Introducing a physician at the triage stage has been shown to expedite patient assessment and care. A study in South-East Queensland found that implementing a PAT model significantly reduced ED length of stay and improved various outcomes, including time to clinician assessment and meeting national emergency access targets. This approach facilitates timely medical intervention, enhancing patient flow and satisfaction.

4.2.3. Establishing Medical Assessment Units (MAUs)

MAUs provide rapid assessment and short-term management for patients with acute medical conditions, aiming to reduce unnecessary admissions. Research indicates that MAUs can decrease ED length of stay, reduce inpatient admissions, and lower overall hospital bed occupancy. Additionally, they have been associated with cost savings and improved patient outcomes, including no significant impact on re-admission rates.

4.2.4. Utilizing Audit-and-Feedback with Peer Comparison

Implementing audit-and-feedback mechanisms with peer comparison among ED physicians can enhance individual

performance and departmental efficiency. A study involving 36 ED physicians revealed that providing daily, quarterly, and annual performance reports led to a decrease in admission rates, reduced time to admission, and shorter discharge times. This strategy also minimized variation in physician performance, contributing to improved patient throughput.

4.2.5. Enhancing Care Team Collaboration

Effective communication and collaboration among multidisciplinary care teams are essential for improving ED throughput. Utilizing Clinical Collaboration and Communication (CC&C) platforms enables real-time, secure messaging among care team members, facilitating timely decision-making and coordination. This approach has been shown to reduce delays in patient care, leading to improved patient outcomes and satisfaction.

4.2.6. Optimizing Physical Layout and Workflow

Redesigning the physical layout of the ED and optimizing patient flow can significantly enhance throughput. A study in a hospital's ED found that restructuring consultation areas, increasing the number of consultation rooms, and improving signage facilitated smoother patient movement through the department. These changes led to reduced waiting times and improved patient satisfaction.

4.3 Enhanced resource utilization and cost savings.

Enhanced resource utilization and cost savings in Emergency Departments (EDs) are critical for improving operational efficiency and patient care. Recent studies have identified several strategies and models that contribute to these objectives.

4.3.1. Simulation Optimization for Resource Allocation

A study utilized simulation optimization to determine the optimal allocation of resources in an ED, considering factors like community health workers, nurses, cardiologists, and beds. The proposed model reduced patient wait times by 49.6% and decreased operational costs by 51%, demonstrating the effectiveness of strategic resource planning.

4.3.2. Utilization Review Software

Implementing utilization review software in the ED led to a decrease in inpatient admission rates from 14.2% to 12.8%, an increase in discharge rates from 82.4% to 83.4%, and a reduction in estimated costs by \$193.17 per visit. These changes suggest that better resource utilization can lead to significant cost savings.

4.3.3 Pharmacist Interventions

The presence of emergency medicine pharmacists in the ED resulted in 894 interventions over a study period, leading to an estimated cost avoidance of \$143,132. This equates to approximately \$1,671 in cost savings per shift, highlighting the financial benefits of integrating pharmacists into ED teams.

4.3.4. Structured Emergency Nursing Framework

The implementation of the HIRAID (History, Inspection, Risk, Assessment, Intervention, and Documentation) framework in EDs led to significant cost benefits. The structured approach improved documentation accuracy and patient assessment, contributing to more efficient resource utilization and reduced costs.

4.3.5. Goal Programming for Resource Allocation

A study applied goal programming to optimize the allocation of resources such as doctors, nurses, and beds in an ED. The model demonstrated that strategic adjustments in staffing and bed availability could reduce the number of patients leaving without service by 61.7% and decrease waiting times, leading to improved patient throughput and cost efficiency.

4.3.6. Real-Time Resource Allocation

Implementing real-time resource allocation strategies, informed by predictive models and process mining, can enhance ED performance. By dynamically adjusting resources based on real-time data, EDs can improve patient flow, reduce overcrowding, and optimize resource utilization, leading to cost savings.

4.4 Increased staff satisfaction due to optimized scheduling.

Optimized scheduling in Emergency Departments (EDs) has been shown to significantly enhance staff satisfaction by promoting work-life balance, reducing burnout, and fostering a positive work environment. Implementing advanced scheduling systems that consider staff preferences and equitable shift distribution can lead to improved morale and retention.

4.4.1. Improved Work-Life Balance

Flexible scheduling allows ED staff to better balance their professional and personal lives. By accommodating individual preferences and providing control over work hours, staff experience reduced stress and increased job satisfaction. This flexibility is particularly beneficial in high-pressure environments like EDs, where shift work is common.

4.4.2. Reduction in Burnout

Overwork and irregular hours contribute to burnout among healthcare professionals. Optimized scheduling helps distribute shifts more evenly, reducing the need for excessive overtime and ensuring adequate rest periods. This approach leads to lower fatigue levels, improved focus, and a decrease in burnout rates, ultimately enhancing staff well-being and performance.

4.4.3. Enhanced Job Satisfaction

When ED staff have input into their schedules and experience fairness in shift assignments, their overall job satisfaction increases. Studies have shown that staff who feel their scheduling needs are met are more engaged and motivated, leading to higher quality patient care and a more cohesive team environment.

4.4.4. Increased Retention Rates

Organizations that implement optimized scheduling practices often see a decrease in staff turnover. By addressing the scheduling needs of ED staff, hospitals can retain experienced professionals, reducing recruitment and training costs associated with high turnover rates.

4.4.5. Implementation of Advanced Scheduling Tools

Utilizing specialized scheduling software can automate and streamline the scheduling process. These tools can consider various factors such as staff availability, preferences, and regulatory requirements, leading to more efficient and satisfactory scheduling outcomes.

5. SYSTEM

5.1 These are now more standard than exceptions compared to the first year of emergency care. References (18, 19, 20, 21, 22) examine the outcomes of acceptance of several rules for clinical decisions and acceptance by practitioners. Standards for behavior, protocols, and clinical decisions are particularly attractive for ED management as they can provide specific orders in a chaotic environment. Great temptation, operations, protocols, clinical decisions for some ED management to implement as many conditions as the team can meet - manufacturing support. You may not recognize that ED is a complex system. It is difficult to predict all the events that can occur in a complex system. It is best to keep your goals simple and clear, to achieve three or four main goals of a practitioner, and to enable practitioners to organize and achieve them on their own.

5.2. Logistics and supplies

ED Management should ensure that team members have the equipment and consumption materials needed to care for patients. You don't have to be distracted by the incorrect device or supply. For example, if your practitioner wants to perform the procedure, it wastes time when he has to search for EDS to find gloves. Standardization of layouts for advice, revivals and other areas of work also contributes to this efficiency.

5.3. Performance indicators

Gottfredson and Schaubert (23) advised that management should know where it is starting from, i.e., diagnose its organization's point of departure and then know where it is going, in other words, map their point of arrival and make a plan.

Researchers (24, 25, 26) have measured and tracked different ED performance indicators. ED senior management will have to know their point of departure and arrival when deciding what to measure and track.

5.4. Contingency planning

Clothing Procedures and McCormick16 listed emergency plans for rare emergencies as one of the central activities of emergency care. One of the unique tasks of an ED manager is to plan and prepare a disaster.(27)

In the past decade, the world has encountered terrorist attacks, earthquakes, infectious diseases such as serious acute respiratory syndrome (SARS), and transport accidents.

6. PLACE

6.1. Deployment of physical space

When planning the layout of different work areas within a department footprint, ED conducting managers should consider the composition of the patient population and the flow of different subgroups within and outside the ED. If the layout of the work area cannot be changed, the routes that the patient must absorb must be planned from the ED. The goal is to maintain a minimum. This is important to protect patients and employees, especially when infections erupt, such as SARS.

The physical environment was identified as a critical source of communication sensitivity to security. Eisenberget al recommended that the creation of viable behind-the-

scenes areas be reduced to end the conversation and reduce misunderstandings and errors. There should also be quiet rooms and areas in the ED to break excited patients and their families, suspicious or victims of abuse, and bad news. One way to improve security for ED employees is to provide separate entrance doors from the public.

6.2. Surge capacity

A part of [contingency planning](#) is to plan an area or areas to accommodate surges in patients, whether from infectious disease outbreaks like [H1N1 influenza](#) in 2009(27) or from [overcrowding](#) (although we agree with Ovens(28) that ED overcrowding is a system problem requiring a system solution).

6.3. Physical environment

The ED operates 24 hours a day. This must be emphasized to the supporting departments, like housekeeping, facilities, etc. ED senior managers must arrange and ensure that their team receives the same level of support during and outside office hours, on weekdays and weekends.

The ED senior managers must be vigilant about the cleanliness of their ED, as this is one of the first impressions the public has of the facility but more importantly plays a part in infection control.

7. LEADING AND MANAGING

Christmas et al(29) found that having a consultant working nights resulted in reduced process times and a decrease in the rate of admission. In this site, the consultants volunteered to cover the night shifts and received extra remuneration for doing so. Christmas et al(29) wondered whether these consultants would have volunteered without the extra remuneration.

A common puzzle ED senior management faces from time to time is a physician who can attend to more patients but stops or “slows down” when he or she has achieved his or her “target number”. This “target number” is often the average number (or slightly higher) of patients attended to by the rest of the team. “Most people entering medicine and nursing do so with some belief that they will be able to help people (i.e., they should be more internally driven by the desire to do a good job than need constant external monitoring).”(30) This is generally true of ED teams, but there will be occasions when motivation is weak, morale is low, or disciplinary actions are required.

How can ED leaders and managers motivate their teams to do their best? Smith(31) in his book *Leading the Professionals – How to Inspire and Motivate Professional Service Teams* offered three suggestions. First, teams require leaders who are energetic and enthusiastic, and have a vigorous drive. Next, certain leadership skills such as giving recognition for performance, getting to know team members well, and creating an enjoyable [work environment](#) can inspire and motivate teams, and the third, creating flexibility in working methods as long as service quality and output are not compromised.

When leaders and managers fail to inspire and motivate their teams, there can be problems with staff retention, burn-out in their team members, underperformance, poor quality service, inefficiencies, etc. Contrary to popular belief, it is not only leadership skills that are required to inspire and motivate teams but also management ones. [Table 1](#) illustrates the more common leadership and management activities undertaken by leaders(31) such as the ED senior management.

Table 1. Typical leadership and management activities

Leadership	Management
Getting team members to provide their ideas on direction, objectives, and strategies	Making short-term plans
Leading by example	Acquiring and allocating resources
Communicating and enthusing people about the agreed direction, objectives, and strategies	Getting the right people into the right jobs
Inspiring people to overcome obstacles and to try new ways of working	Seeing that policies, procedures, and systems are observed
Creating the conditions where people will be motivated to achieve outstanding results	Providing authority and encouraging responsibility
Coaching people to help them to change and to perform more effectively	Monitoring performance
Fostering teamwork	Coping with disciplinary issues

Leadership	Management
	Resolving conflicts

The effectiveness of an organization depends on leadership qualities and management skills, and the appropriate balance. ED management must guide and ensure that teams provide the best possible care to their patients and continue to provide the ED with the most efficient and rare emergency events.

One of the most important management and management activities that ED management must support in managing your team. Changes are a challenge for every team.(32) To quote Arnold Bennett, there are all changes, better, better, always with even changes to disadvantages and symptoms. Communication is key to management, but this is difficult with EDS if team members do not stop layers and operations. ED Management is the first goal of a change to define the goal. The next thing to do is to know their stakeholders and take their concerns into consideration. Communication must be tailored according to the stakeholder perspective and requires feedback. This is very important, so changes should be introduced at a reasonable time. (33)

When managing changes, senior ED managers must accept that not everyone is convinced at the same time. Rogers(34) described users in five categories: Innovators and early users change early, with early majority and late majority demanding management to persuade them, and stragglers and poor employers may not be convinced, but their concerns should continue to be addressed. They are people who can influence and stay open to their colleagues, so it's important even if they're not a volume. 15

Changes are rarely accepted immediately. Ed's senior management needs to use "soft start" because team members need time to apply and need to adapt. Team members must undergo a transition. However, in a crisis, team members must be able to fully and immediately comply. During the 2003 SARS outbreak, this change was the norm for the ED team at Tan Tock Seng Hospital in Singapore. In a crisis, ED management must not only be command and control-

dependent managers, but also trust-inducing executives.(35) To quote former IBM President Thomas Watson, the real difference between organizational success and failure can be attributed very much to the question of how well an organization produces the great energy and talent of their people.

8. CONCLUSION

Emergency Departments (EDs), particularly in acute care hospitals, frequently oscillate between stable operational states and unpredictable surges in demand. These fluctuations can result in rapid transitions from organized workflow to operational complexity or even systemic chaos within a matter of hours. In such a volatile environment, the effectiveness of demand-based capacity planning is directly influenced by the leadership, capacity of ED executives and operational managers.

A systematic review of current literature on demand-based capacity planning in EDs reveals a shift from traditional static planning models to dynamic, data-driven strategies. These strategies utilize real-time patient flow data, historical volume trends, predictive analytics, and simulation modeling to anticipate demand and allocate resources accordingly. Effective demand-based planning in EDs has been associated with measurable reductions in patient length of stay (LOS), decreased rates of left without being seen (LWBS), improved staff utilization, and enhanced patient satisfaction.

The implementation of these planning models depends on several interrelated factors: the availability of real-time data systems (e.g., electronic health records with integrated dashboards), predictive tools (e.g., machine learning algorithms), and decision-support mechanisms embedded within ED operations. Leadership plays a pivotal role in operationalizing these tools by coordinating interdisciplinary workflows, instituting flexible staffing protocols, and deploying surge-capacity models.

Moreover, successful demand-based planning is not solely a technical function—it is also an organizational capability. Leadership commitment to continuous quality improvement, frontline staff engagement, and iterative performance evaluation is critical to sustain these systems. Studies consistently underscore the importance of incorporating clinical insights from nurses and physicians into planning processes, thus closing the gap between administrative strategy and bedside operations.

In the context of increasing ED visit volumes and constrained healthcare resources, demand-based capacity planning emerges from this review as a strategic framework rather than an isolated intervention. It enables high-performing EDs to respond proactively to patient demand variability while maintaining clinical quality and operational efficiency. The systematic evidence emphasizes that sustainable impact depends on strong governance structures, cross-departmental coordination, and leadership that is both data-literate and responsive to dynamic care environments.

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