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Nicole Melissa Rivera Sánchez
Walden University

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Walden University

College of Management and Human Potential

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Nicole Melissa Rivera Sánchez

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Dr. Kourtney Nieves, Committee Chairperson, Health Sciences Faculty

Dr. Kristin L. Wiginton, Committee Member, Health Sciences Faculty

Chief Academic Officer and Provost

Sue Subocz, Ph.D.

Walden University

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Strategies to Reduce Emergency Department Overcrowding at Hospitals in Puerto Rico

by

Nicole Melissa Rivera Sánchez

MA/MS, Atlantis University, 2022

BS, Pontifical Catholic University of Puerto Rico, 2017

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Abstract

Emergency department (ED) overcrowding has become an increasingly critical issue for the healthcare system of Puerto Rico, resulting in delayed care and increased patient morbidity, among other challenges faced by hospital leaders and administrators. This paper explores evidence-based strategies tailored to the Puerto Rican healthcare context to alleviate ED overcrowding. An integrative review of literature published between 2020 and 2025 was conducted. For this review, 15 articles were selected and appraised using the Johns Hopkins Evidence-Based Practice Model for Nursing and Healthcare Professionals. The strategies gleaned from the literature comprised six themes and 21 subthemes, centered on two major outcomes: reducing wait times and reducing ED overcrowding. These strategies include patient education to redirect patients with non-emergent cases to alternate urgent care locations, building and establishing a specialized team to address overcrowding, and optimizing the hospital's operations, such as improving patient flow. The results show that the efficiency and sustainability of the ED depends on a system-wide integration (i.e., triage redesign, diagnostic acceleration, capacity optimization, and data-driven management). Recommendations for professional practice focus on the implementation of a collaborative triage redesign, integrate point-of-care testing (POCT), adopt predictive data tools, and set quality and safety mechanisms into routine ED operations. The implications for social change include promoting equitable access to care, enhancing workforce resilience, and fostering the public's trust through transparency and adaptability. Despite limitations, the review proposes transforming the EDs in Puerto Rico into responsive, data-driven ecosystems to reduce wait times and overcrowding.

Part 1: Practice-Based Problem

Problem of Interest

Emergency department (ED) overcrowding is a phenomenon that impacts the hospital and the patient. For the hospital, overcrowding represents a decrease in the quality of the services offered, a waste of resources, and increased patient wait times, among other consequences (Darraj et al., 2023). For the patient, overcrowding results in a high mortality rate and an increase in the length of stay. The longer a patient must wait in the ED, the more complicated scenario evolves for the healthcare professionals in the ED and the patients. Identifying the factors that lead to overcrowding is key for each hospital and the ED to develop solutions aligned with the contributing factors of overcrowding.

Most research focuses on identifying the factors that contribute to overcrowding and possible solutions to reduce overcrowding based on those factors. Savioli et al. (2022) identified several key contributors to ED overcrowding, such as an increase in patient admissions, insufficient inpatient bed availability, delays in patient discharges, and a lack of accessible primary care options, which often leads individuals to use emergency services for non-urgent issues. Identifying what or who are the most affected by overcrowding helps to identify the different areas that are impacted by overcrowding and how to address those problems. Amin and Haswita (2023) established that overcrowding significantly affects patients, healthcare practitioners in the ED, and the overall health system.

Research has also shown that these solutions do not necessarily reduce ED overcrowding. This highlights the need for further study and analysis of the issue. By doing so, hospitals can develop individualized strategies tailored to the specific factors

contributing to overcrowding in their facilities. Sartini et al. (2022) proposed analyzing data specific to a hospital that can help pinpoint the areas where patient flow is impeded, resulting in overcrowding. Understanding these bottlenecks is essential for targeted interventions.

Healthcare Administration Problem

Background

The definition of *overcrowding* is based on the inability of the ED to provide the care services required to satisfy patients' needs for care (Amin & Haswita, 2023). Overcrowding is related to patient flow. Savioli et al. (2022) proposed the input, throughput, and output models to explain the three operations patients go through when accessing care services from the ED. Input level is the volume of patients arriving at the ED; throughput is services that may require patients to wait to receive them; and output is the volume of patients discharged from care. Any impact in any of the levels of operations, such as an increase in the volume of patients arriving in the ED, delays in the wait times to receive care, and delays in the volume of patients released from care, could increase the likelihood of overcrowding in the ED. Overcrowding is often associated with *access block* (i.e., the delay of the admission process for patients who require services beyond the ED), and *boarding* (i.e., patients who are waiting to be assigned to a bed in the ED), which are the proper terms for two of the major contributors to overcrowding and patient flow (Savioli et al., 2022).

It is essential to mention that the increased volume of patients is not the most relevant factor in overcrowding. The volume of patients is a variable that an ED or a hospital cannot control. This inability to control how many patients the ED is going to

receive means that, from a hospital's perspective, the factors that inhibit the ED from providing patients with the care services they require are most relevant (Savioli et al., 2022).

Operational Problem

Analyzing the different factors contributing to overcrowding allows us to detect a pattern and identify the most common reason patients visit the ED; then, it can be determined that the input level is a factor of overcrowding by default, meaning overcrowding will happen. Also, it can be determined what throughput and output levels contribute to overcrowding. Maninchedda et al. (2023) categorized different factors that contribute to overcrowding per level of operations, allowing the ED to easily identify what factors lead to overcrowding in their hospitals and develop the corresponding decisions.

The problem with overcrowding is not its occurrence but the length of time it lasts. Extended overcrowding periods result in permanent repercussions. The longer a patient stays in the ED, the higher the likelihood of overcrowding (Altun et al., 2024). Increased mortality rates, patients facing delayed diagnosis and treatment, overworked staff, poor quality of care, access block, and boarding result from overcrowding in the ED (McKenna et al., 2019). The goal of providing care to patients within a specific time frame in the ED acknowledges the possibility of overcrowding; however, it emphasizes implementing strategies to manage such situations efficiently while ensuring that patients receive timely and appropriate care. (Jung et al., 2021).

Overcrowding is a phenomenon that is hard to prevent and complicated to solve once it occurs; for the hospitals to be able to develop strategies to reduce overcrowding in

their EDs in Puerto Rico, understanding patient flow leads to focusing on specific operational areas that require attention. A study conducted in 2012 showed that a major contributor to overcrowding in hospitals in Puerto Rico is the delay in the transfer of patients to beds, which, at the time of the study, meant hospitals were operating at full capacity over 60% of the time (Peña-Orellana et al., 2012; see also Stimpson et al., 2024).

The healthcare administrators in Puerto Rico face challenges in allocating and redistributing resources; overcrowding places more significant pressure on the administrators as more of the limited resources need to be allocated to the ED to provide patients with the care they need. From a hospital's perspective, overcrowding is not easily solved by improving patient flow or implementing strategies to improve the efficiency of the operations (Rutherford, 2022).

Overcrowding is not limited to the clinical setting; it expands to the administrative operations of the hospital. Overcrowding is like a virus that quickly spreads through the organization, undermining healthcare administrators' efforts to maintain the quality standards every hospital should offer their patients. If those quality standards and regulations are unmet, the hospital exposes itself to fines that then become a financial burden (Martinez, 2020).

Ideal State of Operations

An ideal state of operations for EDs in Puerto Rico involves a strategy focused on resource optimization and reducing access blocks. Altun et al. (2024) emphasized addressing access blocks—delays in transferring patients to inpatient beds—which significantly drives overcrowding, a prevalent issue in Puerto Rico due to limited hospital infrastructure and declining bed availability. The high rates of chronic illness and limited

access to primary care result in frequent and occasionally avoidable ED visits. Most residents rely on EDs as their main point of care due to poverty, geographic barriers, and inadequate healthcare infrastructure. Additionally, limited inpatient capacity causes admitted patients to be held in the ED for extended periods, further straining resources and preventing timely care for incoming emergencies (ASES, 2023).

Professional Practice Gap Statement

Establishing the goal of reducing the wait times for patients in the EDs in hospitals in Puerto Rico from the current wait time of 14 hours (Balaguer et al., 2019) to 4 hours (Campbell et al., 2017) is aimed at identifying the factors in the ED in the different levels of operations (i.e., input, throughput, and output) that need to be addressed to reduce overcrowding and provide patients with a better quality of service. The current average ED wait time in Puerto Rico is approximately 14 hours and 30 minutes—more than triple the U.S. national average of 4 hours and 18 minutes (Balaguer et al., 2019). In some hospitals, such as the Metropolitan Hospital in San Juan, wait times reach 15 hours and 39 minutes before admission (Balaguer et al., 2019). The goal is to reduce this average wait time to align with the U.S. benchmark of approximately 4 hours, following quality standards observed in well-functioning systems and supported by international metrics such as the National Health Service’s 4-hour emergency care target (Campbell et al., 2017). Patients visit the ED for multiple reasons; denying service is not an option but working to provide the quality of service patients deserve and the care they require is an achievable goal by identifying the problem and the corresponding solutions.

Summary of Evidence

Globally, ED overcrowding stems from delayed admissions, staffing shortages, and inefficient throughput processes (McKenna et al., 2019; Savioli et al., 2022). Asplin et al. (2003) proposed a conceptual model identifying three main contributors: input (increased demand), throughput (delays in care), and output (inability to admit or discharge patients). Kelen et al. (2021) found that ED overcrowding is an event reflecting the health system dysfunction. Jung et al. (2021) further demonstrated that overcrowding impacts admission rates based on triage levels, showing inequities in care. Altun et al. (2024) emphasized how access block correlates strongly with increased crowding, as measured by the National Emergency Department Overcrowding Study score.

In Puerto Rico, structural issues such as rural healthcare disparities, staffing shortages, and underfunding exacerbate ED congestion (Peña-Orellana et al., 2012; Rodríguez, 2021). Economic instability has strained hospital budgets, limiting investment in process improvement and staff retention (Martínez-Vega, 2020). Peña-Orellana et al. (2012) reported that EDs were unprepared for high patient volumes even before mass casualty events, and these deficiencies are more pronounced in island hospitals due to logistics and supply issues.

The literature reveals a practice gap in resource optimization and patient flow management within Puerto Rican EDs. Ahsan et al. (2019) reviewed optimization models and concluded that data-driven resource allocation (e.g., flexible staffing, fast-track units, and predictive analytics) significantly reduces crowding. However, such strategies are underutilized in Puerto Rican EDs due to administrative inertia and a lack of tailored operational models.

EDs in Puerto Rico lack data-informed resource optimization strategies and standardized flow protocols, resulting in prolonged patient wait times, increased access blocks, and preventable care delays. Healthcare leaders can address this through targeted interventions like real-time capacity management, bed tracking systems, and triage redesign—practical, scalable solutions suited to Puerto Rico’s resource-constrained context (Amin & Haswita, 2023; Rutherford, 2022).

Purpose of the Integrative Review

Overcrowding persists as higher volumes of patients continue to arrive at the ED to receive care. The belief that the ED has all the services necessary to make a proper diagnosis and provide treatment is a common reason why patients visit the ED. This results in patients creating the habit of going to the ED first instead of seeking healthcare services in other care locations.

Puerto Rico has limited healthcare resources (Rodríguez, 2021). Puerto Rico is an island with an economic deficit that impacts the pillars of the society: security, health, and education. These economic challenges make it difficult to allocate and distribute resources, creating resource gaps and increasing the waste of resources. Puerto Rico is also prone to natural disasters, which further complicates the issue. Overcrowding impacts the response time of the ED after such events happen. For example, in 2017, hurricane Maria went through Puerto Rico. The devastation left behind caused a permanent strain on the infrastructure of the hospitals of Puerto Rico, limiting the areas of the hospital where patients could receive healthcare services (Altun et al., 2024; International Medical Corps, 2024). These factors increase the volume of patients in the ED, impacting the patient flow and overcrowding. The study aims to evaluate effective

strategies for reducing ED wait times to under 4 hours, addressing the issue of overcrowding, and improving patient flow, processes, and overall system efficiency in hospitals across Puerto Rico (Campbell et al., 2017).

Integrative Review Question

What is the best approach to reduce waiting times, and what strategies may be implemented to reduce ED overcrowding at hospitals in Puerto Rico?

Theoretical Framework

The open systems theory model by Katz and Kahn (1978) proposes that external and internal factors can be transformed into resources for an organization to improve the production and distribution of their product. The open systems theory also acknowledges the organization is easily susceptible to the influences of the environment, and this can impact the desired outcome. The open systems theory is a framework that views organizations as dynamic systems that continuously interact with their external environment.

This theory allows for the transformation of the factors to be evaluated through feedback, providing an opportunity to improve and redirect these sources to achieve the set goal. Katz and Kahn (1978), in their theory, established that there are different paths to achieving the goal, and this achievement might not require any correction as the influences of internal and external factors will organically reach said goal.

The ED is categorized as an open system since its operation and functionality are easily influenced by external and internal factors (Asplin et al., 2003). Defining the ED as an open system provides a fundamental way to identify the external sources contributing

to overcrowding. As a result, the sources turned into strategies to reduce overcrowding and improve the systems in the EDs at hospitals in Puerto Rico.

This theory allows for the strategies to be adjusted while moving forward to achieve the goal through feedback; instead of requiring a new strategy, the open systems theory sets the fundament for the ED to turn an external factor, such as patients with no urgent situations into a resource by identifying ways for these patients to not stay for long periods in the ED. Applying this model to overcrowding in the ED helps analyze the issue by breaking it down into inputs, processes, outputs, and feedback within a constantly changing environment (Kelen et al., 2021).

Part 2: Literature Review, Quality Appraisal, and Analysis

Literature Search Strategy

An integrative review of literature published between 2020 and 2025 was conducted (see Appendix B). The databases searched for this review included PubMed, Google Scholar, PubMed Central, Cochrane Library, and EBSCO. The keywords used in the search strategy were *emergency department crowding*, *emergency department overcrowding*, and *emergency department overcrowding* and *NEDOCS*. For the literature research, Boolean operators (e.g., “AND”) were used to combine keywords and improve the breadth and precision of the search strategy across the selected databases.

Table 1 outlines the inclusion and exclusion criteria established for this review. The studies included to determine whether they discussed contributing factors to ED crowding or evaluated strategies and interventions to reduce ED crowding, with a publication date between 2020 and 2025. Literature specifically addressing ED crowding in Puerto Rico was also included. The articles were excluded if they focused on the effects of ED crowding on specific age groups (e.g., children, elderly) or patients with chronic conditions—the review aimed to synthesize recent and broadly applicable findings to support general ED operational improvements.

Table 1*Inclusion and Exclusion Criteria*

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Factors contributing to emergency department crowding in the last 5 years. • Solutions to reduce crowding in the emergency department. • Emergency department crowding in Puerto Rico. 	<ul style="list-style-type: none"> • Emergency department crowding impacting a specific age group (children, teenager, adult, elderly). • The impact of emergency department crowding in patients with chronic conditions.

A total of 21 articles were initially selected for the preliminary review. Of these, 15 articles were retained after the inclusion and exclusion criteria were applied (see Appendix A). Six articles were excluded during full-text review for the following reasons: lack of relevant information related to the integrative review objectives, duplication or significant content similarity with other included studies, a focus on illnesses or procedures as the primary cause of ED overcrowding rather than broader systemic factors, and publication dates exceeding the 5-year inclusion window (2020–2025).

Literature Quality Appraisal

A total of 15 articles were included for quality appraisal. The articles were appraised using the Johns Hopkins Evidence-Based Practice Model for Nursing and Healthcare Professionals, specifically the Research Evidence Appraisal Tool and the Non-Research Evidence Appraisal Tool. Of the 15 articles, 11 were appraised using the research evidence appraisal tool, and four were appraised with non-research evidence

appraisal tool (see Appendix D). Of the research-based sources, six articles were rated as Level III with good quality, and five articles were rated as Level III with high quality. The four non-research-based sources, four articles were appraised as Level V, one article high and three articles good quality. The collective findings of these studies provide consistent evidence supporting various strategies to address ED overcrowding in hospitals across Puerto Rico.

Thematic Analysis of Literature

Most of the selected articles were systematic reviews, meta-analyses, or scoping reviews that utilized retrospective data analysis and literature synthesis to evaluate interventions targeting ED overcrowding (Altun et al., 2024; Jaramillo et al., 2025; Lauque et al., 2023; Maninchedda et al., 2023; Nummedal et al., 2024). Authors employed various quality metrics such as length of stay, NEDOCS score, and throughput to assess ED performance and effectiveness of implemented strategies (Ahsan et al., 2019; Grant et al., 2020; Mostafa & El-Atawi, 2024). Several studies emphasized system-level interventions like fast-track units, split-flow models, and physician-led triage to reduce wait times and improve care delivery (Azari et al., 2023; Darraj et al., 2023; Wallingford et al., 2024). Use of early warning software, point-of-care testing (POCT), and diagnostic streamlining was highlighted to support proactive clinical decision-making and reduce delays (Prabhu et al., 2022; Testa et al., 2024; Tuominen et al., 2023). Across the literature, themes of performance metrics ($n = 8$), triage redesign or physician-led triage ($n = 5$), length of stay ($n = 5$), fast-track implementation ($n = 6$), and quality of care ($n = 14$) emerged consistently. Other noted limitations included single-site data

collection ($n = 4$), variability in intervention adoption ($n = 3$), and limited generalizability to smaller or resource-limited settings ($n = 2$).

Table 2

Total Number of Themes and Subthemes from Appendix D

Themes	Subthemes
Patient Flow Redesign	Fast Track Split Flow Triage Redesign and Physician-led Triage Team Triage
Diagnostics and POCT	Point of Care Testing Streaming Imaging Work Reduced Diagnostic Relays
Capacity and Resources	Staffing (Staff and Skill Mix) Bed Management Resource Allocation Throughput Management
Systems Level and Access Management	Address Access Block Non-Emergency Department Solutions Boarding Time Reaction Hospital Level Inefficiencies
Quality, Safety and Population Specific Care	Quality of Care Length of Stay Geriatric-Focused Strategies
Data, Metrics, and Early Warning	NEDOCS Performance Metrics Early Warning (Predictive Models)

Figure 1*Integrative Review Themes and Subthemes*

Themes and Subthemes	Relationship to Open Systems Theory
Patient Flow Redesign <ul style="list-style-type: none"> • Fast Track • Split Flow • Triage Redesign and Physician-led Triage • Team Triage 	The emergency department adapts its internal processes (flow models) in response to the unpredictable external environment (variable patient arrivals).
Diagnostics and POCT <ul style="list-style-type: none"> • Point of Care Testing • Streaming Imaging Work • Reduced Diagnostic Relays 	Represents the transformation process where resource-intensive inputs (labs, imaging) are optimized to produce quicker outputs.
Capacity and Resources <ul style="list-style-type: none"> • Staffing (Staff and Skill Mix) • Bed Management • Resource Allocation • Throughput Management 	Shows system-environment interdependence — staffing and beds must scale with patient inflow (external environment).
Systems Level and Access Management <ul style="list-style-type: none"> • Address Access Block • Non-Emergency Department Solutions • Boarding Time Reaction • Hospital Level Inefficiencies 	Illustrates boundary-spanning — ED overcrowding is not solvable internally but requires interaction with external subsystems (inpatient units, community care).
Quality, Safety and Population Specific Care <ul style="list-style-type: none"> • Quality of Care • Length of Stay • Geriatric-Focused Strategies 	Ensures the system does not sacrifice quality while adapting for efficiency — balancing environmental pressures with organizational integrity.
Data, Metrics, and Early Warning <ul style="list-style-type: none"> • NEDOCS • Performance Metrics • Early Warning (Predictive Models) 	Feedback loop made explicit — data enables the ED to anticipate changes in its environment and adapt dynamically.

Part 3: Presentation of Results and Interpretation of Findings

Presentation of Results

This thematic concept map was developed with 15 sources. The sources focus on two targeted outcomes, and each outcome has three major themes for a total of six themes (i.e., patient flow redesign; diagnostic and POCT; capacity and resources; system level and access management; quality, safety, and population-specific care; and data, metrics, and early warning), and 21 subthemes combined. The codes aligned with the review question and were obtained from the sources used in the thematic analysis. The themes and subthemes that propose concrete strategies aimed to reduce the probability of the status of overcrowded to be reached in the ED of hospitals in Puerto Rico. See Appendix D and Appendix E, respectively, for the thematic analysis results and the thematic concept map.

Refine Theme and Subthemes

Review question: What is the best approach to reduce waiting times, and what strategies may be implemented to reduce ED overcrowding at hospitals in Puerto Rico?

Reduced Wait Times

1. Patient Flow Redesign
 - a. *Fast Track*: diverts low acuity patients to a streamlined care track.
 - b. *Split Flow (horizontal/vertical)*: separates patients by severity and complexity.
 - c. *Triage Redesign and Physician-led Triage*: ensures early clinical decision-making.

- d. *Team Triage and Bedside Registration*: integrates administrative and clinical intake to minimize delays.

2. Diagnostics and POCT

- a. *Point of Care Testing*: accelerates laboratory results at the bedside.
- b. *Streamed Imaging Work*: Prioritizes ED imaging when scheduling queues.
- c. *Reduced Diagnostic Relays*: shortens handoffs and redundant checks.

3. Capacity and Resources

- a. *Staff and Skill Mix*: aligns work supply with patient demand.
- b. *Bed Management*: ensures inpatient and observation beds are available for admissions.
- c. *Resource Allocation*: matches physical and technological assets to peak demand.
- d. *Throughput Management*: monitors and adapts to patient volumes in real time.

Connections Between Themes

The patient flow, diagnostics, and POCT themes are interdependent; for instance, rapid testing only has an impact if patients are streamed efficiently, while flow stalls if diagnostics lag. The capacity and resources underpin both, without adequate beds or staff, optimized flow or fast diagnostics are still bottlenecked. Efficient patient flow cannot be sustained without timely diagnostics, while flow and diagnostics depend on adequate capacity and resources. Together, these themes form a reinforcing cycle: capacity enables flow, flow reduces diagnostic congestion, and rapid diagnosis accelerates throughput. In this cycle, the improvements in the area support gains in the others.

Reduce ED Overcrowding

1. Systems Level and Access Management
 - a. *Address Access Block*: expand inpatient bed availability and discharge efficiency.
 - b. *Non-ED Solutions*: Use urgent care or community care alternatives.
 - c. *Boarding Time Reaction*: expedite transfers and admissions.
 - d. *Hospital-level Inefficiencies*: target bottlenecks beyond the ED walls.
2. Quality, Safety, and Population-Specific Care: directed to the improvement of patient safety and outcomes while reducing delays.
 - a. *Quality of Care*: Prevent safety trade-offs during the high volume of patients.
 - b. *Length of Stay*: Ensure safe and efficient discharges.
 - c. *Geriatric-Focused Strategies*: Tailor care to high-risk, high-need populations.
3. Data, Metrics, and Early Warning: aimed to monitor, measure, anticipate overcrowding before it escalates.
 - a. *NEDOCS*: real-time measurement of overcrowding status.
 - b. *Performance Metrics*: benchmark throughput and quality.
 - c. *Early Warning (Predictive Analytics)*: forecast crowding before it escalates.

Connection Between Themes

The system-level and access management themes address structural bottlenecks, while data and metrics make those bottlenecks visible and predictable. The quality and

safety theme ensures that interventions to reduce overcrowding do not compromise outcomes (this theme safeguards the other two). System-level strategies fix structural issues, data and early warning systems (predictive analytics) provide visibility and predictive insight, and quality measures ensure that efficiency gains remain patient-centered. The three major themes are complementary: data provides insight, system-level fixes address root causes, and quality ensures sustainability.

Accountability and Collaboration

The successful implementation of the strategies requires cross-departmental collaboration and clear accountability. For instance, the fast-track, split flow, and team or physician-led triage requires the ED leadership and the medical director to collaborate and be accountable for outcomes of these strategies. Following this line, the POCT and imaging workflow requires collaboration and accountability between the laboratory, radiology, and the ED. The staffing, bed management, access block and boarding, and the collaborations and accountability of the hospital administration, throughput, bed control, and inpatient services. NEDOCS, performance metrics, and early warning/predictive tools require collaboration and accountability in the ED analytics, quality, and IT-Data Science. The quality safeguards, length of stay, mortality mitigation, geriatric care, the collaboration and accountability of the quality and patient safety, and the geriatric ED team.

Interpretation of Findings

Overcrowding has already been established as a dangerous problem for hospitals. It poses a threat to the safety and health of patients and impacts the quality of care, of the services patients receive (Maninchedda et al., 2023). The hospitals of Puerto Rico face

challenges that impact wait times and increase the probability of reaching the state of overcrowding in the ED. It has been already determined that each hospital requires an evaluation of the state of its ED to be able to identify the factors that lead to the ED reaching the state of overcrowding and to determine which is the best strategy to implement to reduce ED overcrowding. The state of overcrowding is reached if there is a delay in any of the three macro levels of operation in the ED (Asplin et al., 2003; Savioli et al.,2022). The findings show a common denominator; the strategies to reduce overcrowding in the ED focus on optimization of the operations that compose the throughput macro level of operation in the ED. The open systems theory model (Katz & Kahn, 1978) applies to the ED, because the department is constantly adapting to inflow patient fluctuations and requires a coordination with other departments and community systems. The two major outcomes—reduced wait times and reduce emergency overcrowding—can be achieved by implementing the strategies proposed in the six major themes, which focus on the external and internal factors that contribute to overcrowding, allows for these factors to be turned into strategies to achieve the desired outcome and making changes based on the feedback collected.

Patient Flow Redesign

The patient flow theme focuses on strategies that restructure the patient movements through the ED for efficiency. Jaramillo et al (2025) showed there is a significant reduction in the patient's length of stay through certain interactions in the ED, including a physician triage (reduced the wait times by 22 minutes), POCT (reduced wait times by 42 minutes), and fast track (reduced wait times by 22 minutes). The implementation of these interactions represents the improvement of the efficiency and the

patient flow in the ED. Redesigning the patient flow allows for the non-urgent cases to be moved to an area where they get their cases to be seen and prevents the slow down the waiting queue nor delay the delivery of their treatment, overall reducing overcrowding. The restructuring of the patient flow and redesign of the triage are critical leverage point in the patient flow chain, since the failure to optimize the triage activities contribute to the bottlenecks and this leads to overcrowding, (Maninchedda et al., 2023). The split flow reduces the length of stay, improves the triage and the care segmentations (Wallingford et al., 2024). The throughput strategies have been proven effective in reducing overcrowding in the ED and it is shown in the interventions review (Grant et al.2020). Further, Azari et al. (2023) showed that through the years many large hospitals have adopted interventions like these that have shown relevant results in the reduction of wait times and preventing the overcrowding state to be reached. The application of the open systems theory in the patient flow redesign: the ED adapting to the internal process (flow models) in response to the unpredictable external environment (variable patient arrivals).

Diagnostics and POCT

Diagnostics and POCT aims to speed up the diagnostic turn around to shorten the stays in the ED. Diagnose depends on tests results and most the waiting time patients do is due the amount of time it takes to gather the sample, if required, move to the imaging department, and wait for those results to come back to the physician. Point of care takes most of the testing to the location of patient, and the testing provides immediate results which facilitate the delivery of care. Prabhu et al. (2021) highlighted the impact the imaging workflow has on the flow of the ED. Creating a streamlining the imaging workflow reduces the turnaround time in the ED, reducing the diagnostic delays, and

improves the operations in the throughput level. Maninchedda et. al. (2023) proposed the implementation of diagnostic streamline strategies to achieve overcrowding control in the ED. Ahsan et al. (2019) mentioned that optimization of resources include diagnostics and testing, acknowledging that delays in the diagnostics and testing create backups that contribute to longer length of stays. For this theme the application of the open systems represents the transformation process where resource-intensive inputs (laboratory results, imaging) are optimized to produce quicker outputs.

Capacity and Resources

Capacity and resources focus on ensuring there are enough human and physical resources to handle the demand of care in the ED. The optimization of resources is a strategy to improve the performance of the ED (Ahsan et al., 2019), it ensures the department can allocate the resources to the areas it requires it without wasting those resources. Capacity and resources work with the patient flow and diagnostics and POCT; patient flow will ensure the patients go through the proper areas of the department, diagnostics and POCT will facilitate the diagnosis operations, whereas capacity and resources ensure the department has everything they need to achieve. Lack of resources and reduced capacity contributes to the ED reaching an overcrowded state. Grant et. al. (2020) proposed throughput interventions that centered in capacity with the aim of reducing overcrowding in the ED. Moreover, Maninchedda et al. (2023) recommended resource management and staffing solutions, and Jaramillo et al. (2025) pointed towards strategies to reduce length of stay through resource alignment. The application of the theory shows the systems-environment interdependence (staffing and beds must scale with patient inflow [external environment]).

System Level and Access Management

The system level and access management is focused on fixing the bottlenecks outside of the ED that cause overcrowding. Access block contributes to overcrowding by leading to boarding (increased patient wait times) and delaying the service, the care patients require and the seek in the ED. If access block is addressed, overcrowding can be reduced (Altun et al., 2024). Patient flow already proposes the implementation a non-urgent care in the ED to redirect non-urgent cases to the special unit, non-urgent care is focused on the patient education and keeping the patient out of the ED and guiding them to other HSO in which their non-urgent care needs can be satisfied. Butun et al. (2023) showed the causes of overcrowding in ED that are tied to hospital inefficiencies. Nummedal et al. (2024) showed an impact on the number of visits to the ED after interventions that redirected the patient to other HSO were used to reduce the visits to the ED and propose non-ED interventions to reduce the utilization of the ED. In this theme specifically, the application of the open systems theory acknowledges the ED overcrowding is not solvable internally but requires interaction with external subsystems (inpatient units, community care).

Quality, Safety, and Population Specific Care

The quality, safety, and population-specific care is directed to the improvement of patient safety and outcomes while reducing delays. Senior patients could be more to visit the ED to receive care that they would usually receive from their primary care physician. The implementation of strategies that are designed to provide specialized geriatric care helps to improve the outcomes for that specific population (Testa et al. 2024). Identifying the causes of overcrowding helps to identify the solutions most importantly, identify the

areas in which the patients is exposed, and their safety is compromised and develop strategies to make patients safe as they receive care (Butun et al. 2023). The delay of care is an unsafe practice that is often associated with negative clinical outcomes such as a prolonged length of stay (Lauque et al., 2023) and reduce the quality of care (Darraj et al., 2023). Reducing the length of stay is not getting the patient to be discharged quickly, but ensuring the patient is stable and can safely be discharged. Strategies aimed to redesign the patient flow show a reduction of the length of stay of the patients (Grant et al., 2020). The application of the theory framework ensures the system does not sacrifice quality while adapting for efficiency balancing the environmental pressures with the organizational integrity.

Data, Metrics and Early Warning

The data, metrics, and early warning is aimed to monitor, measure, anticipate overcrowding before it escalates. Using metrics like NEDOCS help to measure the level of overcrowding in the ED and together with the predictive analytics it can help in real time implement strategies that help reduce overcrowding (Maninchedda et al., 2023). Overcrowding is expected to happen and the leaders in the ED should be prepared to reduce it, not adapt to it. The implementation of predictive flow models results in the ED from a tailored analysis, meaning, the specialized EDOP team has data to consider before implementing any strategy, instead of randomly implementing the strategy. The revision of these performance metrics and strategies is focused on achieving the reduction of overcrowding in the ED (Mostafa & El-Atawi, 2024). Tuominen et al. (2023) showed that early warning software identifies the risk of overcrowding and eases the decision-making process for the leaders in the ED to prevent the leaders being overwhelmed by

the data. The main goal of the data, metrics is exactly to be able to detect the patterns of overcrowding and take timely action to prevent it from escalating. Azari et al. (2023) showed that the adoption of the overcrowding interventions in the hospitals in the United States are metric based. The application of the open systems theory made the feedback loop explicit; data enables the ED to anticipate changes in the environment and adapt dynamically.

Part 4: Recommendation for Professional Practice and Implications for Social Change

Recommendations for Professional Practice

The recommendations for professional practice emerge to guide ED leaders, clinicians, and policymakers in Puerto Rico. The recommendations of this integrative review are based on Katz and Kahn's (1978) open systems theory. The results demonstrate the effectiveness of the fast-track units, split-flow models, and physician-led triage in improving patient throughput (Grant et al., 2020; Wallingford et al., 2024). The leaders in the ED should integrate these models into local protocols, with shared accountability among emergency physicians, nursing teams, and hospital administrators. A structured communication system and real-time monitoring of flow metrics can ensure that these operational models can adapt dynamically to patient volumes, which is consistent with the throughput function of open systems. The integration of diagnostics and point-of-care testing has had an impact on reducing diagnostic delays, shortening the length of stay, and improving patient care quality, (Ahsan et al., 2019; Prabu et al., 2022). Hospitals should establish standardized turnaround time benchmarks and foster collaboration among the ED, laboratory, and radiology departments. Capacity management, workforce composition, and bed coordination can directly impact performance in the ED (Butun et al., 2023; Maninchedda et al., 2023). Hospitals should adopt predictive workload models and data-driven scheduling to ensure equitable staff distribution, with a particular focus on staff allocation during peak hours. Implementing the use of tools like NEDOCS overcrowding scores and early warning systems enables the early detection of overcrowding patterns, allowing for a more proactive approach, (Altun et al., 2024; Mostafa & El-Atawi, 2024; Tuominen et al., 2023). Also, hospitals

should establish centralized data dashboards accessible to both clinical and administrative leaders, enabling continuous feedback and system learning—the core elements of the feedback loop in open systems theory. Finally, the safeguards for the quality of care, strategies focused on geriatric populations, and efforts to mitigate mortality should be added to the standard operating procedures of the ED, (Lauque et al., 2023; Testa et al., 2024).

EDs in Puerto Rico can transform reactive crisis management into proactive, data-driven care by turning the resources available into strategies to reduce ED overcrowding.

Implications for Social Change

The implication for social change of this integrative review in Puerto Rico's healthcare system is promoting equitable access, data-driven accountability, and sustainable ED operations. The redesign of the patient flow, the strategies for diagnostics and POCT, capacity, and resources help minimize delays and help to create a path of access to emergency care for marginalized populations in Puerto Rico. Using data-driven decision-making tools (NEDOCS, predictive analytics) reinforces a much-needed culture of accountability and transparency in the management of the ED. The feedback these tools provide enables healthcare leaders to anticipate overcrowding trends and proactively allocate resources to reduce them. Puerto Rico's population is rapidly aging (Matos-Moreno et al., 2022), and EDs need to incorporate population-focused strategies to continue offering care without compromising the health and safety of others. The identified themes reveal EDs as dynamic, adaptive systems that continually interact with their environment to enhance their outcomes. The objective is not only to improve operational performance, but also to understand that Puerto Ricans rely on the ED as their

primary source of care outside of their primary care physician. The trust the Puerto Rican community places in the ED team to care for them in the moment of need is key to the implications of social change. These strategies aim to transform the delivery of care in the ED from its current state to an equitable, efficient, and learning-oriented system.

Limitations

There are three major limitations in this review that could be addressed in future research. The first is the heterogeneity of the study design and outcomes. The sources included in this review have a diverse range of methodologies (systematic review, quantitative analyses, scoping studies). This diversity contributes to the purpose of the review developing strategies to reduce overcrowding in the ED in hospitals of Puerto Rico, but it also it represents a variability in outcome measures and evaluation criteria. Second, there are contextual and geographical limitations. The sources used originated from international contexts, this represents the context does not capture several realities (operational, socioeconomic, and infrastructural) of the healthcare system of Puerto Rico. The third limitation is the restricted exploration of long-term and interdepartmental effects. The sources assessed the impact of the strategies in a short-term, but there is limited longitudinal evidence that explored sustainability, scalability, and cross-departmental effects. The collaboration proposed between the ED and other units in the hospital it was described conceptually but not empirically evaluated.

Conclusion

This integrative review reaffirms that the challenge of ED overcrowding in Puerto Rico is not simply an operational issue—it is a systems issue that reflects how healthcare institutions interact, adapt, and respond to community needs. Actual hospital

improvement requires a coordinated strategy. The evidence suggests that uniting patient flow redesign, rapid diagnostics, capacity management, and predictive analytics within a culture of collaboration and accountability is essential.

Based on Katz and Kahn's (1978) open systems theory, this perspective reframes the ED as a living, adaptive system—one that thrives through communication, feedback, and continuous learning. By aligning processes, data, and leadership under this framework, hospitals can move beyond crisis management toward sustainable transformation. The goal is not only to reduce overcrowding and wait times, but to build an emergency care system that embodies resilience, equity, and trust—delivering timely, high-quality care for every patient, every time.

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Appendix A: DHA Practice-Based Problem Literature Review Matrix

Author/ date	Theoretical/ conceptual framework	Research question(s)/ hypotheses	Methodology	Analysis & results	Conclusions	Implications for future research	Implications for practice	Empirical research (Yes or No)
Darraj, et al. January 26 2023	Theoretical Framework	Determine if there is an association between delay in treatment and overcrowding in the ED, considering possible solutions based on the findings.	Quantitative Systematic Review and Meta-Analysis (PRISMA)	The result of the systematic review shows the impact on the outcomes of the delay of treatment for patients is going to vary per condition and per patient.	The findings of the systematic review show that using strategies to reduce the delays of treatments creates a pathway to reduce overcrowding.	Determining the factors that contribute to overcrowding and delayed treatment in the ED to find the corresponding solutions.	Solutions to the overcrowding in the ED should consider local factors that are directly impacting the operations of the ED.	No
Watson & Powell-Stuart July 4 2023	Conceptual Framework	Revise the ED overcrowding plan with an interdisciplinary team to reduce the rates of patient wait times, length	Qualitative Methods	It specifically explores the throughput operations of the ED. Identifying factors that can be improved to reduce overcrowding.	The EDOP focuses on the throughput level of operations of the ED. The EDOP requires updates and improvements	Evaluation of resources available to develop a EDOP that adjusts to the needs of the ED.	Identify possible communication challenges that may impact the implementation of EDOP	Yes.

		of stay, and left without being seen rates.		These improvements are based on the NEDOCS scale.	to continue to be effective in an overcrowded ED.			
Jung, et al. February 17 2021	Conceptual Framework	The aim of the study is to analyze the characteristics of admitted patients to overcrowded ED.	Retrospective Cohort Study	The results show that an overcrowded ED impacts the health of the patients that are being to the ED in such state, even if that patient arrived with a non-urgent health case.	The results point toward a relationship between ED overcrowding and patient admission rates. Highlighting the consequences overcrowding has in all kinds patients.	N/A	N/A	Yes
Campbell, Boyle, & Higginson October 25 2017 Professional	Theoretical Framework	Reducing wait times for patients to 4 hours.	Plan-Do-Study-Act Method & Toyota Frame.	To achieve the 4 hour objective it is important to have a clear understanding of the patient flow in the emergency department to identify areas	The target is not only focused on reducing the wait times for the patients, but to improve the quality of care for patients and the	N/A	N/A	No.

Practice GAP				of improvement.	adverse consequences of the long wait times on the health of patients and the operations of the ED.			
Ahsan, et al. November 27 2019 Professional Practice GAP	Theoretical Framework	Optimization of the ED resources to improve the patient flow in the ED.	Systematic Review	The systematic review shows there are different methods available to optimize the patient flow in different scenarios. The findings also show which are the best methods to be used depending on the resources available in the ED, not generalizing the strategies, but focusing in	To achieve optimization of the patient flow the list of resources considered cannot be limited to certain categories, but it has to include a full range of resources to consider for the optimization process to be a success.	This systematic review sets the base for further research in the field, inviting researchers to explore the different angles to approach patient flow optimization with the available resources in the ED.	One of the main contributors to overcrowding is patient flow, if the patient is optimized using the resources available, this can lead to reduction of overcrowding in the ED.	No

				the resources available that could be redirected into an attempt of patient flow optimization.				
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Appendix B: DHA Review Question Search Log

Database or location name	Search Terms	Results	Notes
PUBMED (National Library of Medicine)	Emergency department overcrowding	5 of 1,516 results	Filter: Full Access, Publication date 5 years or less. Excluding 1,511 articles conducted outside of the United States & similar to the articles already selected from other data bases.
Google Scholar	Emergency department overcrowding	9 of 5,550 results	Filter: Review articles, Publication date 4 years, full access. Excluding 5,541 articles not based in the United States & similar to the articles already selected from other data bases.
PUBMED Central	Emergency department overcrowding	10 of 688 results	Filter: Publication dates 5 years. Research funders NIH, CDC & AHRQ, full access. Excluding 678 articles not conducted in the United States & similar to the articles already selected from other data bases.
Cochrane Library	Emergency department overcrowding	1 result	Article was not considered; publication date exceeds the 5 years limit.
EBSCO	Emergency department crowding	4 of 324 results	Filter: Publication date 5 years & Full Access. Excluding 320 articles not conducted in the United States & similar to the articles already selected from other data bases.

Database or location name	Search Terms	Results	Notes
PUBMED (National Library of Medicine)	Emergency department overcrowding & NEDOCS	1 of 17 results	Filter: Full Access, Publication date 5 years or less, NEDOCS. Excluding 16 articles that were not conducted in the United States & used illnesses, procedures as the cause of overcrowding.

Appendix C: DHA Appraisal Results Log

Non-Research Appraisal

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
<p>Maninchedda et al (2023) Main Features and Control Strategies to Reduce Overcrowding in Emergency Departments: A Systematic Review</p>	<p>Level V High Quality</p>	<p>Emergency department. Patient Flow. Identify strategies to reduce emergency department length of stay and delays.</p>	<p>Optimization of ER and the implementation of predictive flow models are the most effective measure to reduce overcrowding. The emergency department benefits from tailored analysis before the implementing strategies.</p>	<p>Metrics: length of stay and delay times in the emergency department. The strategies were statically evaluated.</p>	<p>Site-specific heterogeneity; small selection (18 studies) limits generalizability. Lack of U.S. testing.</p>
<p>Altun et al. (2024) Effect of access block on emergency department crowding</p>	<p>Level V Good Quality</p>	<p>Urban tertiary emergency department. Access block. Quantify boarding’s contribution to</p>	<p>The emergency department was overcrowded at least 81.2% of the time, with an average NEDOCS of 146—</p>	<p>NEDOCS score collected six times daily over 39 days; boarding duration, patient counts</p>	<p>Single center, short duration, hypothetical scenario-based modeling</p>

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
calculated by NEDOCS score		emergency department crowding.	indicating severe crowding. The scores ranged from 62 (moderate) to 315 (extreme overcrowding). Approximately 48.8% of the changes in the NEDOCS can be explained by boarding time, which is the duration patients wait in the ED after being admitted but before being transferred to an inpatient bed. Boarding is identified as the major contributor of overcrowding. In theory, if access block is eliminated, overcrowding could be drastically reduced		

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
			it the emergency department.		
Ahsan et al. (2019) Emergency department resource optimization for improved performance: a review	Level V Good Quality	Emergency Department. Resource optimization. Asses modelling techniques for better flow in the emergency department.	The study reviewed a variety of models and most require extra resources; each has trade-offs; no one-size-fits-all solution.	Metrics: Model-based evaluation of throughput, wait times; often simulated outputs.	Models theoretical, demand site-specific calibration; no empirical validation across contexts
Mostafa & El-Atawi (2024) Strategies to Measure and Improve Emergency Department Performance: A Review	Level V Good quality	Emergency department. Performance & Efficiency. Emergency department resource inefficiencies & crowding.	Lean management, fast-track pathways, improved diagnostics, flexible staffing can improve emergency department function.	None quantitatively reported; descriptive interventions	Narrative synthesis; lacks systematic quality appraisal or outcome data

Research Appraisal

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
Jaramillo et al. (2025) Effective strategies for reducing patient length of stay in the emergency department: a systematic review and meta-analysis	Level III High Quality	Emergency department. Interventions. Reducing the length of stay in the emergency department.	There are certain interventions significantly reduced patient wait times in the emergency department: having a triage physician reduced time by 22 minutes, point-of-care testing (POCT) by 42 minutes and fast-track systems by 22 minutes. These strategies can help improve efficiency and patient flow.	Minutes saved from length of stay.	High heterogeneity in interventions.
Tuominen et al. (2023) Early Warning Software for ED Crowding	Level III Good Quality	Emergency department. Informatics. Prediction tools.	Hourly forecast software improved crowding management.	Forecast accuracy, time range	Single-site pilot trial
Prabhu et al. (2022) Impact of Imaging	Level III Good Quality	Emergency department. Simulation.	Findings: 10% imaging bundling	Time-to-completion, ED cycle time.	Modeling only; not field-tested.

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
Workflow on ED Flow		Imaging bundle process.	improved ED throughput.		
Wallingford Jr et al. (2024) Horizontal and Vertical Split Flow Model of ED Patients	Level III Good Quality	Emergency department. Process Improvement. Patient flow during crowding.	The split flow reduced length of stay and LWBS.	Length of stay, LWBS, patient throughput	Single hospital; comparative design.
Azari et al. (2023) Adoption of emergency department crowding interventions among US hospitals between 2007 and 2020	Level III High Quality	Emergency Department. Intervention trends. Low adoption of ACEP-recommended strategies.	Growth in tech-based interventions (e.g., bedside registration increased by 85.1%, kiosk check-in increased by 144.2%) but overall underutilization of effective solutions.	Adoption rates (%) over 13 years; intervention categories (tech, space, flow)	Self-reported data; no direct link to patient outcomes; observational nature
Nummedal et al. (2024) Non-ED interventions to reduce ED utilization: A scoping review	Level III Good Quality	Emergency Department. Demand management. Overuse of ED for non-urgent care.	Care coordination, financial incentives, education led to reduced ED visits in ~66% of studies.	Emergency department visit rates, hospitalization rates, health/cost outcomes.	Heterogeneous study designs; no meta-analysis; broad scope excludes some system-level reviews.

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
Grant et al. (2020) Throughput interventions to reduce emergency department crowding: A systematic review	Level III High Quality	Emergency Department Throughput Level Long Length of stay, high LWBS.	Effective: fast-track, early triage physicians; some mixed results (POCT); Length of stay reductions 12–114 minutes.	Length of stay, LWBS rates, risk ratios, quality grading (NHLBI, Cochrane RoB-2).	Focused on high-income settings; variation across studies; few cost-effectiveness data.
Lauque et al. (2023) Length-of-Stay in the Emergency Department and In-Hospital Mortality: A Systematic Review and Meta-Analysis	Level III High Quality	Emergency department. Patient outcomes. Effect of prolonged or short emergency department length of stay on mortality.	Emergency Department length of stay over 24h increases ICU mortality (OR 1.396); very short length of stay in non-ICU linked to increased death (OR 0.583).	Emergency department in hours; in-hospital mortality (ORs)	Inconsistent length of stay thresholds across studies; limited causality inference.
Darraj et al. (2023) The Association between Emergency Department Overcrowding and Delay in Treatment: A Systematic Review	Level III Good Quality	Emergency Department. Quality. Crowding-linked delays in care.	Crowding leads to treatment delays (triage, antibiotics, imaging), reducing care quality	Time-to-treatment (triage, meds, imaging)	Varying definitions of ‘overcrowding’ and ‘delay’; primarily observational studies

Author, date, and title	Evidence level and quality rating	Focus: HSO type, Research Domain, and Specific Problem being addressed	Findings that help answer the review question(s)	Metrics and Measures if used	Source Limitations
Butun et al. (2023) Emergency Department Overcrowding: Causes and Solutions	Level III High Quality.	Emergency department. Patient demand & access patterns. non-urgent emergency department usage & overcrowding.	62.8% perceived the emergency department as urgent; 24h availability (36.1%) & faster service (31.4%) were key motivators.	Survey responses (percentages by reason).	Single-country study (Turkey); small sample; generalizability limited
Testa et al. (2024) Strategies to Improve Care for Older Adults Who Present to the Emergency Department: A Systematic Review	Level III Good Quality	Emergency department. Care quality. Ineffective care pathways for older adults.	Dedicated geriatric emergency department teams improve length of stay, staff/patient experience, and post-discharge outcomes.	Length of stay, readmission rates, patient/staff satisfaction.	Variation in interventions and outcomes; inconsistent data reporting

Appendix D: DHA Thematic Analysis Results

Author(s) and Date	Findings with Initial Codes	Code List for Theme Development
<p>Maninchedda et al (2023) Main Features and Control Strategies to Reduce Overcrowding in Emergency Departments: A Systematic Review</p>	<p>Comprehensive review of ED overcrowding control strategies including fast-track, triage redesign, discharge planning.</p> <p>Initial Codes: Fast-track, Triage redesign, Discharge process, System-level strategies.</p>	<p>Fast track. Triage redesign/Physician. Non-Emergency department. Quality Care.</p>
<p>Altun et al. (2024) Effect of access block on emergency department crowding calculated by NEDOCS score</p>	<p>Access block significantly increases ED crowding as measured by NEDOCS; system-level inefficiencies identified.</p> <p>Initial Codes: Access block, NEDOCS score, Flow metrics, Hospital-level inefficiency.</p>	<p>Access block. Point of care testing. Quality of care. NEDOCS.</p>
<p>Ahsan et al. (2019) Emergency department resource optimization for improved performance: a review</p>	<p>Optimization of resources (staffing, beds, diagnostics) improves emergency department performance.</p> <p>Initial codes: Resource allocation, emergency department performance, Staffing, Bed management.</p>	<p>Performance metrics. Resource allocation. Length of stay. Quality of care. Throughput.</p>
<p>Mostafa & El-Atawi (2024) Strategies to Measure and Improve Emergency Department Performance: A Review</p>	<p>Reviews multiple performance metrics and strategies (e.g., LOS, triage, boarding time) for ED improvement.</p> <p>Initial codes: LOS, Triage, Boarding, Performance metrics.</p>	<p>Length of stay. Triage redesign/ Physician. Performance metrics. Quality care.</p>

Jaramillo et al. (2025) Effective strategies for reducing patient length of stay in the emergency department: a systematic review and meta-analysis	Meta-analysis shows significant LOS reduction through fast-track, POCT, and physician-led triage. Initial codes: Fast-track, POCT, Triage physician, LOS reduction.	Fast track. Point of care testing. Length of stay. Triage redesign/Physician.
Tuominen et al. (2023) Early Warning Software for ED Crowding	Early warning software identifies crowding risk and supports proactive decision-making. Initial codes: Early warning, Predictive analytics, Digital tools.	Early warning. Non-Emergency department solutions. Split-flow. Quality of care.
Prabhu et al. (2022) Impact of Imaging Workflow on ED Flow	Streamlining imaging workflow reduces ED turnaround time and improves throughput. Initial codes: Imaging workflow, Throughput, Diagnostic delays.	Triage redesign/physician. Diagnostic delays. Quality of care. Point of care testing.
Wallingford Jr et al. (2024) Horizontal and Vertical Split Flow Model of ED Patients	Horizontal and vertical split-flow improves ED triage and care segmentation. Initial codes: Split-flow model, Patient flow, Triage efficiency.	Triage redesign. Split flow. Performance metrics. Quality of care.
Azari et al. (2023) Adoption of emergency department crowding interventions among US hospitals between 2007 and 2020	Intervention adoption varied widely; larger hospitals more likely to adopt split-flow and fast-track. Initial codes: Intervention adoption, Hospital characteristics, Fast-track.	Fast track. Performance metrics. Split flow. Quality of care.
Nummedal et al. (2024) Non-ED interventions to reduce ED utilization: A scoping review	Community and primary care interventions (e.g., urgent care centers) reduce non-urgent ED use.	Non-emergency department solutions. Point of care testing.

	Initial codes: Non-ED solutions, Demand diversion, Primary care.	Diagnostic delays. Quality of care.
Grant et al. (2020) Throughput interventions to reduce emergency department crowding: A systematic review	Throughput strategies (bedside registration, team triage, diagnostics) reduce ED crowding. Initial codes: Throughput interventions, Diagnostics, Workflow.	Split flow. Performance metrics. Throughput. Quality of care. Diagnostic delays.
Lauque et al. (2023) Length-of-Stay in the Emergency Department and In-Hospital Mortality: A Systematic Review and Meta-Analysis	Prolonged ED LOS associated with increased in-hospital mortality; emphasizes need for timely care. Initial codes: LOS-mortality link, Quality of care, Delay risks.	Length of stay. Quality of care. Diagnostic delays. Performance metrics.
Darraj et al. (2023) The Association between Emergency Department Overcrowding and Delay in Treatment: A Systematic Review	Overcrowding leads to treatment delays; negative clinical outcomes associated. Initial codes: Treatment delay, Overcrowding consequences.	Diagnostic delays. Quality of care. Fast track.
Butun et al. (2023) Emergency Department Overcrowding: Causes and Solutions	Identifies causes (access block, inefficiencies) and solutions (coordination, staffing) to ED crowding Initial codes: Emergency department causes, Coordination, Staffing.	Staffing. Performance metrics. Quality of care.
Testa et al. (2024) Strategies to Improve Care for Older Adults Who Present to the Emergency Department: A Systematic Review	Strategies tailored for older adults (frailty screening, geriatric ED teams) improve outcomes. Initial codes: Geriatric care, Frailty, ED specialization.	Point of care testing. Fast track. Throughput. Geriatric care. Quality of care.

Appendix E: Final Concept/Thematic Map

