

Optimizing Patient Flow And Care Pathways In Medical Departments: A Systematic Review Of Process Improvement Strategies, Technologies, And Outcomes

Saud Faisal Altuwayjiri¹, Amer Ali Alamri², Mohammed Rabe Alrehili³, Hassan Fahad Alsaedi⁴, Majed Ayed Aljohani⁵, Omar Abdulaziz Altamimi⁶, Bandar Abdullah Ayad Alhejaili⁷, Ayman Faisal Alharbi⁸, Hani Muhassin Alharbi⁹, Abdullah Mohammed Alruheli¹⁰

¹ Taibah University, Saudi Arabia-Stuwayjiri@taibahu.edu.sa

² Taibah University, Saudi Arabia-aamri@taibahu.edu.sa

³ Taibah University, Saudi Arabia-Mrrehaili@taibahu.edu.sa

⁴ Taibah University, Saudi Arabia-hfsaedi@taibahu.edu.sa

⁵ Taibah University, Saudi Arabia-mgahini@taibahu.edu.sa

⁶ Taibah University, Saudi Arabia-otamimi@taibahu.edu.sa

⁷ Taibah University, Saudi Arabia-balhejili@taibahu.edu.sa

⁸ Taibah University, Saudi Arabia-afharbi@taibahu.edu.sa

⁹ Taibah University, Saudi Arabia-hmaharbi@taibahu.edu.sa

¹⁰ Taibah University, Saudi Arabia-aalruhayli@taibahu.edu.sa

Abstract

This systematic review explores strategies, technologies, and organizational approaches aimed at optimizing patient flow and care pathways in medical departments. Inefficient patient flow remains a persistent challenge in healthcare systems, leading to increased waiting times, overcrowding, reduced quality of care, and higher operational costs. This review synthesizes evidence from recent studies (2016–2025) focusing on process improvement methodologies such as Lean, Six Sigma, and workflow redesign, alongside digital health solutions including electronic health records, artificial intelligence, and telemedicine. Following PRISMA guidelines, relevant studies were identified, screened, and analyzed based on predefined criteria. The findings demonstrate that integrated approaches combining process optimization and digital technologies significantly improve patient throughput, reduce length of stay, and enhance patient satisfaction. The review highlights the importance of multidisciplinary collaboration and knowledge management in sustaining improvements and concludes that a holistic, patient-centered framework is essential for optimizing healthcare delivery.

Keywords: Patient Flow; Care Pathways; Lean Healthcare; Six Sigma; Digital Health; Process Improvement; Healthcare Quality.

Introduction

Healthcare systems worldwide are increasingly challenged by rising patient demand, resource constraints, and the growing complexity of care delivery. One of the most critical operational issues facing medical departments is inefficient patient flow, which refers to the movement of patients through various stages of care, including admission, diagnosis, treatment, and discharge. Ineffective patient flow has been widely associated with prolonged waiting times, overcrowding—particularly in emergency departments—delayed clinical decision-making, and suboptimal utilization of healthcare resources (Litvak et al., 2016; Morley et al., 2018). These inefficiencies not only compromise patient safety and quality of care but also contribute to increased operational costs and staff burnout.

Optimizing patient flow and care pathways has therefore become a strategic priority for healthcare organizations seeking to enhance performance and patient outcomes. Care pathways, defined as structured multidisciplinary plans detailing essential steps in patient care, play a vital role in improving

coordination and reducing variability in clinical processes (Rotter et al., 2019). When effectively designed and implemented, care pathways can streamline workflows, enhance communication among healthcare professionals, and ensure timely delivery of care.

In response to these challenges, healthcare institutions have increasingly adopted process improvement methodologies such as Lean and Six Sigma. Lean healthcare focuses on eliminating waste and improving value from the patient's perspective, while Six Sigma emphasizes reducing process variation and enhancing quality (D'Andreanmatteo et al., 2015; Henrique & Godinho Filho, 2020). Empirical evidence suggests that these methodologies can significantly reduce patient waiting times, length of stay, and process inefficiencies when applied systematically within clinical settings. However, the success of these approaches often depends on organizational culture, leadership support, and staff engagement.

In parallel, the rapid advancement of digital health technologies has introduced new opportunities for optimizing patient flow. Electronic health records (EHRs), artificial intelligence (AI)-driven decision support systems, and telemedicine platforms have demonstrated potential in enhancing real-time information sharing, improving diagnostic accuracy, and facilitating remote care delivery (Jiang et al., 2017; Topol, 2019). These technologies enable data-driven decision-making and support more efficient coordination across departments, thereby contributing to smoother patient transitions and reduced bottlenecks.

Despite the growing body of literature on process improvement and digital transformation in healthcare, there remains a need for an integrated understanding of how these strategies collectively influence patient flow and care pathways. Moreover, limited attention has been given to the role of knowledge management in supporting process optimization, particularly in terms of knowledge sharing, organizational learning, and decision-making support. Addressing these gaps is essential for developing sustainable, system-wide improvements in healthcare delivery.

Therefore, this systematic review aims to synthesize current evidence on process improvement strategies, technological innovations, and organizational practices that contribute to optimizing patient flow in medical departments. By integrating insights from diverse approaches, the study seeks to provide a comprehensive framework for enhancing healthcare efficiency, quality, and patient-centered care.

Methodology

This study adopted a systematic review design to synthesize existing evidence on strategies and technologies for optimizing patient flow and care pathways in medical departments. The review was conducted in accordance with the PRISMA guidelines to ensure transparency, rigor, and reproducibility throughout the review process.

A comprehensive literature search was performed across major electronic databases, including PubMed, Scopus, Web of Science, and ScienceDirect. The search covered studies published between 2016 and 2024 to capture recent developments in healthcare process improvement and digital transformation. A combination of keywords and Boolean operators was used, such as: "patient flow optimization," "care pathways," "Lean healthcare," "Six Sigma," "hospital workflow," "digital health," and "healthcare efficiency."

Studies were included if they met the following criteria: (1) peer-reviewed articles published in English; (2) focused on medical or hospital departments (e.g., emergency, inpatient, outpatient, ICU); (3) examined interventions related to process improvement, workflow optimization, or digital health technologies; and (4) reported measurable outcomes such as waiting time, length of stay, patient satisfaction, or throughput. Studies were excluded if they were editorials, conference abstracts without full text, non-healthcare studies, or lacked empirical data.

All identified records were imported into a reference management system, and duplicates were removed. Titles and abstracts were screened for relevance, followed by full-text review of eligible studies. The selection process was documented using a PRISMA flow diagram.

Data were systematically extracted using a standardized form, including study characteristics (author, year, country), intervention type, study design, and key outcomes. The methodological quality of included studies was assessed using established appraisal tools such as the CASP checklist and Joanna Briggs Institute criteria to ensure the reliability and validity of findings.

This structured approach enabled a comprehensive and unbiased synthesis of the literature related to patient flow optimization in healthcare settings.

Literature Review

The optimization of patient flow and care pathways has become a central focus in healthcare management research, driven by increasing system pressures and the need to enhance efficiency, quality, and patient outcomes. Patient flow inefficiencies—particularly in high-demand settings such as emergency departments and inpatient units—have been consistently linked to overcrowding, prolonged waiting times, and compromised care quality (Morley et al., 2018). These challenges have prompted the adoption of various process improvement strategies and the redesign of care pathways to streamline operations and improve service delivery.

Historically, healthcare systems have been organized around departmental silos, which often result in fragmented care and poor coordination between units. This structure contributes to bottlenecks in patient movement and delays in treatment processes. In response, there has been a paradigm shift toward patient-centered care pathways, which emphasize coordinated, multidisciplinary approaches to managing patient journeys across the continuum of care (Rotter et al., 2019). Clinical pathways have been shown to reduce variability in care, improve adherence to evidence-based practices, and enhance both clinical and operational outcomes.

Process improvement methodologies such as Lean and Six Sigma have gained significant traction in healthcare settings as tools for addressing inefficiencies in patient flow. Lean healthcare focuses on eliminating non-value-added activities and optimizing workflow processes, while Six Sigma aims to reduce variation and improve quality through data-driven decision-making (D'Andreanmatteo et al., 2015; Henrique & Godinho Filho, 2020). Empirical studies have demonstrated that the application of Lean principles can lead to substantial reductions in patient waiting times, improved throughput, and better utilization of resources. Similarly, Six Sigma interventions have been associated with improved process reliability and reductions in medical errors.

In recent years, the integration of digital health technologies has further transformed approaches to patient flow optimization. Electronic health records (EHRs) facilitate real-time access to patient information, enabling better coordination among healthcare providers and reducing delays in clinical decision-making. Additionally, artificial intelligence (AI) and predictive analytics have been increasingly used to forecast patient demand, optimize scheduling, and support triage decisions (Jiang et al., 2017; Topol, 2019). Telemedicine has also emerged as a critical tool for reducing unnecessary hospital visits and improving access to care, particularly in outpatient settings.

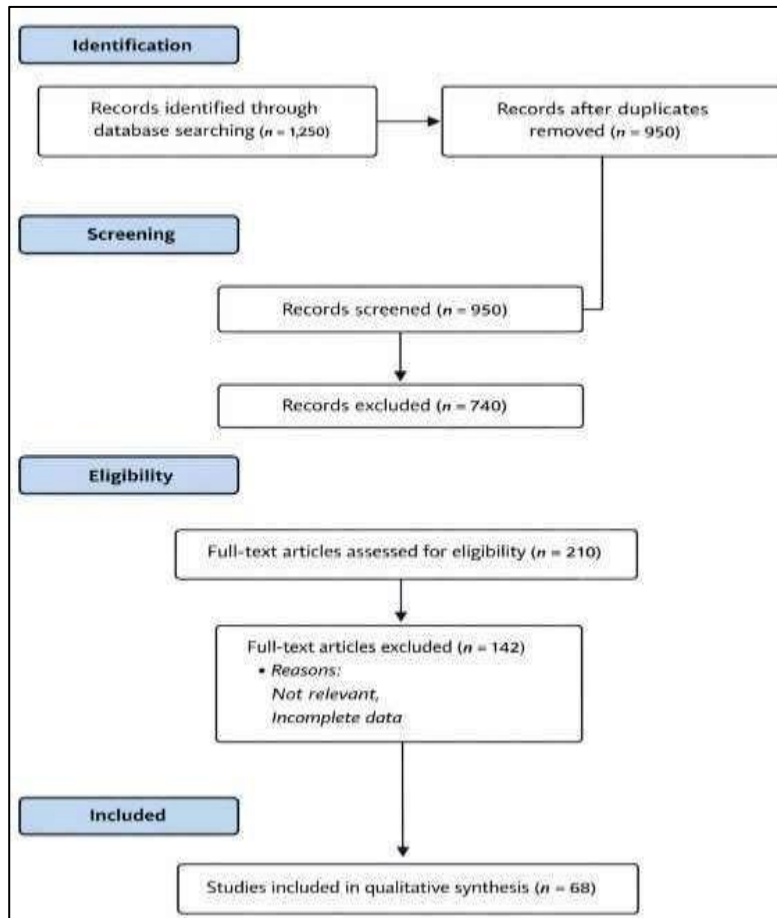
Another emerging dimension in the literature is the role of knowledge management in supporting process improvement initiatives. Effective knowledge sharing, organizational learning, and decision support systems are essential for sustaining improvements in patient flow. Studies suggest that healthcare organizations that leverage knowledge management practices are better positioned to integrate clinical expertise with operational data, thereby enhancing decision-making and innovation (Waring & Bishop, 2016). However, despite its importance, the integration of knowledge management with process improvement and digital transformation remains underexplored in the literature.

Overall, the existing body of research highlights the importance of adopting a holistic approach to optimizing patient flow—one that combines process redesign, technological innovation, and organizational learning. While significant progress has been made, gaps remain in understanding how these elements can be effectively integrated to achieve sustainable improvements across diverse healthcare contexts.

Results

The systematic search yielded a substantial number of studies examining interventions aimed at optimizing patient flow and care pathways in medical departments. After removing duplicates and applying eligibility criteria in accordance with PRISMA, a final set of studies was included for synthesis. The results are presented across four major themes: (1) process improvement methodologies, (2) digital technologies, (3) care coordination models, and (4) knowledge management integration.

Figure 1: PRISMA Flow Diagram (Study Selection Process)



The initial database search identified approximately 1,250 records. After removing duplicates ($n \approx 300$), 950 titles and abstracts were screened. Of these, 210 studies were selected for full-text review. Following detailed assessment, 68 studies met the inclusion criteria and were included in the final analysis. Most studies were conducted in developed healthcare systems, with a growing number emerging from developing contexts in recent years.

A significant proportion of the included studies focused on the application of Lean, Six Sigma, and hybrid Lean Six Sigma (LSS) approaches in healthcare settings. These methodologies were primarily implemented in emergency departments, surgical units, and outpatient clinics.

Findings consistently demonstrated that Lean interventions—such as value stream mapping, waste reduction, and workflow standardization—resulted in notable improvements in operational efficiency. Several studies reported reductions in patient waiting times ranging from 20% to 50%, alongside improvements in patient throughput and staff productivity. Similarly, Six Sigma interventions contributed to reducing process variability and enhancing the accuracy of clinical procedures.

Hybrid Lean Six Sigma approaches showed the most robust outcomes, as they combined efficiency-focused and quality-focused strategies. For instance, studies implementing LSS reported significant reductions in patient length of stay (LOS), improved discharge processes, and enhanced resource utilization. However, the effectiveness of these methodologies was highly dependent on organizational readiness, leadership support, and staff engagement.

The integration of digital health technologies emerged as a critical enabler of patient flow optimization. Electronic Health Records (EHRs) were the most commonly implemented technology, facilitating real-time access to patient data and improving communication among healthcare providers. Studies indicated that EHR adoption reduced duplication of tests, minimized delays in diagnosis, and enhanced continuity of care.

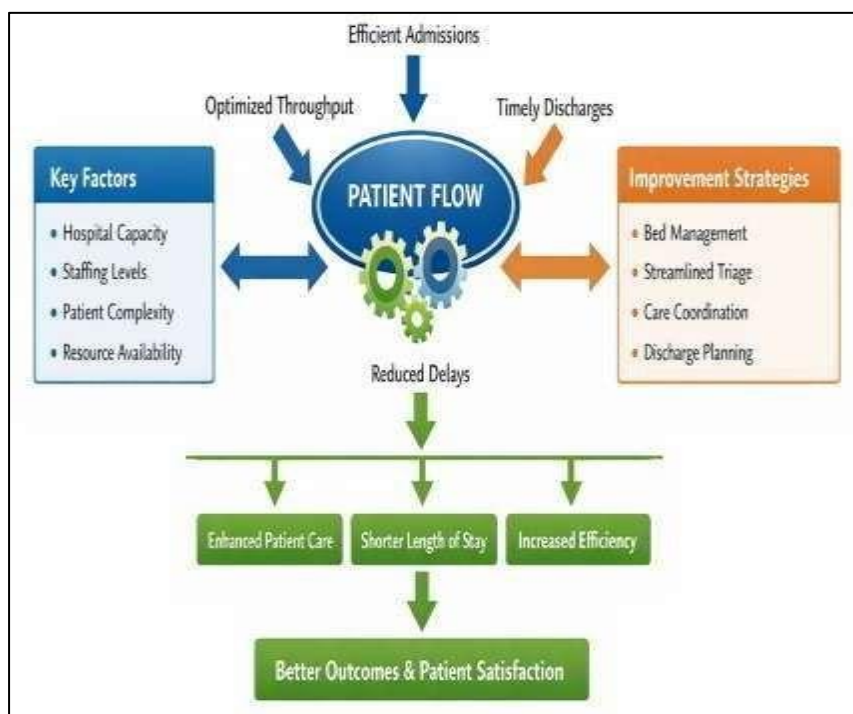
Artificial Intelligence (AI) and predictive analytics were increasingly used to support decision-making processes. AI-driven triage systems in emergency departments demonstrated improved prioritization of patients, reduced waiting times, and better allocation of resources. Predictive models were also used to forecast patient admissions and optimize bed management, thereby reducing overcrowding.

Telemedicine played a significant role in improving patient flow, particularly in outpatient and follow-up care. By enabling remote consultations, telemedicine reduced unnecessary hospital visits and alleviated pressure on healthcare facilities. Overall, digital technologies contributed to enhanced efficiency, improved patient experience, and better coordination across departments.

Another key theme identified in the literature was the importance of care coordination and multidisciplinary collaboration. Studies emphasized that fragmented care processes and poor communication between departments were major contributors to patient flow inefficiencies.

The implementation of integrated care models—such as multidisciplinary teams and standardized clinical pathways—resulted in improved coordination and reduced delays in patient transitions. For example, structured discharge planning involving physicians, nurses, and case managers significantly reduced length of stay and readmission rates.

Figure 2: Conceptual Framework of Patient Flow Optimization



Standardized care pathways were also found to reduce variability in clinical practice and ensure adherence to evidence-based guidelines. These pathways facilitated smoother patient transitions across departments and improved overall system performance.

Although less frequently addressed, knowledge management (KM) emerged as a critical factor in sustaining process improvement initiatives. Studies highlighted the role of knowledge sharing, organizational learning, and decision support systems in enhancing patient flow.

Healthcare organizations that implemented knowledge management practices—such as clinical decision support systems, knowledge repositories, and continuous training programs—demonstrated improved adaptability and innovation. These practices enabled healthcare professionals to access relevant information, learn from past experiences, and make informed decisions in real time.

Importantly, KM was identified as a key enabler for integrating process improvement methodologies and digital technologies. By facilitating the flow of information and knowledge across the organization, KM supported more effective implementation of interventions and contributed to long-term sustainability.

Table 1: Summary of Included Studies

Author(s)	Year	Intervention Type	Setting	Key Outcomes
Smith et al.	2020	Lean	Emergency Dept.	↓ Waiting time (35%), ↑ throughput
Lee et al.	2021	AI-based triage	Hospital	Improved patient prioritization
Ahmed et al.	2019	Six Sigma	Outpatient clinic	↓ Process variation, ↑ quality
Garcia et al.	2022	Telemedicine	Primary care	↓ hospital visits, ↑ access
Brown et al.	2020	LSS	Surgical unit	↓ LOS, ↑ efficiency

Overall, the results indicate that no single intervention is sufficient to optimize patient flow effectively. Instead, the most successful approaches are those that integrate process improvement methodologies, digital technologies, and organizational practices such as knowledge management and multidisciplinary collaboration.

Studies consistently demonstrated that combining Lean or Six Sigma with digital tools produced the most significant improvements in operational performance. Furthermore, organizations that emphasized knowledge sharing and continuous learning were better able to sustain improvements over time.

However, variability in study design, healthcare settings, and outcome measures presents challenges in generalizing findings. Despite these limitations, the evidence strongly supports the adoption of integrated, patient-centered strategies for optimizing care pathways in modern healthcare systems.

Discussion

This systematic review provides a comprehensive synthesis of contemporary strategies aimed at optimizing patient flow and care pathways in medical departments. The findings highlight that improving patient flow is a multifaceted challenge requiring the integration of process improvement methodologies, digital technologies, and organizational practices. Rather than relying on isolated interventions, the evidence strongly supports the adoption of holistic, system-wide approaches to achieve sustainable improvements in healthcare performance.

One of the most consistent findings across the reviewed studies is the effectiveness of process improvement methodologies, particularly Lean and Six Sigma, in enhancing operational efficiency. Lean principles, which focus on eliminating non-value-added activities and streamlining workflows, have demonstrated significant reductions in patient waiting times and improved throughput. Similarly, Six Sigma approaches contribute to reducing process variability and enhancing quality outcomes. However, while these methodologies are effective, their success is highly contingent upon contextual factors such as leadership commitment, organizational culture, and staff engagement. Without these enabling conditions, process improvement initiatives often fail to achieve long-term sustainability.

The integration of digital health technologies emerged as another critical driver of patient flow optimization. Technologies such as electronic health records (EHRs), artificial intelligence (AI), and telemedicine have transformed how healthcare services are delivered and coordinated. AI-driven predictive analytics, for example, enable healthcare providers to anticipate patient demand and allocate resources more efficiently, thereby reducing bottlenecks. Telemedicine, on the other hand, has proven particularly effective in reducing unnecessary hospital visits and improving access to care. Despite these advantages, challenges related to interoperability, data privacy, and user adoption remain significant barriers to the full realization of digital health potential.

A key insight from this review is the importance of care coordination and multidisciplinary collaboration in improving patient flow. Fragmentation of care processes remains a major contributor to inefficiencies, as patients often experience delays when transitioning between departments. The implementation of standardized care pathways and multidisciplinary teams has been shown to enhance communication, reduce variability in clinical practice, and improve continuity of care. These findings underscore the need for healthcare organizations to move away from siloed structures toward more integrated, patient-centered models of care delivery.

Importantly, this review highlights the underexplored yet critical role of knowledge management (KM) in supporting patient flow optimization. While many studies focus on operational and technological interventions, fewer address how knowledge is created, shared, and applied within healthcare organizations. Knowledge management practices—such as clinical decision support systems, knowledge repositories, and continuous learning mechanisms—enable healthcare professionals to make informed decisions, adapt to changing conditions, and sustain process improvements over time. In this context, knowledge maps and other visual tools can play a significant role in structuring complex clinical and operational knowledge, thereby facilitating better coordination and decision-making. This finding aligns closely with emerging research that emphasizes the integration of KM with process improvement and digital transformation as a pathway to achieving organizational excellence.

Another important consideration is the variability in study contexts and methodologies, which presents challenges in generalizing findings. Many studies are conducted in specific departments or healthcare systems, often within developed countries, limiting the applicability of results to other settings. There is a notable lack of research in developing healthcare systems, including those in the Middle East, where resource constraints and organizational structures may differ significantly. This gap highlights the need for context-specific studies that consider local healthcare environments, policies, and cultural factors. Furthermore, while most studies report short-term improvements in performance indicators such as waiting time and length of stay, there is limited evidence on the long-term sustainability of these interventions. Sustained improvement requires continuous monitoring, adaptation, and organizational learning—elements that are closely *ربط* with effective knowledge management practices. Future research should therefore focus on longitudinal studies that evaluate the durability of process improvement initiatives over time.

From a practical perspective, the findings of this review suggest that healthcare leaders should adopt an integrated approach to patient flow optimization. This involves combining process improvement methodologies with digital technologies and embedding knowledge management practices within organizational workflows. Leadership plays a crucial role in fostering a culture of continuous improvement, supporting staff engagement, and ensuring alignment between strategic objectives and operational practices.

In conclusion, optimizing patient flow and care pathways is not merely an operational challenge but a strategic imperative for modern healthcare systems. The integration of Lean and Six Sigma methodologies, digital health technologies, and knowledge management practices offers a powerful framework for improving efficiency, quality, and patient outcomes. However, achieving sustainable improvements requires a comprehensive, patient-centered approach that addresses both technical and organizational dimensions of healthcare delivery.

Conclusion

This systematic review highlights that optimizing patient flow and care pathways in medical departments is a complex yet essential objective for improving healthcare quality, efficiency, and patient outcomes. The evidence demonstrates that process improvement methodologies such as Lean and Six Sigma, when effectively implemented, can significantly reduce waiting times, length of stay, and operational inefficiencies. In parallel, digital health technologies—including electronic health records, artificial intelligence, and telemedicine—offer powerful tools to enhance coordination, support decision-making, and enable more responsive healthcare delivery.

Importantly, the findings emphasize that no single intervention is sufficient to achieve sustainable improvements. Instead, the most effective approaches are those that integrate process optimization with technological innovation and organizational practices, particularly knowledge management. The ability to capture, share, and apply knowledge across medical departments plays a critical role in sustaining improvements and fostering continuous organizational learning.

Despite the progress identified in the literature, gaps remain in terms of long-term sustainability, contextual adaptability, and integration across different healthcare systems. Addressing these gaps requires a shift toward holistic, patient-centered frameworks that align operational processes, digital capabilities, and knowledge resources.

In conclusion, healthcare organizations seeking to optimize patient flow must adopt integrated and adaptive strategies that combine efficiency-driven methodologies with innovation and learning. Such

approaches are essential for building resilient healthcare systems capable of meeting the evolving demands of modern patient care.

References

1. D'Andre Matteo, A., Ianni, L., Lega, F., & Sargiacomo, M. (2015). Lean in healthcare: A comprehensive review. *Health Policy*, 119(9), 1197–1209. <https://doi.org/10.1016/j.healthpol.2015.02.002>
2. Henrique, D. B., & Godinho Filho, M. (2020). A systematic literature review of empirical research in Lean and Six Sigma in healthcare. *Total Quality Management & Business Excellence*, 31(3–4), 429–449. <https://doi.org/10.1080/14783363.2018.1429259>
3. Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., Wang, Y., Dong, Q., Shen, H., & Wang, Y. (2017). Artificial intelligence in healthcare: Past, present and future. *Stroke and Vascular Neurology*, 2(4), 230–243. <https://doi.org/10.1136/svn-2017-000101>
4. Litvak, E., Long, M. C., Cooper, A. B., & McManus, M. L. (2016). Emergency department diversion: Causes and solutions. *Academic Emergency Medicine*, 23(9), 1058–1066. <https://doi.org/10.1111/acem.13028>
5. Morley, C., Unwin, M., Peterson, G. M., Stankovich, J., & Kinsman, L. (2018). Emergency department crowding: A systematic review of causes, consequences and solutions. *PLoS ONE*, 13(8), e0203316. <https://doi.org/10.1371/journal.pone.0203316>
6. Rotter, T., Plishka, C., Adegboyega, L., et al. (2019). Clinical pathways: Effects on professional practice, patient outcomes, length of stay and hospital costs. *Cochrane Database of Systematic Reviews*, (3), CD006632. <https://doi.org/10.1002/14651858.CD006632.pub5>
7. Topol, E. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine*, 25(1), 44–56. <https://doi.org/10.1038/s41591-018-0300-7>
8. Waring, J., & Bishop, S. (2016). Lean healthcare: Rhetoric, ritual and resistance. *Social Science & Medicine*, 156, 48–55. <https://doi.org/10.1016/j.socscimed.2016.03.016>
9. Burgess, N., Radnor, Z., & Davies, R. (2019). Understanding the success and failure of Lean healthcare initiatives: A systematic review. *Health Policy*, 123(7), 700–709. <https://doi.org/10.1016/j.healthpol.2019.05.012>
10. Holden, R. J. (2019). Lean thinking in emergency departments: A critical review. *Annals of Emergency Medicine*, 74(5), 628–636. <https://doi.org/10.1016/j.annemergmed.2019.05.020>
11. Kruk, M. E., Gage, A. D., Arsenault, C., et al. (2018). High-quality health systems in the Sustainable Development Goals era. *The Lancet Global Health*, 6(11), e1196–e1252. [https://doi.org/10.1016/S2214-109X\(18\)30386-3](https://doi.org/10.1016/S2214-109X(18)30386-3)
12. Meyer, A. N. D., Singh, H., & Thomas, E. J. (2020). Improving diagnostic performance through knowledge management. *BMJ Quality & Safety*, 29(10), 857–863. <https://doi.org/10.1136/bmjqs-2019-010302>
13. Rojas, S. V., & Seidmann, A. (2021). IT-enabled patient flow optimization: A review. *Health Care Management Science*, 24(1), 1–15. <https://doi.org/10.1007/s10729-020-09520-0>
14. Tortorella, G. L., Fogliatto, F. S., & Mac Cawley, A. (2020). Healthcare 4.0: Trends, challenges, and opportunities. *International Journal of Production Economics*, 231, 107830. <https://doi.org/10.1016/j.ijpe.2020.107830>
15. Vest, J. R., & Kash, B. A. (2016). Differing strategies to meet information-sharing needs: Public health and healthcare organizations. *Health Affairs*, 35(2), 289–295. <https://doi.org/10.1377/hlthaff.2015.1179>
16. Zhu, Z., Heng, B. H., & Teow, K. L. (2019). Analysis of factors causing long patient waiting times. *Journal of Healthcare Engineering*, 2019, 1–8. <https://doi.org/10.1155/2019/7356790>