

# Review of Integrating Efficient Circulation System in Hospitals: A Thematic Analysis for the Design of Obstetrics Hospital, Ugwolawo

Edime Friday Onechojo<sup>1</sup>; Prof. A.M Babayo<sup>2</sup>; Prof. U.A Jalam<sup>3</sup>; Dr. U.B Wakawa<sup>4</sup>;  
Melentu Giwa Momme<sup>5</sup>; and Jamilu M. Maleka<sup>6</sup>

<sup>1, 2, 3, 4 & 5</sup>Department of Architecture, Abubakar Tafawa Balewa University, Bauchi, Nigeria. <sup>6</sup>Department of Architectural Technology, Federal Polytechnic, Bauchi, Nigeria.

Corresponding author: [edimechojofriday@gmail.com](mailto:edimechojofriday@gmail.com)

DOI: <https://doi.org/10.62154/qjstr.2024.017.010496>

## Abstract

The design of hospital environments is a critical factor in the effective delivery of healthcare services. In specialized units such as obstetrics, where timely and coordinated movement is paramount, the circulation system's efficiency directly impacts patient outcomes, staff productivity, and overall operational effectiveness. This article presents a comprehensive review and thematic analysis of integrating efficient circulation systems in hospital design, focusing specifically on the Obstetrics Hospital in Ugwolawo, Nigeria. Through an extensive literature review, site visits to existing obstetrics hospitals, and engagement with architects, healthcare professionals, and community members, this study identifies key principles and best practices in hospital circulation design. The findings highlight the importance of clear wayfinding, separation of traffic flows, accessibility, flexibility, and strategic proximity of key departments and services. These principles are critical in creating a patient-centered environment that enhances comfort, privacy, and ease of movement, while also optimizing staff workflows and ensuring safety through effective infection control measures. The thematic analysis reveals that patient-centered design should prioritize wide corridors, clear signage, and separate paths for different patient groups to reduce stress and enhance privacy. For staff efficiency, optimizing workflows by locating key areas close to each other and providing dedicated staff routes is essential. Safety and infection control are addressed by designing separated traffic flows for clean and dirty materials and ensuring clearly marked emergency exits. Flexibility and future-proofing involve modular design and scalable infrastructure to adapt to changing needs and future expansions. This review offers practical recommendations for architects and healthcare planners, including implementing clear wayfinding systems, designing for separate traffic flows, ensuring accessibility, and planning for flexibility.

**Keywords:** Circulation Systems, Hospital Design, Patient Flow, Human-Centered Design and Sustainability.

## Introduction

The architecture and design of healthcare facilities are crucial determinants of the quality of care, patient satisfaction, and operational efficiency (Ulrich et al., 2020). In particular, the circulation system within hospitals—which includes the pathways, corridors, elevators, and other movement routes used by patients, staff, and supplies—is vital for the smooth operation of healthcare services (Joseph et al., 2018). Efficient circulation systems are especially important in obstetrics hospitals, where timely and coordinated movement is essential for both routine care and emergency situations (Barach et al., 2018). This article examines the integration of efficient circulation systems in the design of the Obstetrics Hospital in Ugwolawo, Nigeria, through a comprehensive thematic analysis of current best practices and design principles. The circulation system in hospitals includes all pathways and spaces that facilitate movement within the facility. This encompasses hallways, corridors, staircases, elevators, and any other routes that patients, staff, and supplies use. Inefficient circulation systems can lead to several issues, including increased patient and staff stress, higher risks of hospital-acquired infections, delays in care delivery, and overall operational inefficiencies (Joseph et al., 2018). In obstetrics hospitals, these issues are exacerbated due to the unique requirements of maternity care, which often involves urgent and unpredictable scenarios (Barach et al., 2018). Efficient circulation systems are vital for creating patient-centered environments that enhance comfort and reduce stress. According to a study by Ulrich et al. (2020), well-designed circulation paths with clear wayfinding significantly improve patient satisfaction and reduce anxiety. Similarly, clear and logical circulation routes are essential for staff efficiency, enabling healthcare workers to perform their duties more effectively and with less physical strain (Chaudhury et al., 2016). For instance, the proximity of key areas such as operating rooms, delivery suites, and nurses' stations can reduce the time and effort required for staff to move between these critical zones, thereby enhancing the overall efficiency of care delivery (Shepley et al., 2019).

The design of circulation systems also has direct implications for infection control and safety. Separating the movement paths of clean and dirty materials can significantly reduce the risk of hospital-acquired infections (Haugen & Oxman, 2015). Furthermore, ensuring that emergency routes are clearly marked and easily accessible can enhance patient and staff safety during critical situations. The thematic analysis by Joseph et al. (2018) emphasizes that a well-thought-out circulation system is a cornerstone of a safe and hygienic hospital environment. In the context of rapidly evolving healthcare needs, flexibility and adaptability are crucial elements of hospital design. Modular and scalable circulation systems allow for future expansions and reconfigurations without major disruptions (Pati et al., 2021). This is particularly important in obstetrics hospitals, where changes in patient volume and the introduction of new technologies can necessitate adjustments in the layout and circulation routes (Verderber & Fine, 2019).

## Statement of the Problem

The design and architecture of healthcare facilities significantly influence the efficiency and effectiveness of healthcare delivery. In obstetrics hospitals, where rapid and coordinated movements are crucial, the design of the circulation system is paramount. Despite the recognized importance of efficient circulation systems, many hospitals continue to struggle with poor design, leading to operational inefficiencies, increased patient and staff stress, and higher risks of hospital-acquired infections (Haugen & Oxman, 2015; Ulrich et al., 2020). The Obstetrics Hospital in Ugwolowo, Nigeria, exemplifies these challenges, necessitating a detailed examination of how to integrate efficient circulation systems into its design. Operational inefficiencies in hospital settings often stem from poorly designed circulation systems. In the context of the Obstetrics Hospital in Ugwolowo, the lack of a flexible and adaptable circulation system poses a significant challenge.

As the population grows and healthcare needs evolve, the hospital must be able to adjust its layout and circulation paths to meet new demands. This requires a thorough understanding of best practices in hospital circulation design and a commitment to incorporating flexibility into the facility's infrastructure (Pati et al., 2021). Despite the critical importance of efficient circulation systems in hospitals, there is a lack of comprehensive studies that focus specifically on their integration in obstetrics hospitals, particularly in resource-constrained settings like Ugwolowo. While existing research provides valuable insights into general hospital design principles, there is a need for targeted studies that address the unique requirements of obstetrics care and the specific challenges faced by hospitals in developing regions (Chaudhury et al., 2016; Shepley et al., 2019). This study aims to fill this gap by conducting a thematic analysis of efficient circulation system integration in the design of the Obstetrics Hospital in Ugwolowo. By reviewing current literature, conducting site visits, and engaging with stakeholders, this research seeks to identify best practices and practical recommendations that can enhance the hospital's operational efficiency, patient and staff experiences, and overall safety.

## Literature Review

The design of hospital facilities plays a pivotal role in ensuring the efficiency of healthcare delivery, patient satisfaction, and staff productivity. One critical aspect of hospital design is the circulation system, which includes the pathways, corridors, elevators, and other routes used by patients, staff, and supplies. Efficient circulation systems are particularly essential in obstetrics hospitals, where timely and coordinated movement is critical for both routine care and emergencies. This literature review explores current best practices and design principles for hospital circulation systems, with a focus on their application in obstetrics hospitals. Efficient circulation systems in hospitals are crucial for several reasons. Firstly, they facilitate the smooth flow of patients, staff, and supplies, thereby reducing delays in care delivery (Ulrich et al., 2020). Secondly, well-designed circulation systems can minimize the stress and anxiety experienced by patients and visitors by providing clear and intuitive

wayfinding (Chaudhury et al., 2016). Thirdly, efficient circulation can enhance staff productivity by reducing travel distances and physical strain, leading to better job satisfaction and performance (Joseph et al., 2018). Finally, proper separation of clean and contaminated pathways can significantly reduce the risk of hospital-acquired infections (HAIs) (Pati et al., 2021). Several design principles have been identified in the literature as critical for efficient hospital circulation systems:

1. **Zoning and Functional Separation:** Effective hospital design often involves zoning to separate different functions and reduce cross-traffic. For example, separating patient care areas from administrative zones can minimize disruptions and enhance privacy (Verderber & Fine, 2019). In obstetrics hospitals, it is essential to separate maternity wards from other areas to provide a tranquil and secure environment for mothers and newborns (Barach et al., 2018).
2. **Clear Wayfinding:** Wayfinding refers to the use of signage, symbols, and spatial organization to help individuals navigate a complex environment. Clear wayfinding systems are crucial in reducing confusion and anxiety among patients and visitors (Shepley et al., 2019). Techniques such as color-coding, consistent signage, and well-placed maps can significantly improve wayfinding in hospitals (Pati et al., 2021).
3. **Accessibility and Inclusivity:** Hospitals must be designed to accommodate individuals with diverse needs, including those with disabilities. This involves ensuring that circulation routes are accessible to all, including wide corridors, ramps, and appropriately placed elevators (Ulrich et al., 2020).
4. **Flexibility and Adaptability:** The healthcare environment is dynamic, with changing patient demographics and evolving medical technologies. Hospital circulation systems must be designed to adapt to these changes without significant disruptions. Flexible design strategies, such as modular layouts and easily reconfigurable spaces, are essential for future-proofing hospital facilities (Verderber & Fine, 2019).
5. **Safety and Security:** Safety is a paramount concern in hospital design. Efficient circulation systems must incorporate features that enhance the safety and security of patients, staff, and visitors. This includes adequate lighting, secure access controls, and the elimination of potential hazards (Chaudhury et al., 2016).

Research has demonstrated that the design of hospital circulation systems can significantly impact patient and staff outcomes. For patients, efficient circulation systems can reduce anxiety and stress, improve satisfaction, and enhance overall experiences within the hospital (Ulrich et al., 2020). For staff, well-designed circulation routes can reduce physical fatigue, improve workflow efficiency, and enhance job satisfaction (Joseph et al., 2018). A study by Pati et al. (2021) highlighted the importance of separating clean and dirty pathways in reducing the risk of HAIs. The study found that hospitals with well-designed circulation systems reported lower rates of infections, underscoring the critical role of physical environment in infection control. Similarly, research by Shepley et al. (2019)

demonstrated that clear and intuitive wayfinding systems could significantly improve patient experiences and reduce the likelihood of wayfinding-related stress. Despite the clear benefits of efficient circulation systems, several challenges can hinder their implementation. One significant challenge is the cost associated with redesigning existing hospital facilities to improve circulation (Haugen & Oxman, 2015). Retrofitting old buildings with modern circulation systems can be expensive and disruptive, requiring careful planning and resource allocation. Another challenge is the need for stakeholder engagement in the design process. Successful hospital design requires input from various stakeholders, including healthcare professionals, architects, administrators, and patients (Barach et al., 2018). Balancing the diverse needs and preferences of these stakeholders can be complex and time-consuming. Additionally, cultural and regional factors can influence the design of hospital circulation systems. In regions with unique cultural practices or logistical constraints, such as Ugwolawo, Nigeria, it is essential to tailor design solutions to fit local contexts.

This requires a deep understanding of the local culture, healthcare needs, and available resources (Joseph et al., 2018). Several case studies provide valuable insights into best practices for hospital circulation system design. For example, a study by Verderber and Fine (2019) examined the redesign of a major urban hospital, highlighting the importance of zoning, clear wayfinding, and flexibility. The redesign resulted in significant improvements in patient satisfaction, staff efficiency, and overall hospital operations. Another case study by Pati et al. (2021) focused on a rural hospital that implemented modular design strategies to enhance flexibility. The hospital's circulation system was designed to accommodate future expansions and changes in patient demographics, demonstrating the importance of adaptability in hospital design. A study by Adebayo et al. (2021) examined the influence of hospital design on operational efficiency in Nigerian hospitals. The researchers conducted a comparative analysis of hospitals with varying circulation system designs, focusing on travel distances for staff, patient flow, and emergency response times. Their findings revealed that hospitals with well-planned circulation systems demonstrated significantly higher operational efficiency, reduced patient waiting times, and improved staff productivity. The study emphasized the importance of clear zoning and functional separation to minimize cross-traffic and optimize workflow. Chukwu *et al.*, (2020) conducted an empirical study on the impact of wayfinding systems on patient satisfaction in public hospitals in Ghana. The study utilized patient surveys and observational methods to assess the effectiveness of wayfinding elements, such as signage, maps, and color-coded pathways. The results indicated that hospitals with well-designed wayfinding systems reported higher levels of patient satisfaction and reduced instances of patient anxiety and confusion. The study highlighted the need for intuitive and user-friendly wayfinding systems in hospital design.

A study by Mphahlele and Nethengwe (2019) explored the concept of design flexibility and adaptability in South African hospitals. The researchers conducted case studies of hospitals

that had undergone renovations to improve their circulation systems. The findings revealed that flexible design strategies, such as modular layouts and adaptable spaces, allowed hospitals to efficiently manage changes in patient demographics and healthcare practices. The study underscored the importance of incorporating flexibility into hospital circulation systems to future-proof healthcare facilities. The relationship between circulation system design and infection control was investigated by Okeke et al. (2022) in a study focused on Nigerian hospitals. The researchers analyzed the impact of circulation pathways on the incidence of hospital-acquired infections (HAIs). Their study found that hospitals with separate pathways for clean and contaminated materials had significantly lower rates of HAIs.

The research highlighted the critical role of efficient circulation design in mitigating infection risks and improving patient safety. A study by Ahmed and Suleiman (2021) examined the relationship between hospital circulation systems and staff productivity in Kenyan hospitals. The researchers conducted ergonomic assessments and staff surveys to evaluate the impact of circulation design on physical strain and workflow efficiency. The study found that hospitals with ergonomic circulation designs reported higher levels of staff productivity and lower incidences of work-related injuries. The findings emphasized the importance of designing circulation systems that consider the ergonomic needs of healthcare staff. The empirical studies reviewed above provide a comprehensive understanding of the critical factors influencing the design of efficient hospital circulation systems in the African context. Key insights include:

1. **Operational Efficiency:** Efficient circulation systems with clear zoning and functional separation enhance operational efficiency, reduce patient waiting times, and improve staff productivity (Adebayo *et al.*, 2021).
2. **Patient Satisfaction:** Intuitive wayfinding systems, including clear signage and color-coded pathways, significantly enhance patient satisfaction and reduce anxiety (Chukwu *et al.*, 2020).
3. **Design Flexibility:** Flexible and adaptable design strategies enable hospitals to manage changing healthcare needs and patient demographics effectively (Mphahlele & Nethengwe, 2019).
4. **Infection Control:** Proper separation of clean and contaminated pathways in circulation design is crucial for mitigating the risk of HAIs (Okeke *et al.*, 2022).
5. **Staff Productivity:** Ergonomic circulation designs that consider the physical needs of healthcare staff improve productivity and reduce work-related injuries (Ahmed & Suleiman, 2021).

### Theoretical Framework

The theoretical and conceptual frameworks for integrating efficient circulation systems in hospitals draw upon established theories and concepts that are pertinent to healthcare architecture and design. In the context of designing the Obstetrics Hospital in Ugwolawo,

Nigeria, these frameworks encompass theories related to systems thinking, human-centered design, evidence-based design, and sustainability principles such as:

## 1. Systems Thinking

**Theory:** Systems thinking provides a holistic approach to understanding the interdependencies and interactions within complex systems, such as hospitals. It emphasizes the interconnectedness of various components and processes within the healthcare environment, including physical infrastructure, staff workflow, patient care pathways, and resource management (Bertalanffy, 1968).

**Application:** Applying systems thinking in hospital design involves optimizing circulation systems to enhance operational efficiency, minimize bottlenecks, and improve patient outcomes through streamlined workflows and integrated processes.

## 2. Human-Centered Design

**Theory:** Human-centered design (HCD) focuses on creating solutions that are deeply informed by understanding the perspectives, behaviors, and needs of the people who will use them. In healthcare, HCD emphasizes the importance of designing environments that promote patient well-being, comfort, and safety, while also supporting healthcare providers in delivering effective care (Norman & Stappers, 2015).

**Application:** Integrating HCD principles into the design of the Obstetrics Hospital involves engaging stakeholders—patients, healthcare providers, and community members—in the design process to ensure that circulation systems are intuitive, accessible, and supportive of positive user experiences.

## 3. Evidence-Based Design (EBD)

**Theory:** Evidence-based design involves using empirical evidence and research to inform design decisions that improve healthcare outcomes. This approach integrates findings from scientific studies, best practices, and expert knowledge to create healthcare environments that are safe, efficient, and conducive to healing (Ulrich et al., 2020).

**Application:** Applying EBD principles in hospital circulation design requires leveraging research on spatial layout, wayfinding systems, infection control measures, and ergonomic considerations to optimize the design of circulation pathways in the Obstetrics Hospital.

## 4. Sustainability Principles

**Theory:** Sustainability principles in healthcare design focus on minimizing environmental impact, optimizing resource use, and promoting health and well-being for both patients and staff. Sustainable design considers factors such as energy efficiency, use of natural light, materials selection, and waste reduction strategies (Lee & Burnett, 2018).

**Application:** Integrating sustainability principles into the design of the Obstetrics Hospital involves adopting environmentally responsible practices in the planning and construction



of circulation systems, contributing to long-term operational efficiency and environmental stewardship.

### Methodology

This study employs a mixed-methods approach, combining qualitative and quantitative research methods to comprehensively analyze the integration of efficient circulation systems in the design of the Obstetrics Hospital in Ugwolawo, Nigeria. The research design includes a literature review, thematic analysis, site visits, and stakeholder interviews to ensure a holistic understanding of best practices and design principles. Site visits to existing obstetrics hospitals in Nigeria were conducted to observe and document the current state of circulation systems. These visits focused on hospitals with both efficient and inefficient circulation designs to provide a comparative analysis. During the site visits, observational checklists and photographs were used to capture details of the physical environment, circulation pathways, and wayfinding systems. Semi-structured interviews were conducted with key stakeholders, including architects, healthcare professionals, hospital administrators, and patients. The interviews aimed to gather firsthand insights into the challenges and successes of current hospital circulation systems. Stakeholders were selected based on their involvement in hospital design and operations to ensure diverse perspectives. Interview questions focused on the functionality, efficiency, and user experience of hospital circulation systems.

### Results

The thematic analysis of integrating efficient circulation systems in the design of Obstetrics Hospital Ugwolawo reveals several key findings:

1. **Optimized Patient Flow:** By implementing systematic circulation pathways and strategically locating key facilities such as delivery rooms and neonatal units, the hospital can achieve enhanced patient flow. This optimization ensures timely access to care and reduces congestion, thereby improving patient outcomes.
2. **Enhanced Staff Efficiency:** Clear and intuitive circulation systems contribute to improved staff efficiency. Nurses and doctors can navigate the hospital more efficiently, reducing response times during emergencies and enhancing overall operational effectiveness.
3. **Improved Patient Experience:** Human-centered design principles integrated into circulation systems promote a positive patient experience. Wayfinding signage, comfortable waiting areas, and accessible pathways contribute to patient comfort and satisfaction.
4. **Support for Healthcare Practices:** Evidence-based design elements, such as infection control measures integrated into circulation pathways, help mitigate the risk of hospital-acquired infections. This supports safer healthcare practices and enhances patient safety.



5. **Sustainability Considerations:** Incorporating sustainability principles in circulation system design contributes to environmental stewardship. Energy-efficient lighting, natural ventilation systems, and sustainable material choices reduce the hospital's environmental footprint.

## Conclusion

Integrating efficient circulation systems in the design of Obstetrics Hospital Ugwolawo is crucial for optimizing healthcare delivery and improving overall hospital performance. By leveraging systems thinking, human-centered design, evidence-based design, and sustainability principles, the hospital can create a cohesive environment that enhances patient care, supports staff effectiveness, and promotes sustainable practices. The thematic analysis underscores the importance of tailored design solutions that address local healthcare needs and environmental context. By focusing on optimizing patient flow, enhancing staff efficiency, improving patient experiences, and supporting healthcare practices, the Obstetrics Hospital Ugwolawo can serve as a model for effective hospital design in similar contexts.

Moving forward, continued research and adaptation of best practices in hospital design will further refine the integration of efficient circulation systems, ensuring that healthcare facilities like Obstetrics Hospital Ugwolawo continue to meet the evolving needs of patients, healthcare providers, and the community at large.

## Recommendations

1. **Adopt Comprehensive Wayfinding Systems:** Implement intuitive wayfinding signage and digital navigation aids throughout the hospital to assist patients, visitors, and staff in navigating the facility efficiently.
2. **Design Patient-Centered Spaces:** Create comfortable waiting areas and clear patient pathways that prioritize patient privacy, comfort, and ease of access to medical services.
3. **Enhance Staff Training on Circulation Systems:** Provide ongoing training for healthcare staff to familiarize them with hospital layout and circulation systems, ensuring they can navigate swiftly during emergencies and routine tasks.
4. **Integrate Technology for Efficiency:** Utilize technology such as real-time location systems (RTLS) to track equipment, monitor patient flow, and optimize staff deployment based on demand within the hospital.
5. **Regular Maintenance and Evaluation:** Establish protocols for regular maintenance of circulation systems to ensure continued efficiency. Conduct periodic evaluations to identify and address any bottlenecks or areas for improvement.

6. **Engage Stakeholders in Design Processes:** Involve patients, healthcare providers, and community members in the design and evaluation of circulation systems to ensure they meet the diverse needs of all stakeholders.
7. **Implement Sustainable Practices:** Integrate sustainable design principles, such as energy-efficient lighting, natural ventilation, and eco-friendly materials, to minimize environmental impact and operational costs.

## References

- Adebayo, O., Oladapo, I., & Adedayo, A. (2021). Impact of Hospital Design on Operational Efficiency: A Comparative Analysis of Nigerian Hospitals. *Journal of Healthcare Management*, 66(3), 189-200. <https://doi.org/10.1097/JHM-D-20-00287>
- Ahmed, R., & Suleiman, H. (2021). Ergonomics and Staff Productivity: An Empirical Study of Hospital Circulation Systems in Kenya. *Journal of Healthcare Engineering*, 2021, Article 9812345. <https://doi.org/10.1155/2021/9812345>
- Barach, P., Rivard, P., & Flin, R. (2018). Obstetrics and gynaecology safety and quality: Structures, processes, and outcomes. *British Medical Journal*, 362, k3444. <https://doi.org/10.1136/bmj.k3444>
- Bertalanffy, L. von. (1968). *General System Theory: Foundations, Development, Applications*. George Braziller.
- Chaudhury, H., et al. (2016). The Impact of Environmental Design on Care Quality and Patient Outcomes: A Systematic Review. *HERD: Health Environments Research & Design Journal*, 9(2), 151-171. <https://doi.org/10.1177/1937586715599653>
- Chukwu, E., Amankwah, A., & Boateng, E. (2020). The Role of Wayfinding Systems in Enhancing Patient Satisfaction in Public Hospitals: Evidence from Ghana. *International Journal of Healthcare Management*, 13(2), 123-131. <https://doi.org/10.1080/20479700.2018.1564029>
- Haugen, A. S., & Oxman, A. D. (2015). A systematic review of safety interventions in obstetrics. *BMC Health Services Research*, 15, 277. <https://doi.org/10.1186/s12913-015-0902-7>
- Joseph, A., Rashid, M., & Shukla, S. (2018). The Role of the Physical Environment in Promoting Health, Safety, and Effectiveness in the Healthcare Workplace. *The Center for Health Design*. <https://doi.org/10.13140/RG.2.2.22657.84323>
- Lee, J. H., & Burnett, E. (2018). Sustainable Hospital Design: A Review of Environmental and Operational Factors. *Journal of Healthcare Engineering*, 2018, Article 6546871. <https://doi.org/10.1155/2018/6546871>
- Mphahlele, M., & Nethengwe, T. (2019). Design Flexibility and Adaptability in South African Hospitals: A Case Study Approach. *African Journal of Health Architecture*, 5(1), 45-58. <https://doi.org/10.15641/ajha.v5i1.845>
- Norman, D. A., & Stappers, P. J. (2015). DesignX: Complex Sociotechnical Systems. *She Ji: The Journal of Design, Economics, and Innovation*, 1(2), 83-106. <https://doi.org/10.1016/j.sheji.2016.01.002>
- Okeke, C., Nnamani, P., & Eze, C. (2022). Circulation Design and Infection Control in Nigerian Hospitals: Mitigating the Risk of Hospital-Acquired Infections. *African Journal of Infectious Diseases*, 16(1), 24-33. <https://doi.org/10.4314/ajid.v16i1.3>
- Pati, D., Harvey, T. E., Jr., & Cason, C. (2021). Flexibility in Healthcare Facility Design: A Scoping Review. *HERD: Health Environments Research & Design Journal*, 14(2), 28-41. <https://doi.org/10.1177/1937586720965185>
- Shepley, M. M., Rybkowski, Z. K., & Alenazi, A. (2019). Designs for Effective Hospital Wayfinding Systems: A Literature Review. *Journal of Environmental Psychology*, 64, 56-69. <https://doi.org/10.1016/j.jenvp.2019.05.003>

- Ulrich, R. S., et al. (2020). A Review of the Research Literature on Evidence-Based Healthcare Design. *HERD: Health Environments Research & Design Journal*, 7(4), 61–125. <https://doi.org/10.1177/19375867140070040>
- Verderber, S., & Fine, D. J. (2019). *Healthcare Architecture in an Era of Radical Transformation*. Yale University Press.