DOI: https://doi.org/10.4038/sljma.v25i1.5502

The Sri Lanka Journal of Medical Administration Volume 25 Issue I Oct 2024 ISSN: 1391-2909

The Sri Lanka Journal of Medical Administration

https://sljma.sljol.info/

Original Article:

# Integrating Modern Design and Sustainability in Healthcare Architecture: A Comparative Case Study of Sri Lanka's National Nephrology Hospital and the UK's NHS New Hospital Programme

Kumara M.K.S.I.[1]

[1]*James Paget University Hospitals NHS Foundation Trust, United Kingdom*

***Keywords:*** hospital architecture, sustainability, digital integration, Low and Middle-Income Countries (LMICs)

Correspondence to:
Dr. M.K.S.I. Kumara
Email: mksindika@gmail.com

## Abstract

Hospital architecture has evolved significantly, influenced by advancements in medical science, technology, and societal needs. This paper examines the historical progression of hospital architecture, highlighting modern trends such as patient-centred design, modular construction, sustainability, and digital integration. It emphasizes the relevance of these trends to Low and Middle-Income Countries (LMICs), focusing on the China-Sri Lanka Friendship National Nephrology Hospital (NNSH) in Polonnaruwa. The study employs a qualitative approach, utilizing historical data, literature reviews, and case studies from developed and developing countries, primarily focusing on the NNSH and the UK's NHS New Hospital Programme (NHP).

The NNSH exemplifies innovative hospital design, incorporating energy-saving technologies, climate-responsive features, and disaster resilience. It functions as a community hub, promoting health education and outreach. Insights from the NHP emphasize the integration of digital solutions, standardized designs, and sustainable practices, which are pivotal for enhancing healthcare infrastructure in LMICs.

Strategic recommendations address challenges such as cost constraints, infrastructure gaps, and technical expertise in LMICs, including digital transformation, net-zero carbon strategies, green practices, and adherence to standardized guidelines. This comparative study underscores the importance of adaptable and sustainable hospital architecture in improving healthcare delivery and outcomes in Sri Lanka and other LMICs.

***Keywords:*** hospital architecture, sustainability, digital integration, Low and Middle-Income Countries (LMICs)

## Introduction

Hospital architecture has evolved significantly, reflecting advances in medical science, technology,

and societal needs. This transformation is especially important for Low and Middle-Income Countries (LMICs) like Sri Lanka, where efficient hospital designs can greatly improve public health. This article examines the historical evolution of hospital architecture, current trends, and their relevance to LMICs, focusing on the China-Sri Lanka Friendship National Nephrology Hospital in Polonnaruwa. It also explores insights from the UK's NHS New Hospital Programme (NHP) to adapt these innovations for Sri Lanka and other LMICs.

## Methodology

This article employs a qualitative approach, reviewing historical data on hospital architecture, examining modern architectural trends through literature reviews, and analyzing case studies from developed and developing countries. Primary case studies include the China-Sri Lanka Friendship National Nephrology Hospital and the UK's NHS New Hospital Programme. Data sources consist of architectural records, government reports, and scholarly articles, emphasizing design principles, sustainability measures, and local adaptability.

### *Historical Evolution of Hospital Architecture*

The history of hospital architecture can be traced back to ancient civilizations where healing spaces were often rudimentary. The Asclepieia of ancient Greece, dedicated to the god of healing, were among the earliest known healing temples, emphasizing a holistic approach to health. During the Middle Ages, monastic hospitals in Europe focused on care for the sick and poor, often characterized by large, open wards [1].

The Renaissance saw the emergence of more structured hospital designs, such as Filippo Brunelleschi's Ospedale degli Innocenti in Florence. This period marked the beginning of architecture specifically tailored for healthcare, with considerations for hygiene and patient segregation becoming more prominent [2].

The 19th and early 20th centuries introduced the pavilion hospital design, which separated patients based on the type of illness, improving infection control. Florence Nightingale's principles of hospital design emphasized ventilation, natural light, and hygiene, which became standard in hospital architecture [3].

The late 20th century saw the advent of high-tech hospitals, integrating advanced medical equipment and technology into their designs. This period also marked the beginning of patient-centred care, with architecture focusing on creating healing environments that promote recovery.

### *The Sri Lankan context and world history*

The architectural history of Sri Lanka is rich and diverse, with its earliest known hospital, Mihintale Hospital, established in the 3rd century BC during the spread of Buddhism. Mihintale Hospital is considered one of the world's oldest known hospitals, showcasing the region's early advancements in medical care and hospital design. The historical significance of Mihintale highlights Sri Lanka's longstanding commitment to healthcare infrastructure [4].

In ancient Egypt, architecture laid the foundation as an art of design and construction. Residential and public buildings were constructed mainly of air-dried brick, so they almost did not survive, and stone was used only for tombs and

 

temples. Interestingly, the first known ancient Egyptian architect, Imhotep, who created the first pyramid in the 27th century BC, is also considered the founder of ancient medicine [5].

It is assumed that clinics at temples, where nobles were treated, existed already in ancient Mesopotamia (3rd millennium BC). Medical hospitals established for permanent care were also known in India about 100 BC [6].

### *Modern Trends in Hospital Architecture*

Modern hospital architecture prioritizes functionality, patient comfort, and adaptability to technological advancements. Key trends include:

1. Patient-Centred Design: Modern hospitals focus on creating healing environments that reduce stress and promote recovery. This includes the use of natural light, green spaces, and noise reduction techniques [7].
2. Modular Construction: Modular and prefabricated components allow for faster construction and flexibility in expanding or reconfiguring hospital spaces as needed [8].
3. Sustainable Design: Energy-efficient buildings, sustainable materials, and waste reduction practices are becoming standard, addressing environmental concerns and reducing operational costs [9].
4. Technology Integration: Incorporating advanced medical technologies and digital infrastructures, such as telemedicine capabilities and electronic health records, is essential for modern healthcare delivery [10].
5. Building Information Modeling (BIM) and Digital Twin technologies are transforming hospital design and management by enabling detailed 3D modelling and real-time data integration [11].
6. Net Zero Carbon (NZC) strategy aims to reduce the carbon footprint of hospital buildings through energy-efficient designs, renewable energy sources, and carbon offset measures [12].
7. BREEAM (Building Research Establishment Environmental Assessment Method) is a leading sustainability assessment method for buildings, promoting sustainable practices in hospital design and operation [12].
8. Digital Transformation in Healthcare: The NHS New Hospital Programme in England exemplifies the integration of digital technologies in healthcare infrastructure, enhancing patient care and operational efficiency [13].
9. Regenerative architecture uses natural systems as fundamental components, fostering harmony between structures and ecosystems. This sustainable approach, evident in Sri Lanka's ancient Ritigala monastery and modern Kandalama, represents the pinnacle of eco-friendly design [14].

### *Adaptability of Hospital Architecture to LMICs: The Case of Sri Lanka*

In Sri Lanka and similar LMICs, hospital architecture must overcome resource constraints, climate variability, and the need for resilient infrastructure. The 2023 Central Bank report underscores economic challenges limiting new healthcare investments. Despite this, soft loans from the World Bank and Asian Development Bank via the PSSP and RBLP enable healthcare administrators to focus on modern, well-planned healthcare settings that incorporate new technologies and sustainable architecture.

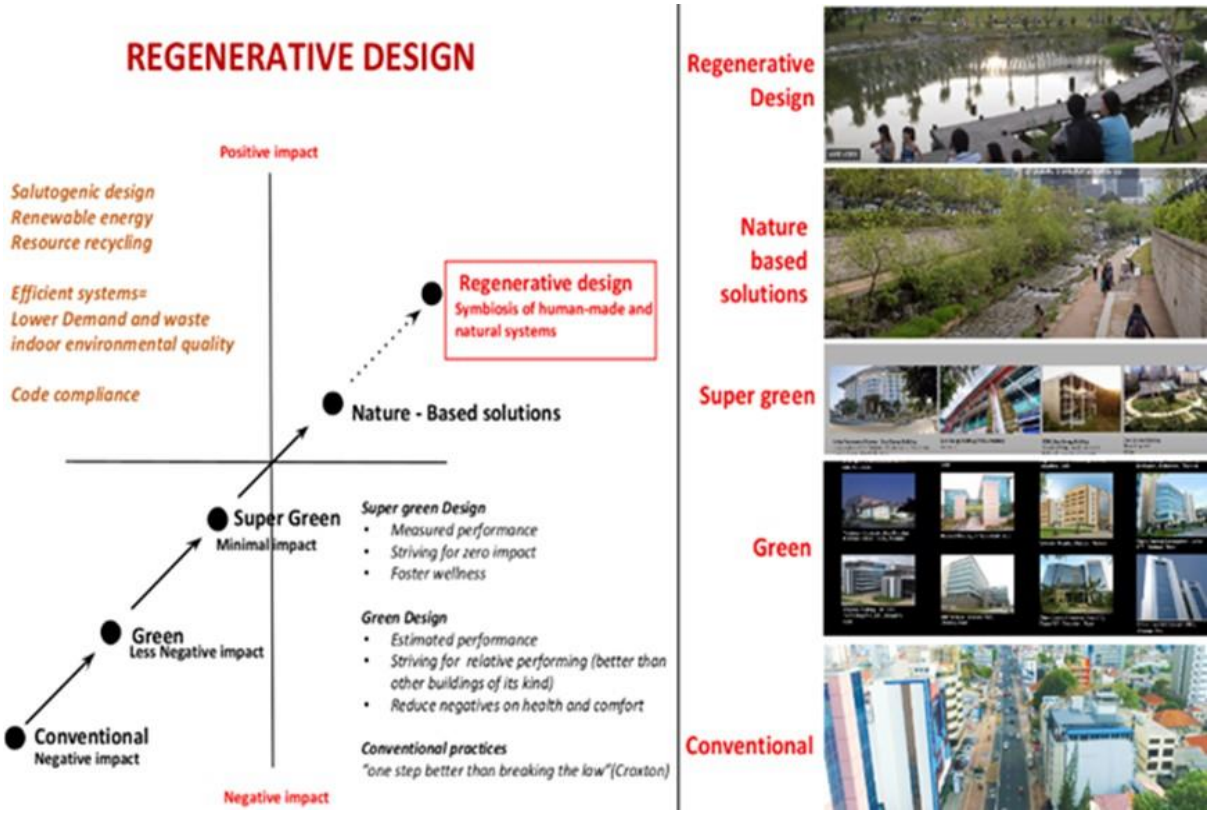

Figure 01: Regenerative design

1. Cost-Effective Construction: Utilizing local materials and labour can reduce costs and support the local economy. Modular construction methods can also provide scalable and flexible solutions [15].
2. Climate-Responsive Design: Hospital designs must consider Sri Lanka's tropical climate, incorporating passive cooling techniques, natural ventilation, and rainwater harvesting systems to enhance sustainability and comfort [16].
3. Disaster Resilience: Sri Lanka is prone to natural disasters such as floods and cyclones. Hospitals must be designed to withstand these events, ensuring the continuity of medical services during emergencies [17].
4. Community Integration: Hospitals should serve as community hubs, providing not only medical care but also health education and outreach services. This can be achieved through multifunctional spaces and accessible designs [18].
5. Net Zero Carbon Strategy: Implementing energy-efficient designs, renewable energy sources, and carbon offset measures to reduce the environmental footprint of healthcare facilities [12].
6. Digital Transformation: Incorporating advanced digital technologies such as BIM, electronic health records, and telemedicine to improve healthcare delivery and operational efficiency [11].
7. Green and Sustainable Practices: Using sustainable materials, waste reduction practices, and climate-responsive

 

designs to enhance the sustainability of hospital buildings [9].

8. Infection Control and Safety: Designing healthcare facilities with stringent infection control measures, safety protocols, and high-quality care standards to ensure patient safety and quality care [19].
9. Patient Privacy and Comfort: Incorporating design elements that prioritize patient privacy, comfort, and dignity fosters a healing environment [7].
10. Adopting Standardized Guidelines: Sri Lanka should adopt standardized guidelines like the UK's Hospital Building Notes (HBN) and Health Technical Memoranda (HTM). These guidelines offer best practice recommendations to ensure the safety, privacy, and dignity of patients, staff, and visitors, while also providing cost-effective solutions for the planning and design of healthcare facilities [19].

**Case Study: China-Sri Lanka Friendship National Nephrology Specialized Hospital, Polonnaruwa**

***Project Overview and Background***

The National Nephrology Specialized Hospital (NNSH) in Polonnaruwa, Sri Lanka, is a critical initiative addressing the high incidence of chronic kidney disease and enhancing the region's healthcare infrastructure. This China-aid project covers 6.64 hectares with a total floor area of 25,917 m², including both aboveground and underground facilities. It features 200 hospital beds, 100 haemodialysis beds, and staff accommodations [20].

The NNSH offers comprehensive nephrology services, including outpatient care, haemodialysis, peritoneal dialysis, and specialized medical and surgical departments. The hospital includes administrative offices, a multi-function hall, an ICU, and staff accommodations with parking for 300 vehicles. It is designed to handle 660 daily outpatient visits, 198,000 annual outpatient visits, and 109,500 annual dialysis visits, along with kidney transplants and common surgeries [20]

Funded by LKR 12 billion donation from China, the project was managed by the Beijing Institute of Architectural Design and Research Institute Co. Ltd and Top International Engineering Co. Ltd of China, in collaboration with the Ministry of Health, Sri Lanka and District General Hospital, Polonnaruwa, from December 2015 to February 2021. The facility emphasizes sustainable practices, energy-efficient designs, and robust infection control measures. It adheres to local and international standards, incorporating advanced mechanical and electrical systems, fire safety, and earthquake resilience to ensure a safe and sustainable healthcare environment.

Figure 02: Bird view of the National Nephrology Specialized Hospital project in Polonnaruwa

***Design Principles***

The NNSH design is guided by principles of functionality, economy, sustainability, and aesthetics. It employs energy-saving technologies and natural ventilation to reduce energy consumption. The layout,

featuring slab-type buildings with inner courtyards, enhances natural ventilation and daylighting. The use of local materials and traditional architectural elements ensures cultural relevance and sustainability.

### *Climate-Responsive Features*

The NNSH incorporates passive cooling techniques, including natural ventilation, shaded outdoor areas, and green spaces, to reduce heat absorption and energy use, thereby enhancing comfort and minimizing the environmental impact.

### *Disaster Resilience*

The hospital's design addresses natural disaster risks with elevated structures, concrete roofs, and robust drainage systems to maintain operations during adverse weather. It also includes seismic-resistant infrastructure to ensure safety.

### *Community Integration*

NNSH functions as a community hub, providing health education and outreach services. Multifunctional spaces support community meetings, health workshops, and public health initiatives, strengthening local engagement.

Figure 03: Accommodations area - National Nephrology Specialized Hospital Polonnaruwa - 2022

## The NHS New Hospital Programme (NHP) Experience

### *Introduction*

The NHS in England plans to modernize its aging infrastructure by building 40 new hospitals by 2030 through the NHP. This initiative aims to update hospital design and construction to meet innovative national standards and deliver high-quality healthcare.

### *Objectives of the NHP*

1. Delivering hospitals for less cost and less time by addressing critical infrastructure risks and improving value for money;
2. Ensuring new hospitals integrate innovative national standards for healthcare infrastructure;
3. Supporting the co-design and co-creation of schemes in collaboration with local and regional health systems;
4. Building the foundations for an enduring national capability for enhanced healthcare infrastructure delivery.

### *Hospital 2.0 Design*

Hospital 2.0 is a standardized design for future hospitals that incorporates digital solutions and optimized layouts to benefit patients and staff. This approach reduces development and construction time and costs through economies of scale.

### *Regulations and Codes of Practice*

The NHS Premises Assurance Model (PAM) and other regulations such as the Health and Safety at Work Act ensure that healthcare facilities are safe and meet national best practice standards. These frameworks guide the design, construction, and operation of healthcare buildings.

### *Health and Social Care Act 2008 & Regulations 2014*

This regulation ensures that care premises and equipment are clean, suitable, maintained, and properly used. Providers remain legally responsible even when delegating tasks to third parties, and must ensure compliance with the regulation, as any deficiencies remain their responsibility.

### *Climate Change Considerations*

The Climate Change Act 2008 mandates measures to mitigate and adapt to climate change impacts, such as energy efficiency and flood resilience. Hospitals are required to adopt sustainable practices to reduce their environmental footprint.

### *Building Information Modeling*

BIM is a critical tool in the NHP, facilitating the digital representation of buildings throughout their lifecycle. It enhances client visualization, improves design accuracy, and supports efficient maintenance and operations.

### *Modern Methods of Construction*

MMC involves offsite manufacturing and onsite techniques that offer alternatives to traditional construction methods. These methods improve productivity, efficiency, and quality while reducing greenhouse gas emissions.

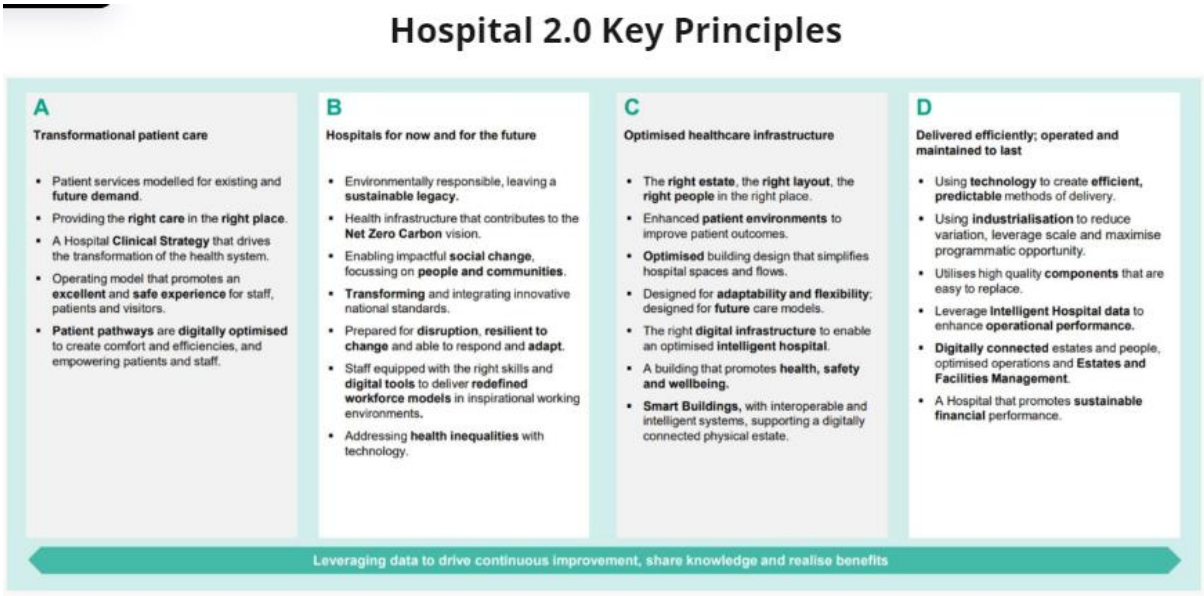


Figure 04: Hospital 2.0 Key Principles

## Discussion

### *Comparison: High Investment in Western Countries vs. LMICs*

Western countries, with their substantial investments in healthcare infrastructure, lead in adopting new technologies and sustainable practices in hospital design. In countries like the United States and the United Kingdom, significant financial resources are dedicated to constructing and renovating hospitals, incorporating state-of-the-art technologies and sustainable building practices.

In Western countries, BIM is extensively utilized in hospital design and construction, enabling precise planning, efficient

resource allocation, and effective collaboration among stakeholders [11].

Digital Twin Technology is increasingly adopted in Western healthcare facilities, providing a virtual replica of the hospital that allows for real-time monitoring and management of building systems, enhancing operational efficiency, reducing maintenance costs, and improving patient safety.

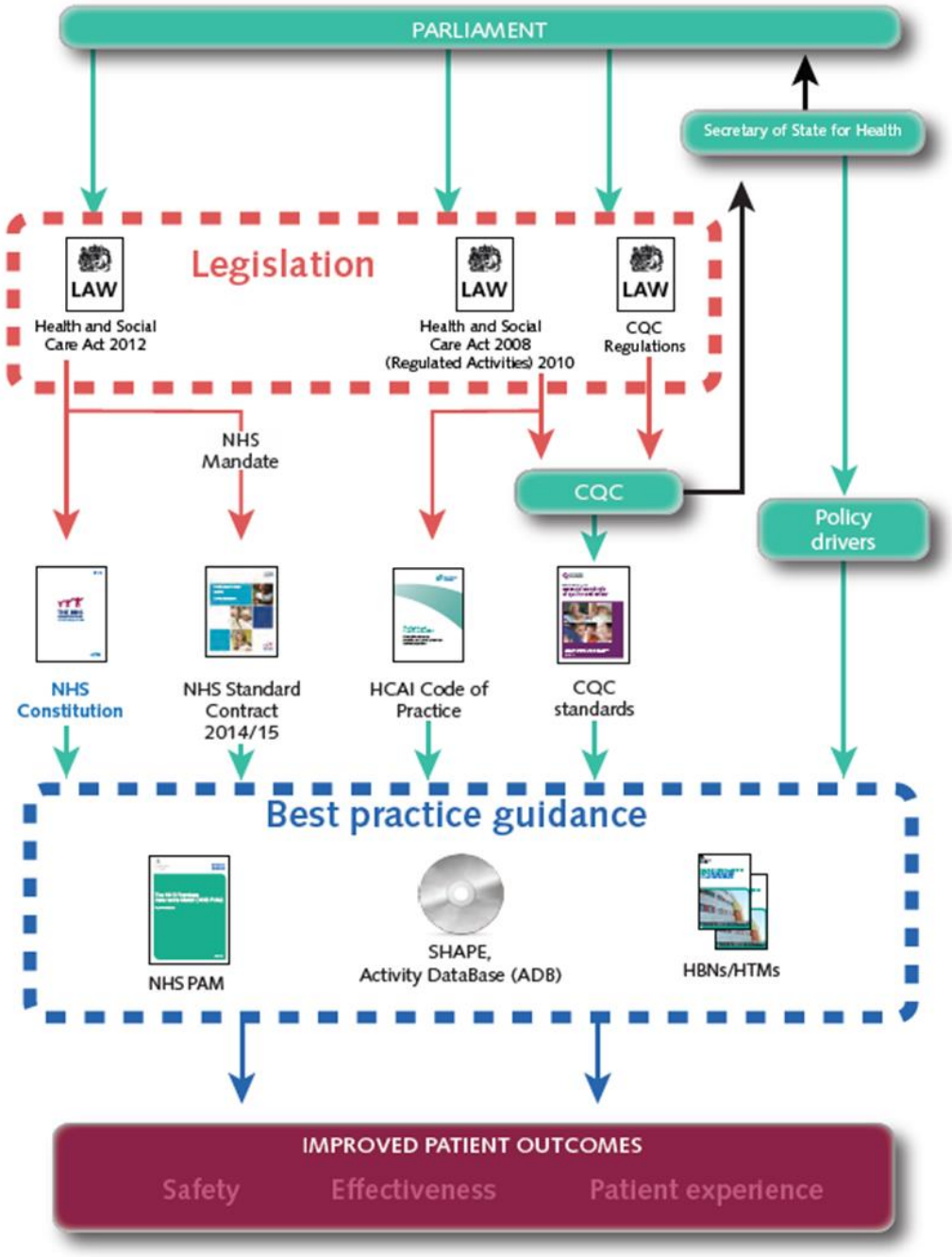


Figure 05: HBNs and Legislative Framework – NHS, UK

 

Hospitals in Western countries actively pursue NZC strategies to minimize their carbon footprint, involving the use of renewable energy sources, energy-efficient building designs, and carbon offset measures [12].

BREEAM certification ensures that hospitals meet high environmental performance standards, promoting sustainability and reducing operational costs [12].

### *Challenges in LMICs and Sri Lanka*

Sri Lanka's health system is recognized regionally and globally as a high-impact, low-cost model, built on the foundation of free healthcare since 1926 and advancing the Declaration of Alma-Ata in 1978. Despite commendable health outcomes that exceed its income level, Sri Lanka faces several challenges.

Cost Constraints: Financial limitations in LMICs often restrict the adoption of advanced technologies and sustainable practices. The high initial costs of implementing BIM, digital twin technology, and NZC strategies can be prohibitive.

Infrastructure Gaps: Inadequate infrastructure, such as unreliable power supply and poor internet connectivity, hinders the implementation of digital technologies in hospitals, affecting the efficiency and effectiveness of hospital operations.

Technical Expertise: The lack of technical expertise and trained professionals in LMICs poses a significant challenge. Training and capacity building are crucial for the successful adoption and implementation of advanced technologies and sustainable practices in hospital architecture.

## Conclusions

The evolution of hospital architecture reflects changes in medical practices, technology, and societal values. For LMICs like Sri Lanka, adaptable and sustainable designs are essential for improving healthcare delivery. The Sri Lankan healthcare system, recognized for its cost-effective and high-impact model, must address challenges such as financial constraints, infrastructure gaps, and a lack of technical expertise through strategic investments in training, infrastructure, and technology.

The National Nephrology Specialized Hospital, Polonnaruwa exemplifies the benefits of innovative hospital design. Additionally, insights from the NHS New Hospital Programme highlight the importance of integrating digital solutions, standardized designs, and sustainable practices. These lessons are pivotal for developing resilient healthcare infrastructures in Sri Lanka and other LMICs, promoting improved health outcomes and operational efficiencies.

## Recommendations

1. Digital Transformation: Integrate advanced digital technologies, including Building Information Modeling (BIM), electronic health records (EHRs), and telemedicine, to enhance healthcare delivery and operational efficiency.
2. Net Zero Carbon Strategies: Implement energy-efficient designs, utilize renewable energy sources, and adopt carbon offset measures to minimize the environmental impact of healthcare facilities.

3. Green and Sustainable Practices: Use sustainable materials, implement waste reduction practices, and design climate-responsive buildings to improve the sustainability of hospital infrastructure.
4. Infection Control and Safety: Design healthcare facilities with robust infection control measures, safety protocols, and high-quality care standards to ensure patient safety and exceptional care.
5. Patient Privacy and Comfort: Integrate design elements that prioritize patient privacy, comfort, and dignity, creating a healing environment.
6. Standardized Guidelines: Implement guidelines resembling the UK's Hospital 2.0 Design, Health Building Notes (HBN), and Health Technical Memoranda (HTM) to ensure safety, privacy, dignity, and cost-effective planning in healthcare facilities.
7. Legislative Framework: Establish clear, enforceable standards for healthcare facilities and equipment maintenance, ensuring providers remain legally responsible for compliance, even when outsourcing tasks to third parties.

## References


1. Mending Bodies, Saving Souls: A History of Hospitals, Guenter B. Risse: April 1999: Oxford University Press: Vol 1: 1-752
2. The Ospedale degli Innocenti and the Bambino of the American Academy of Pediatrics: Lawrence Kahn, MD Pediatrics: July 2002: 110 (1): 175–180 https://doi.org/10.1542/peds.110.1.192
3. Evidence-based medicine and hospital reform: Tracing origins back to Florence Nightingale: Maya Aravind, BA and Kevin C. Chung, MD: doi:10.1097/PRS.0b013e3181c2bb89: available in PMC 2015 Apr 6.
4. Historia hospitalium: Murken, Axel Hinrich, Deutsche Gesellschaft für Krankenhausgeschichte: 1975, 65-71.
5. Evolution of medical architecture: Nadezhda Tesler: 2018 https://doi.org/10.1051/matecconf/201817003015
6. Studies on Indian medical history / edited by G. Jan Meulenbeld and Dominik Wujastyk: Delhi: 2001
7. Effects of healthcare environmental design on medical outcomes: The Role of the Physical Environment in the Hospital of the 21st Century. California: Ulrich RS: Center for Health Design; 2008
8. Re-engineering through pre-assembly: client expectations and drivers: Gibb, Alistair G.F.; Isack, Frank (2003) Loughborough University. Journal contribution. https://hdl.handle.net/2134/9018
9. Green building costs and financial benefits: Kats G. Massachusetts Technology Collaborative: 2003. https://www.wbdg.org/files/pdfs/green_bldg_costs_kats.pdf. [Accessed on 10th June 2024].
10. A roadmap for the adoption of e-health: Dixon BE: e-Service Journal 5(3):3-13. July 2007. DOI: 10.1353/esj.2008.0001.
11. Building Information Modeling (BIM) for existing buildings—Literature review and future needs: Volk R, Stengel J, Schultmann F. Autom Constr. 2014; 38:109-27.
12. NHS Net Zero Building Standard, A greener NHS Estates: NHS England 2022, (1 – 141)
13. Digital Transformation in the NHS, National Audit office, 15 May 2020, (1 - 53)


 

14. Sustainable hospital development: https://bioinquirer.org/ Sri Lanka, Upendra Randeniya: 2023
15. Renewable energy and sustainable construction in Sri Lanka: Renewable energy: Current research and future scope. Jayasinghe MTR, Attalage RA. New Delhi: The Energy and Resources Institute; 2011. p. 204-25.
16. Vernacular architecture and traditional building forms of Sri Lanka: Sustainability in Energy and Buildings: Manawadu L. New York: Springer; 2000. p. 59-72.
17. Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions. In: Measuring vulnerability to natural hazards: towards disaster resilient societies: Birkmann J. Tokyo: United Nations University Press; 2006.p.9-54. https://collections.unu.edu/eserv/UNU:2880/n9789280812022_text.pdf. [Accessed on 8th June 2024].
18. Journal of Burn Care & Research, Patricia Blakeney, DPh, James Partridge, OBE, DSc, Nichola Rumsey, DPh, Volume 28, Issue 4, July-August 2007, Pages 598-601, https://doi.org/10.1097/BCR.0B013E318093E493 Community Integration Published: 01 July 2007
19. Health Building Note 00-01: General design principles: Health Building Note 00-09: Infection Control in the built Environment, Crown copyright 2013 First published 2002. [Accessed on 06th May 2024]
20. Development Design Description: Project of National Nephrology Specialized Hospital in Polonnaruwa, Sri Lanka, Beijing Institute of Architectural Design, 2017

 