MEDICAL RESEARCH

Review Article

Influence of the Architectural Design of Hospital Spaces on Newborns

Jorge Pablo Aguilar-Zavaleta

Faculty of Engineering and Architecture, Professional School of Architecture, César Vallejo University, Peru

***Corresponding author:**

Jorge Pablo Aguilar-Zavaleta

Faculty of Engineering and Architecture, Professional School of Architecture, César Vallejo University, Peru, Email: ejoaguilarz@ucvvirtual.edu.pe

Received : February 03, 2026

Published : August 25, 2026

ABSTRACT

The architectural design of hospital environments has a quantifiable impact on neonatal health, merging scientific evidence with spatial innovation. Recent studies reveal that single-family-room (SFR) neonatal intensive care units (NICUs) reduce nosocomial infections by 50% compared to open-plan designs, optimizing the safety of premature newborns, who represent 10% of global births. This configuration, supported by evidence-based design (EBD) principles, also increases breastfeeding rates by 25% and decreases hospital stays by 15%. Strategically integrated natural light regulates circadian rhythms in 80% of premature neonates, improving neurological development, while noise levels below 45 dB, achieved through acoustic ceilings, reduce parental stress by 30%. Historically, the transition from centralized nurseries to family-centered spaces reflects a paradigm focused on psychoemotional wellbeing. However, challenges persist: 60% of hospitals in low- and middle-income countries face budget constraints in implementing SFR designs, despite their long-term cost-effectiveness. Future trends emphasize "healing architecture," incorporating antimicrobial biomaterials and intelligent environmental-monitoring systems, projecting a 20% reduction in costs associated with neonatal complications. By integrating nature, technology, and family involvement, hospital design emerges not only as a physical framework but as a catalyst for holistic health, redefining the future of neonatal care.

Keywords: Architectural Design, Construction, Hospital Spaces, Newborns

INTRODUCTION

The architectural design of hospital spaces, particularly those serving newborns, sits at the intersection of the built environment and health outcomes. As hospitals evolve to better support patient recovery, growing evidence links specific design elements, spatial configuration, lighting, acoustics, and color, to the wellbeing of infants and their families, with direct implications for neonatal intensive care units (NICUs) and related facilities [1,2].

ISSN: 2689-8365

Hospital design has undergone a marked transformation since the nineteenth century. Foundational principles proposed by Florence Nightingale in the 1860s emphasized cleanliness and natural light as drivers of recovery, laying the groundwork for the more systematic, evidence-based approaches that emerged in the mid-twentieth century [1]. Wartime shortages during the Second World War pushed hospitals toward standardized, operations-research-informed layouts, exemplified by the Greater Baltimore Medical Center's traffic-pattern studies, reinforcing a broader shift toward data-driven design [1]. Within obstetric and neonatal care specifically, this evolution moved units away from sterile, centralized nurseries that limited parental contact and toward single-family-room NICUs that support breastfeeding, kangaroo care, and family bonding [2,3]. The formalization of evidence-based design (EBD) as a methodology, popularized by Roger Ulrich's 1984 study linking views of nature to faster recovery, provided the empirical foundation on which contemporary NICU design now rests [1].

This progress is not without tension. Debates persist over the balance between cost and design quality, the risk that single-family rooms may inadvertently isolate families, and the practical difficulty of integrating nature and positive distraction into clinical settings. Critics point to budget constraints that limit ideal implementations, while advocates argue that the long-term benefits of investing in healing environments outweigh upfront costs [2,4,5].

Building on this historical trajectory, the present article synthesizes current evidence on how architectural design shapes neonatal outcomes and family experience, with three aims: (1) to identify the key architectural elements shown to affect neonatal and family wellbeing, (2) to examine the empirical evidence linking these elements to clinical and psychosocial outcomes, and (3) to situate these findings within the trends expected to shape NICU design over the next decade. The article is organized accordingly: Section 2 outlines the architectural elements considered; Section 3 presents the evidence on their impact on newborn health; Section 4 discusses design guidelines, implementation challenges, and future trends; and Section 5 offers concluding recommendations for healthcare planners and architects.

Figure 1 illustrates this contrast: traditional open-bay NICUs concentrate multiple newborns in a shared space with greater noise, staff traffic, and cross-infection risk, whereas single-family-room NICUs support acoustic control, natural lighting, privacy, and the continuous presence of parents. According to WHO data (2023), premature births account for roughly 10% of births worldwide, underscoring the stakes of this design choice.

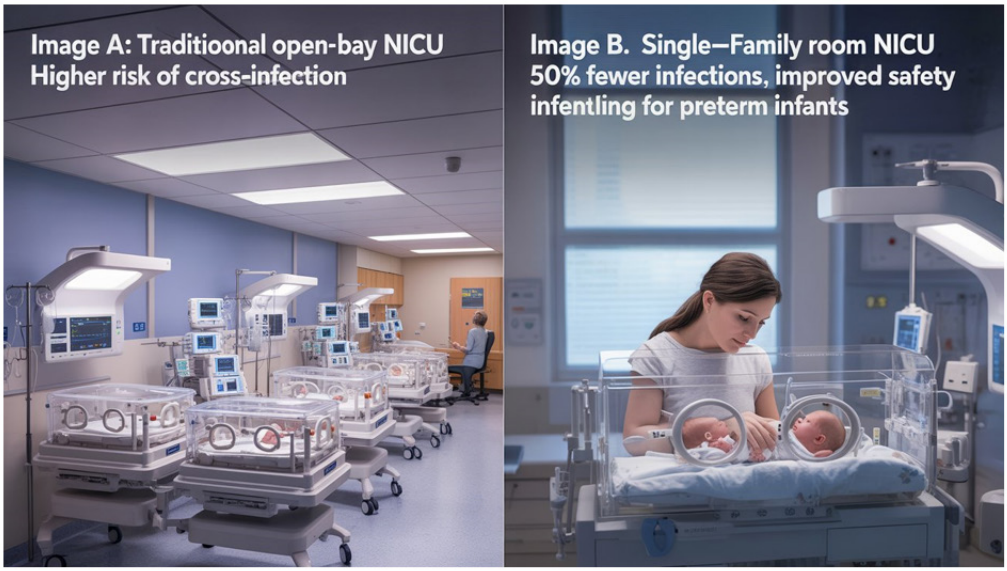

Figure 1: NICU architectural comparison: open design vs. single-family rooms

DOI: https://doi.org/10.35702/mrj.10016

ISSN: 2689-8365

METHODS

This article synthesizes peer-reviewed and professional-practice literature on NICU architecture, organized around five architectural elements most consistently associated with neonatal and family outcomes in the sources reviewed: color and light, acoustics, spatial configuration, safety and security, and flexibility.

Color and Light

Color plays a documented role in patient comfort and outcomes: softer, restful tones in patient rooms create a therapeutic environment, while more vibrant colors in public spaces can stimulate a positive atmosphere [1]. Access to natural daylight is equally important, with demonstrated effects on the wellbeing of patients in NICUs specifically [2].

Acoustic Considerations

Environmental noise in NICUs can adversely affect both newborns and families, increasing stress and impairing developmental outcomes. Acoustic ceiling tiles and strategic layout planning have produced measurable reductions in decibel levels, improving the overall healing environment [2].

Spatial Configuration

The choice between single-family-room (SFR) units and open-bay layouts is central to NICU design. SFRs improve privacy, infection control, and family presence during care, though they raise concerns about potential isolation and higher operational costs [2].

Safety and Security

Controlled access points, intuitive wayfinding, and secure outdoor areas contribute to a reassuring environment. Advanced safety protocols, including access and threat-detection systems, must be integrated without compromising the healing atmosphere essential to recovery [4].

Flexibility and Adaptability

Modular building forms and local material sourcing support both ecological sustainability and the capacity of a facility to adapt to changing clinical requirements over time [9].

RESULTS

Advances in evidence-based neonatal care have improved survival rates for high-risk newborns, underscoring the role of the physical environment in supporting their health and development [10]. The subsections below present the evidence linking the elements identified in Section 2 to specific clinical and psychosocial outcomes.

Family-Centered Care

Family-centered care has emerged as a central organizing principle for NICU design. Minimizing noxious stimuli while providing positive sensory input is essential for preterm infant development, and parental presence measurably mitigates stress in both infants and families. Realizing this principle in practice, however, remains inconsistent: a multi-hospital study found that despite widespread intent to adopt family-centered practices, few centers effectively integrated families as full members of the care team, pointing to a gap between design intent and operational reality [2].

Infection Prevention and Control

Infection control remains critical in NICUs, where vulnerable infants face heightened risk of hospital-acquired infections. Locating handwashing stations close to infant beds measurably reduces infection rates, and single-room designs have been shown to halve the incidence of nosocomial infections relative to open-bay units, directly linking architectural configuration to clinical safety [5].

Environmental Factors

Lighting and noise conditions further shape neonatal outcomes. Optimal lighting supports circadian-rhythm development in preterm infants, a factor essential to healthy growth, while single-room configurations are associated with higher parental satisfaction and, in turn, greater capacity for emotional engagement with infants [11-18].

Cost of Care Considerations

These clinical gains carry economic implications. As mortality and morbidity among very-low-birth-weight infants have declined, longer hospital stays have driven up the direct costs of care; design strategies that reduce infection rates and shorten hospitalization can offset some of this cost growth from a health-system perspective, distinct from the upfront construction costs discussed in Section 4 [11].

ISSN: 2689-8365

Table 1: Architectural comparison: neonatal spaces A *vs*. B

Architectural Aspects	Image A – Standard Environment	Image B – Optimized Environment
Lighting	Homogeneous artificial lighting (fluorescent or LED without circadian control).	Regulated natural light (high windows, skylights) promotes circadian rhythm in 80% of premature newborns.
Acoustic Treatment	No sound absorption; noise levels above 60 dB (risk of sensory overstimulation).	Acoustic ceilings and sound-absorbing materials; sound level <45 dB, reducing parental stress by 30%.
Privacy and Family Connection	Shared space with little privacy; limited interaction between parents and newborns.	Single or semi-single room; greater privacy and the possibility of continuous kangaroo care.
Emotional and Visual Environment	Cold environments, saturated with technical stimuli; limited personalization.	Biophilic design and environmental control; a warm atmosphere that promotes containment and bonding.
Documented Clinical Impact	Higher incidence of nosocomial infections and environmental stress.	Decreased infections, improved neurodevelopment, and improved vital signs in premature infants.

Figure 2: Architectural comparison between standard neonatal environments and those optimized for circadian and sensory development

Taken together, these findings show a consistent pattern: architectural choices around family presence, infection control, and environmental regulation translate into measurable clinical and economic benefits. The next section considers how these findings translate into design guidance, the practical challenges of implementation, and the trends likely to shape NICU architecture going forward.

DISCUSSION

The following subsections translate the evidence presented in Section 3 into practical design guidance, examine the tensions that complicate implementation, and consider how these findings are likely to evolve as new trends reshape NICU architecture.

Design Guidelines, Standards, and the Implementation Gap

Effective NICU design begins with spatial allocation: guidelines call for maximizing usable space for patients, families, and staff while minimizing unnecessary circulation area, ensuring room for equipment alongside family privacy [2]. A systematic review of NICU design features found that optimizing architectural design can improve breastfeeding rates, strengthen infection control, and shorten hospitalization duration, with the single-family-room model consistently identified as the most effective configuration for noise control and infection prevention [12]. The Consensus Committee to Establish Recommended Standards for Newborn ICU Design

ISSN: 2689-8365

(2002) translates these findings into a comprehensive set of benchmarks covering spatial configuration, lighting, noise control, and the integration of family spaces, and remains a key reference point for contemporary projects [2]. Translating these standards into practice, however, requires more than compliance with physical specifications: as the family-centered care findings in Section 3 suggest, few hospitals have fully integrated families as members of the care team, and design processes that actively involve the perspectives of children and families, though logistically challenging, are essential to closing this gap [13].

Balancing Safety, Nature, and Family Accommodation

Beyond the core elements outlined in Section 2, several design tensions recur across the literature reviewed. Security measures, controlled access, wayfinding, and, where warranted, threat-detection systems, must be layered into the environment without eroding the sense of comfort central to healing spaces, calling for careful integration rather than the visibly institutional security aesthetics common in general hospital settings [3,14]. Incorporating nature through windows, skylights, and views of the outdoors is consistently associated with reduced stress, improved outcomes, and the aesthetic appeal that supports emotional wellbeing for patients and families, though it remains difficult to reconcile with the tight footprints and infection-control constraints typical of NICUs [8,13,15]. Family accommodation raises a related tension: supporting overnight stays through comfortable seating and dedicated amenities is essential to sustaining the parental presence identified in Section 3 as a driver of better outcomes, yet it competes for space with clinical needs [8,13]. Positive distraction, murals, engaging flooring, playful lighting, and age-appropriate customization for the wider pediatric population extend this logic, softening a clinical environment for children of different developmental stages without compromising its functional requirements [3,4]. Across these tensions, the common challenge is the same: reconciling clinical and safety imperatives with the psychosocial benefits of a less institutional environment.

Cost and Resource Constraints

Beyond the health-system cost dynamics discussed in Section 3, upfront construction costs and ongoing operational expenses remain a primary barrier to implementing single-family-room designs: roughly 60% of hospitals in low- and middle-income countries report budget constraints limiting adoption despite its long-term cost-effectiveness. Regulatory requirements and material availability further shape these costs, making careful planning and phased implementation essential to capture the long-term clinical and economic benefits identified above without inducing financial strain [2].

Future Trends in NICU Design

Looking ahead, four developments are likely to shape the next generation of NICU design. First, "healing architecture," a concept popularized by Ulrich's 1984 work, is expanding beyond natural light and calming aesthetics toward antimicrobial biomaterials and intelligent systems that monitor environmental variables in real time [17]. Second, sustainability considerations are pushing hospitals toward eco-friendly materials, energy-efficient systems, and flexible infrastructure suited to local building practices, a shift with particular relevance for facilities in low- and middle-income countries balancing cost, climate resilience, and clinical standards [6]. Third, technology integration, automated monitoring, workflow optimization, and bacteria-resistant surfaces, is expected to become standard rather than exceptional, extending the infection-control gains documented in Section 3 [7]. Fourth, hospitals are increasingly incorporating communal spaces for patients, families, and staff, reflecting a growing recognition that neonatal care is a social and emotional undertaking as much as a clinical one [9,18].

Collectively, these trends extend the historical arc traced in Section 1, from Nightingale's emphasis on cleanliness and light, to today's evidence-based, family-centered NICU, toward environments that are not only safer and more efficient but actively therapeutic.

CONCLUSIONS

The evidence reviewed here supports five main conclusions. First, architectural design is not a peripheral consideration in neonatal care but a measurable determinant of clinical outcomes: single-family-room NICUs are associated with fewer nosocomial infections, higher breastfeeding rates, and shorter hospital stays relative to open-bay designs. Second, these clinical gains are inseparable from family-centered care; environments that sustain parental presence and involvement consistently outperform those that do not, even where formal adoption of family-centered practice lags behind design intent. Third, environmental regulation, natural light, acoustic control, and biophilic elements, functions as a comparatively low-cost, high-impact lever for improving

DOI: https://doi.org/10.35702/mrj.10016

ISSN: 2689-8365

both neonatal neurodevelopment and parental wellbeing, and should be prioritized even where budget constraints limit more extensive renovation. Fourth, cost remains the central barrier to wider adoption of evidence-based NICU design, particularly in low- and middle-income countries, making phased implementation and context-sensitive standards, rather than a single universal model, a more realistic path forward. Fifth, the emerging generation of NICU design, incorporating antimicrobial biomaterials, real-time environmental monitoring, and sustainable infrastructure, extends rather than replaces the historical trajectory traced in Section 1: from Nightingale's emphasis on cleanliness and light, through the formalization of evidence-based design, to today's family-centered, technologically enabled NICU. For healthcare planners and architects, the implication is direct: hospital design for newborns should be treated as a clinical intervention in its own right, one whose costs and benefits merit the same rigor applied to other elements of neonatal care.

REFERENCES

1. Kisacky J. (2024). When Designs Became Interventions in Hospitals. AMA Journal of Ethics. 26(12):E948-962.
2. Felipe BL. (2001). New trends in health architecture for children and the effects of the built environment on young patients.
3. Pinegar J. (2024). Designing Children's Hospitals for Better Health Outcomes. VCBO Architecture.
4. Impact of Single Family NICU Rooms. The Center for Health Design.
5. Zabloudil B. (2025). Building Hope: Key Considerations for Pediatric Healthcare Design.
6. Caira C, Orstadius A, Berg M. (2018). Concept design for a new mother and baby unit at Panzi Hospital, Bukavu, DR Congo. SALUS.
7. Yu S, Lui K, Fiebig DG, Travadi J, Homer CS, Sinclair L, et al. (2025). The impact of neonatal care on moderate-risk infants: Evidence from healthcare use in the first two years of life. Journal Of Health Economics. 102:102995.
8. Design of Neonatal Intensive Care Units - Obgyn Key.
9. O'Callaghan N, Dee A, Philip RK. (2019). Evidence-based design for neonatal units: a systematic review. Maternal health, neonatology and perinatology. 5:6.
10. Nilsson C, Wijk H, Höglund L, Sjöblom H, Hessman E, Berg M. (2020). Effects of Birthing Room Design on Maternal and Neonate Outcomes: A Systematic Review. HERD. 13(3):198-214.
11. Design Principles - Institute for Healthcare Improvement.
12. (2019). Designing for wellbeing in children's hospitals – Pursuit.
13. (2026). How HOK Is Influencing the Future of Pediatric Healthcare Design.
14. (2017). Designing Memorable Experiences in Women & Infant Care - HDR.
15. (2022). The healing power of design in neonatal care - Silentia Screen.
16. (2024). Designing Healthcare Spaces to Transform Quality of Care.
17. (2018). Hospital Architecture Design & Planning: Promoting Patient Safety. HMC Architects.
18. Growth & Expansion: A hospital designed for women and infants.