



Linking Evidence and Spatial Configuration: A Typological Review and Analysis of Neonatal Intensive Care Unit (NICU) Design

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1. Objectives
2. Systematic Literature Review
3. Spatial Configuration Analysis
4. Discussion and Conclusion

AGENDA



OBJECTIVES



RESEARCH OBJECTIVES

- To systematically review empirical literature on NICU patient rooms, staff spaces, and ancillary areas to identify documented design outcomes across common spatial models.
- To establish an Evidence-Based Design (EBD) framework for NICU environments by systematically synthesizing and categorizing documented performance outcomes (e.g., clinical, behavioral, staff experience) reported in the literature across defined spatial categories: patient rooms, nurse stations, and ancillary support areas.
- To analyze the spatial configurations of NICU case studies using Space Syntax depth maps and J-graphs to quantify the predicted functional performance of different typologies.
- To develop comparative diagrams that visually link the EBD framework with measured spatial metrics, creating a practical design support tool for NICU planning.



PHASE 1.

SYSTEMATIC LITERATURE REVIEW



SYSTEMATIC LITERATURE REVIEW

Focusing on three categories of NICU spaces: patient rooms, staff spaces, and ancillary areas. The identified literature was analyzed and categorized based on reported design outcomes.

The literature review identified distinct performance profiles for each spatial category. An evidence-based design (EBD) framework for NICU environments was established based on these findings, while also highlighting a lack of sufficient research for several emerging or hybrid NICU layouts

Outcome	Study	Nurse Stations				Notes
		Centralized	Decentralized	Decentralized+Huddle	Hybrid	
Communication	Gurascio-Howard & Baseline	Baseline	increased	NA	NA	
	Zborowsky et al. (2015)	Baseline	decreased	NA	NA	
	Zhang et al. (2015)	Baseline	NA	NA	no change	
Teamwork	Fay et al. (2022)	Baseline	decreased	NA	NA	
	Pati et al. (2015)	Baseline	decreased	NA	NA	
	*Zhang et al. (2015)	Baseline	NA	NA	decreased	
Satisfaction	*Fay et al. (2022)	Baseline	increased	NA	NA	
Time at Nurse station	*Pati et al. (2015)	Baseline	decreased	NA	NA	



SYSTEMATIC LITERATURE REVIEW

SPACE	Patient Room				
LAYOUT	SFR	Open Bay	SFRN	Couplet Care	Dual Ocuupancy
OUTCOME	Infection Control	Length of Stay	Acoustics	Parent Satisfaction	...
SPACE	Nurse Station				
LAYOUT	Centralized	DNS	DNS+Huddle	Hybrid	Mixed
OUTCOME	Patient Outcome/Safety	Patient Satisfaction	Visibility	Stress and Well-being	...



PHASE 2.

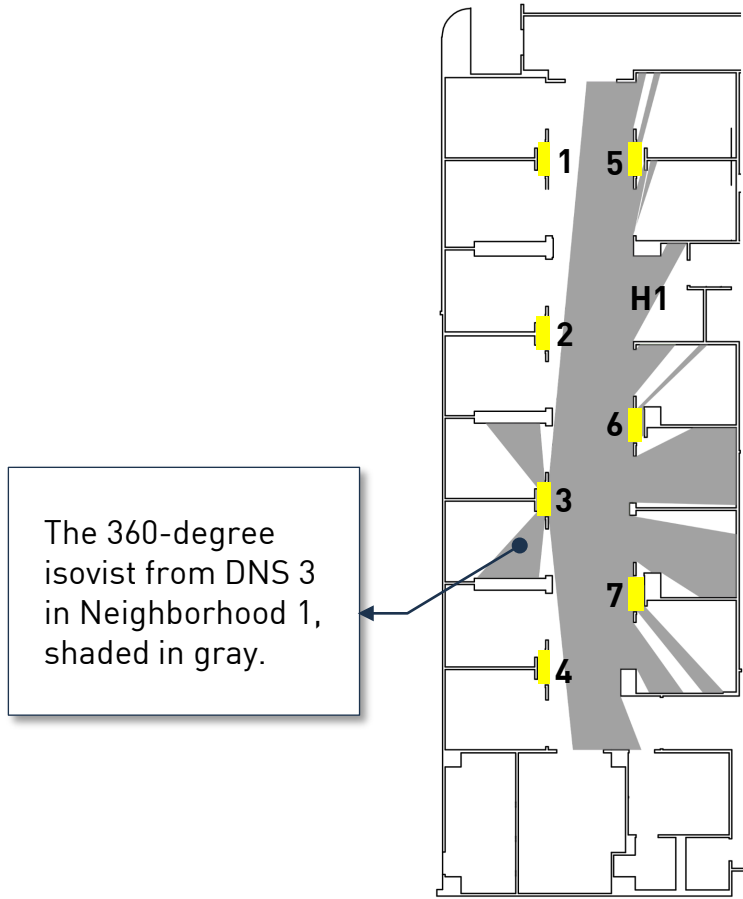
SPATIAL CONFIGURATION ANALYSIS



SFR | NEIGHBORHOOD DNS | HUDDLE

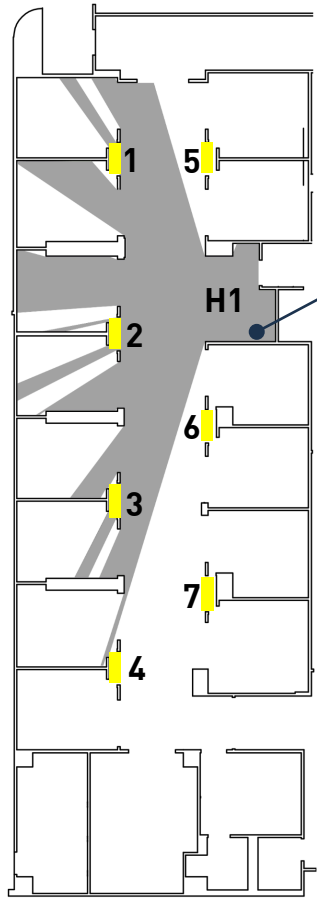


SFR | NEIGHBORHOOD DNS | HUDDLE



The 360-degree isovist from DNS 3 in Neighborhood 1, shaded in gray.

Neighborhood 1
DNS 3



The 360-degree isovist from the staff desk of the Huddle Station in Neighborhood 1, shaded in gray.

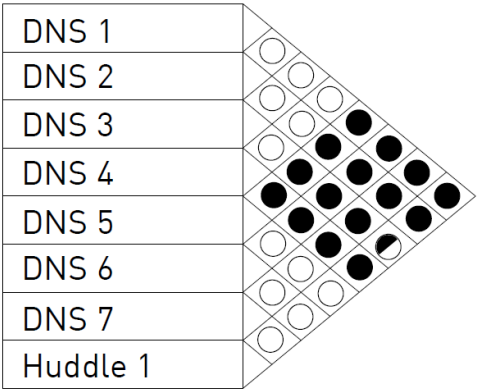
Neighborhood 1
Huddle Station (H1)

Mutual Visibility Score Calculation

Workstations visible to DNS 3 include DNS 5, DNS 6, and DNS 7. Workstations visible to Huddle Station include DNS 1, DNS 2, and DNS 3. Since the visibility between DNS 3 and Huddle Station was one-directional, the mutual visibility score was calculated as 0.5.

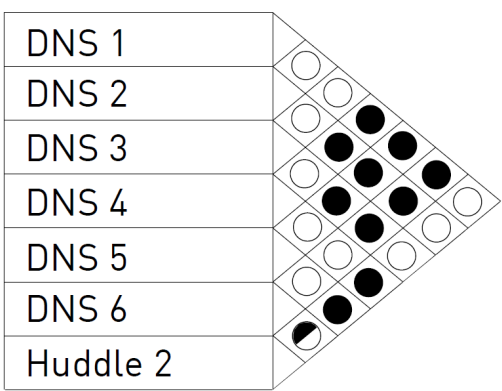


SFR | NEIGHBORHOOD DNS | HUDDLE



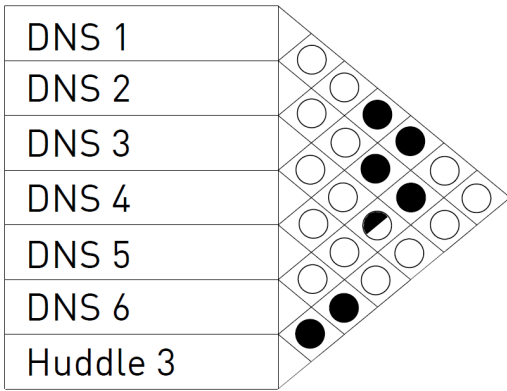
Neighborhood 1

DNS-to-DNS Mutual Visibility: 12 (57%)
DNS-Huddle Mutual Visibility: 3.5



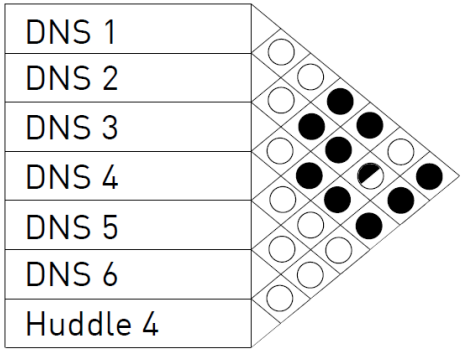
Neighborhood 2

DNS-to-DNS Mutual Visibility : 8 (53%)
DNS-Huddle Mutual Visibility : 2.5



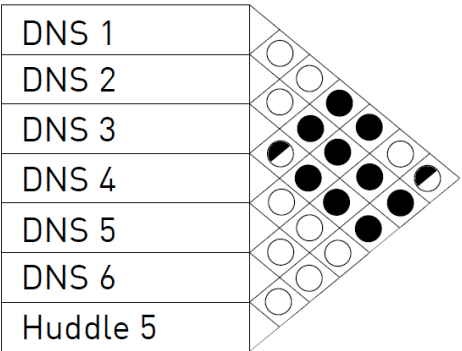
Neighborhood 3

DNS-to-DNS Mutual Visibility : 4.5 (30%)
DNS-Huddle Mutual Visibility : 2



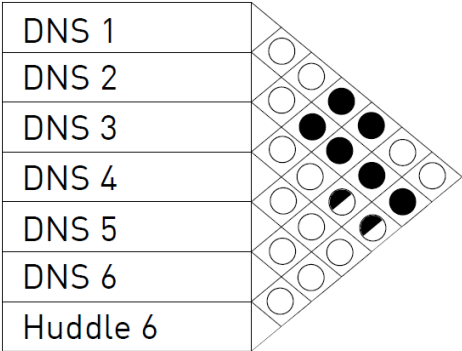
Neighborhood 4

DNS-to-DNS Mutual Visibility : 6.5 (43%)
DNS-Huddle Mutual Visibility : 3



Neighborhood 5

DNS-to-DNS Mutual Visibility : 7.5 (50%)
DNS-Huddle Mutual Visibility : 2.5



Neighborhood 6

DNS-to-DNS Mutual Visibility : 5.5 (37%)
DNS-Huddle Mutual Visibility : 1.5

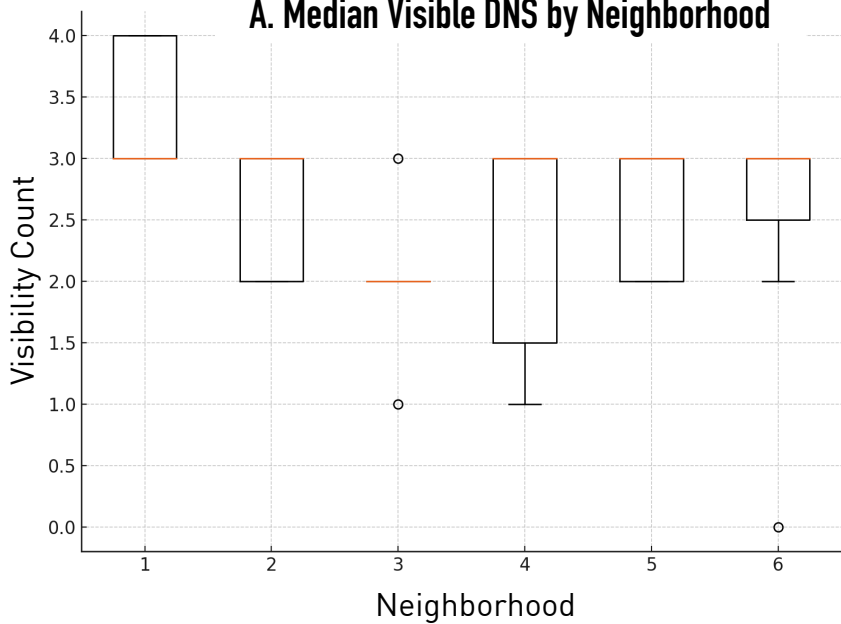
DNS-to-DNS and DNS-Huddle Mutual Visibility

- Indicates a pair of mutually visible relationship between two workstations (i.e., DNS-to-DNS or DNS-Huddle), and the mutual visibility score was registered as 1.0
- ◐ Indicates one directional visibility between two workstations, with mutual visibility score registered as 0.5

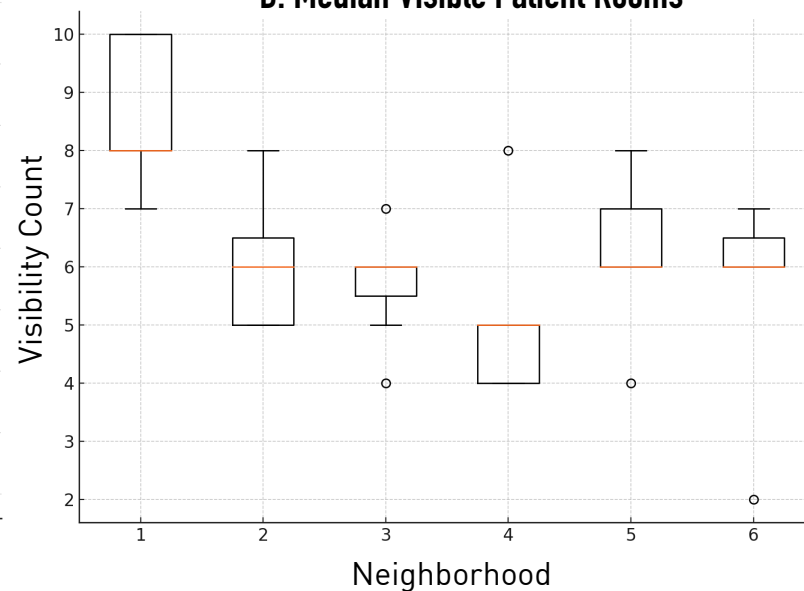


SFR | NEIGHBORHOOD DNS | HUDDLE

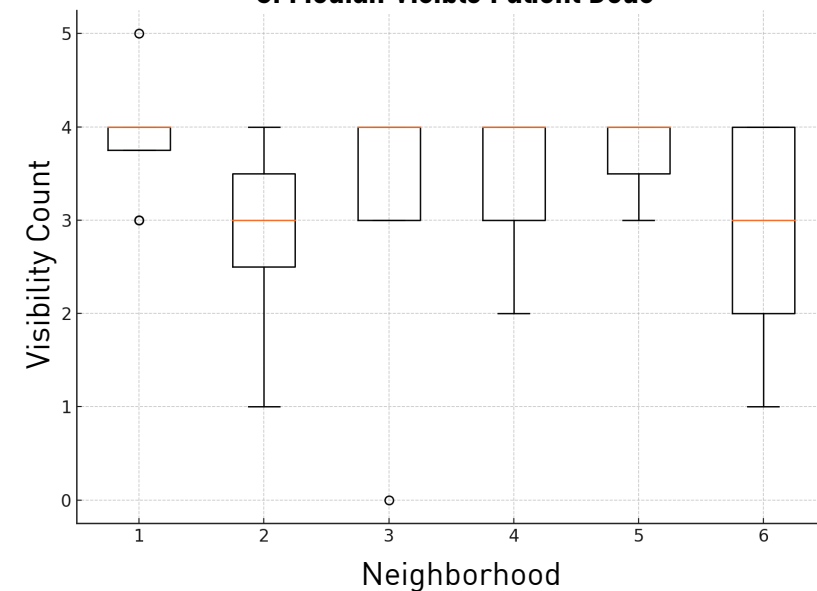
A. Median Visible DNS by Neighborhood



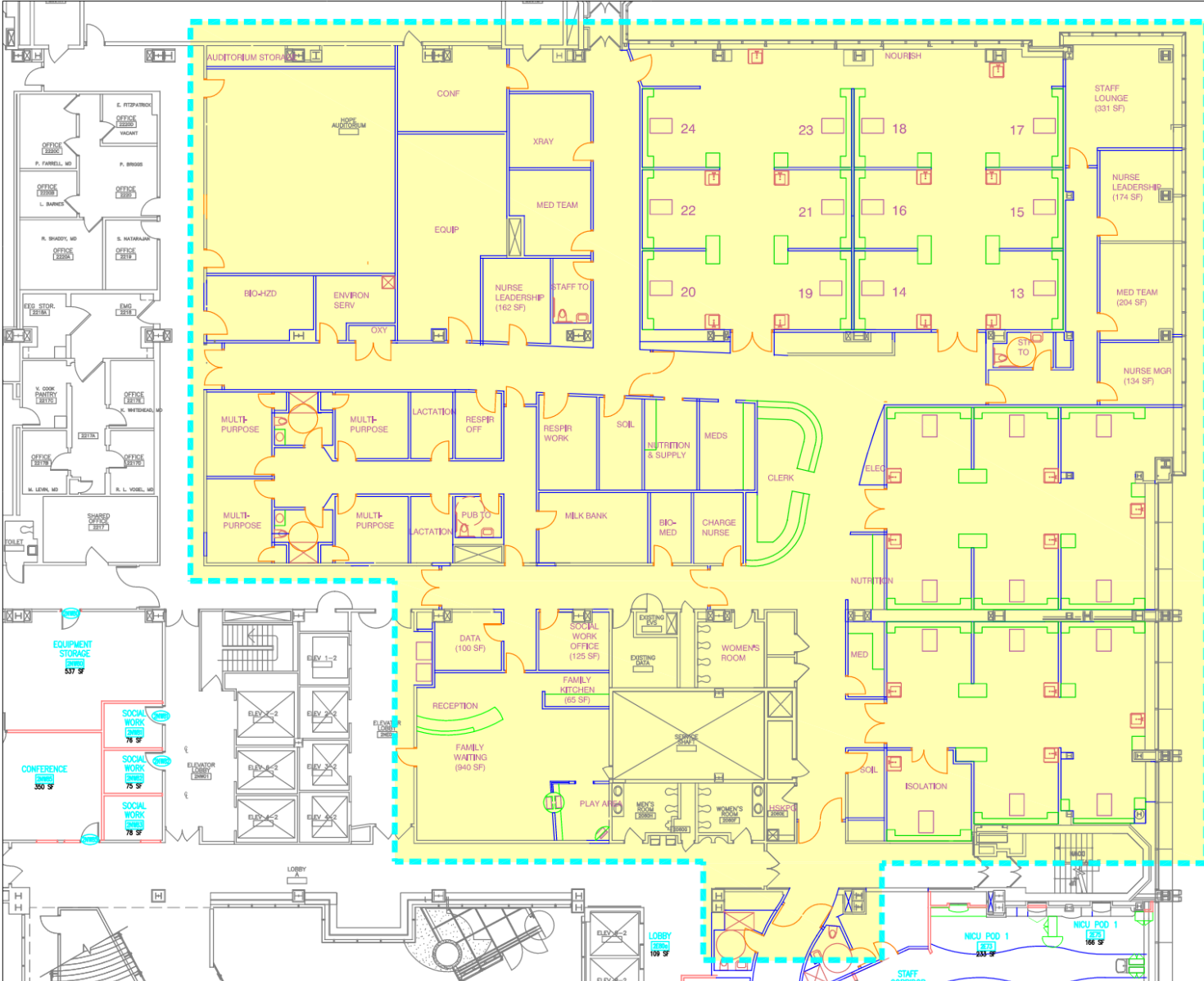
B. Median Visible Patient Rooms



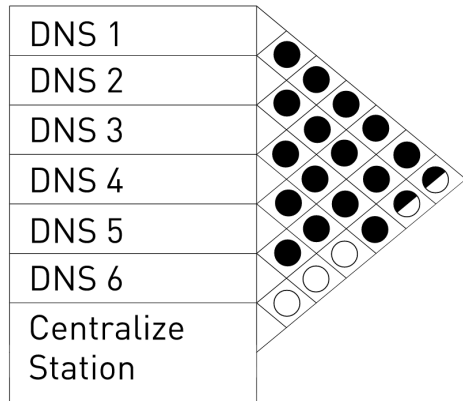
C. Median Visible Patient Beds



OPEN BAY | DNS | CENTRALIZED NURSE STATION

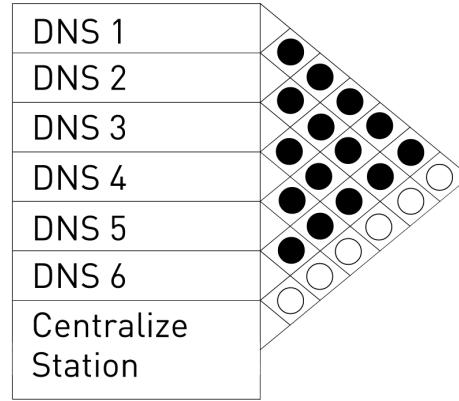


OPEN BAY | DNS | CENTRALIZED NURSE STATION



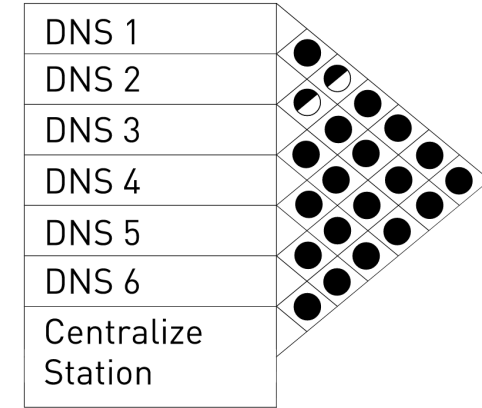
Bay 1

DNS-to-DNS Mutual Visibility: 15 (100%)
DNS-Centralize Station Mutual Visibility: 2



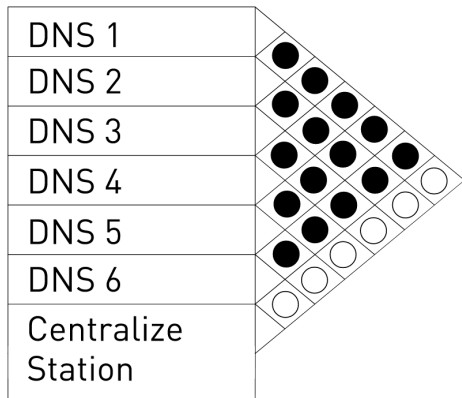
Bay 2

DNS-to-DNS Mutual Visibility: 15 (100%)
DNS-Centralize Station Mutual Visibility: 0



Bay 3

DNS-to-DNS Mutual Visibility: 14 (93.33%)
DNS-Centralize Station Mutual Visibility: 6



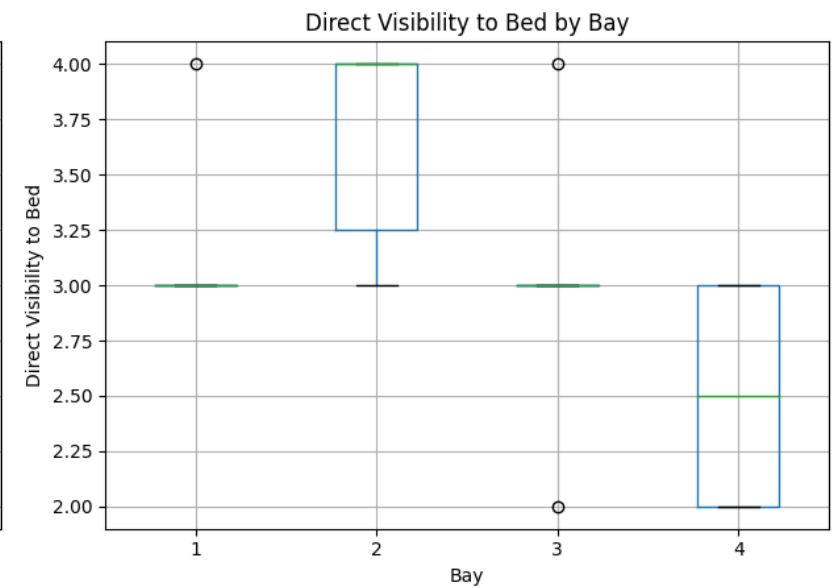
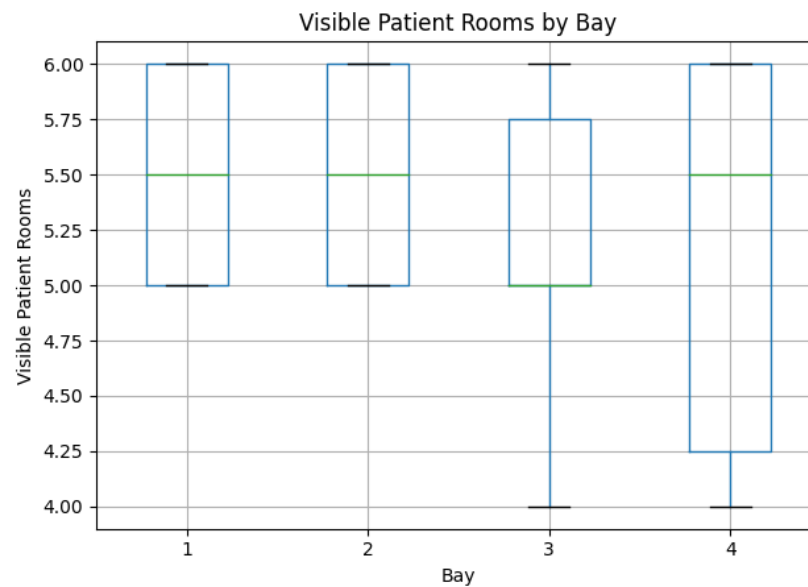
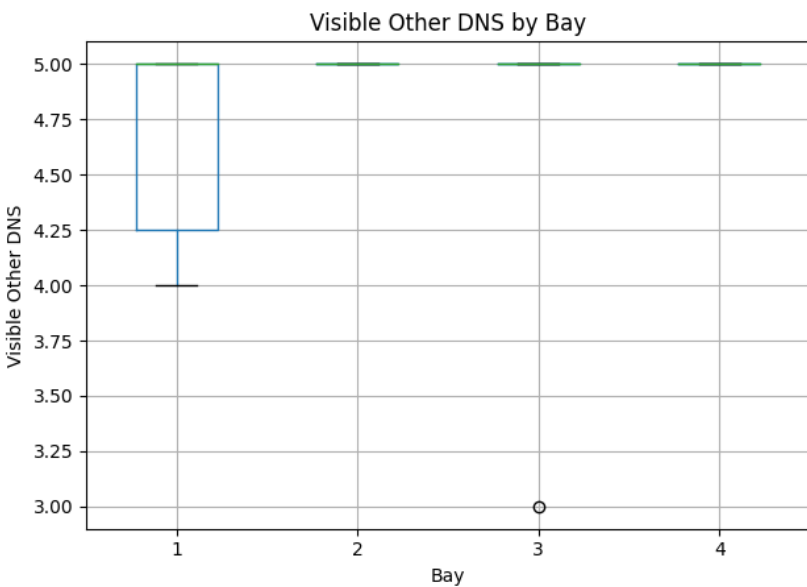
Bay 4

DNS-to-DNS Mutual Visibility: 15 (100%)
DNS-Centralize Station Mutual Visibility: 0

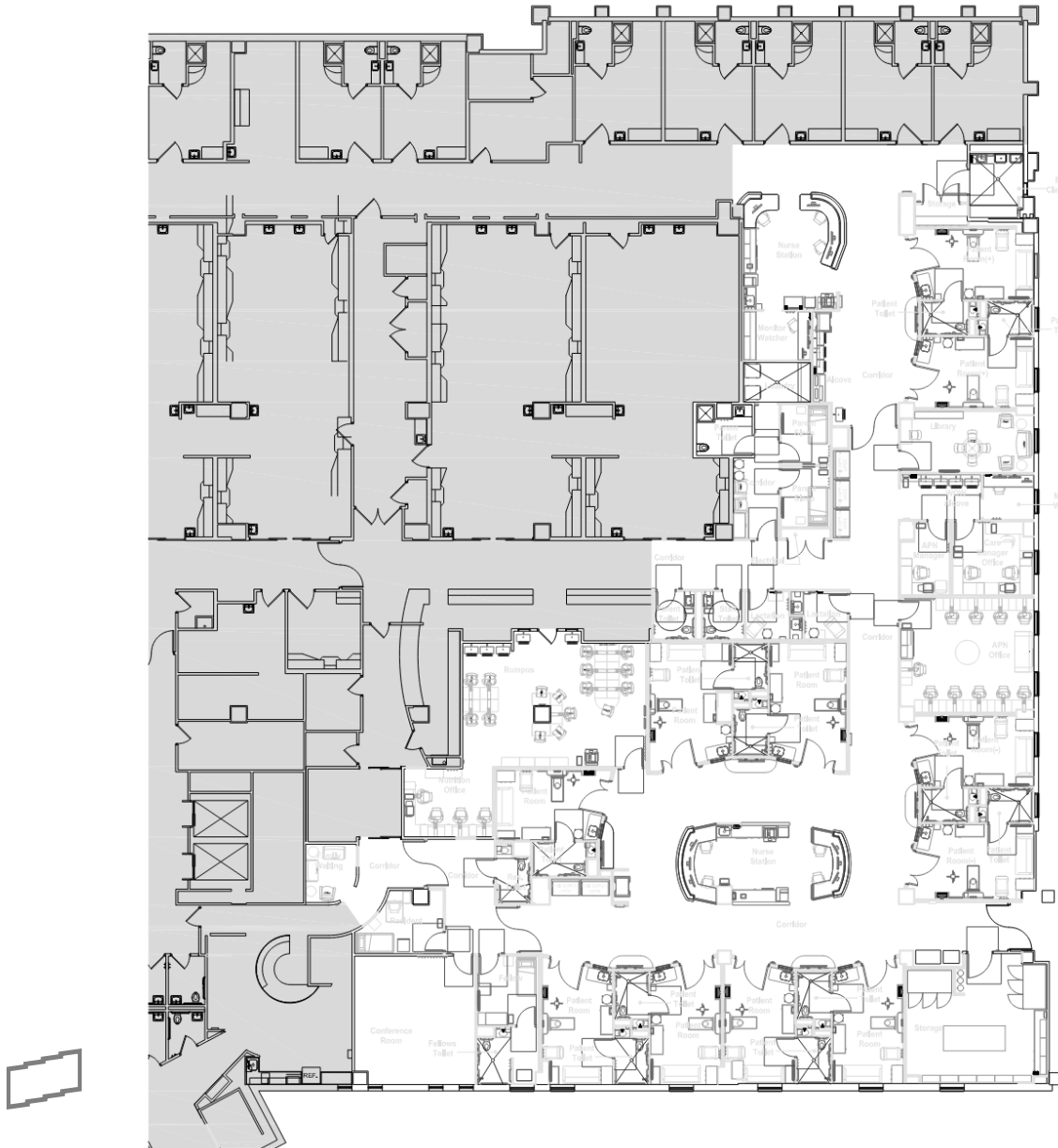
DNS-to-DNS and DNS-Centralized Nurse Station Mutual Visibility

- Indicates a pair of mutually visible relationship between two workstations (i.e., DNS-to-DNS or DNS-Centralized Nurse station), and the mutual visibility score was registered as 1.0
- ◐ Indicates one directional visibility between two workstations, with mutual visibility score registered as 0.5

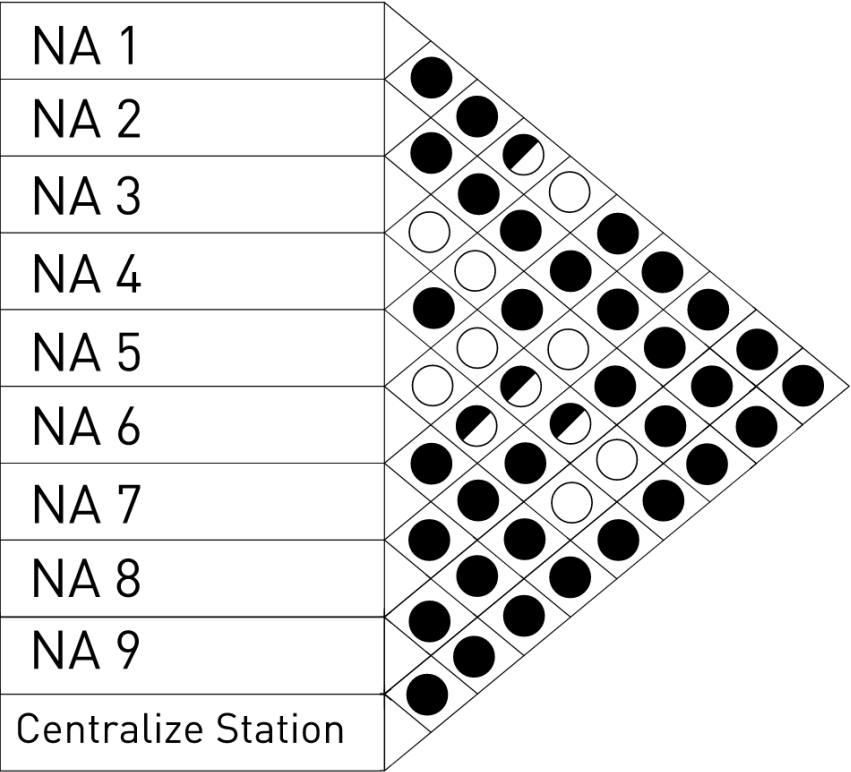
OPEN BAY | DNS | CENTRALIZED NURSE STATION



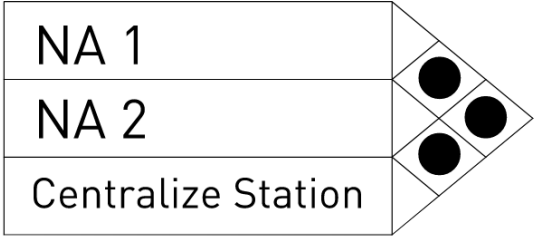
SFR | NURSE ALCOVE | CENTRALIZED NURSE STATION



SFR | NURSE ALCOVE | CENTRALIZED NURSE STATION



Zone 1
NA-to-NA Mutual Visibility: 26 (**72.22%**)
NA-Centralize Station Mutual Visibility: 9



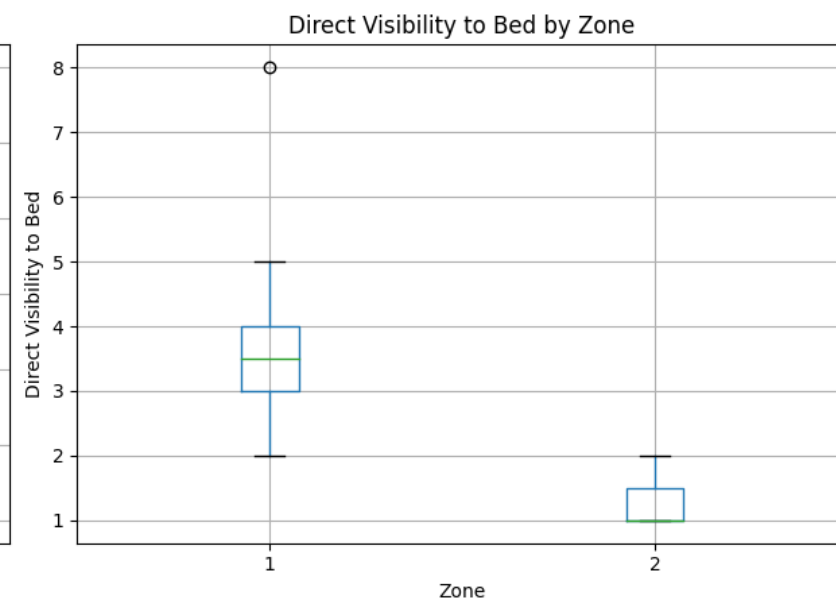
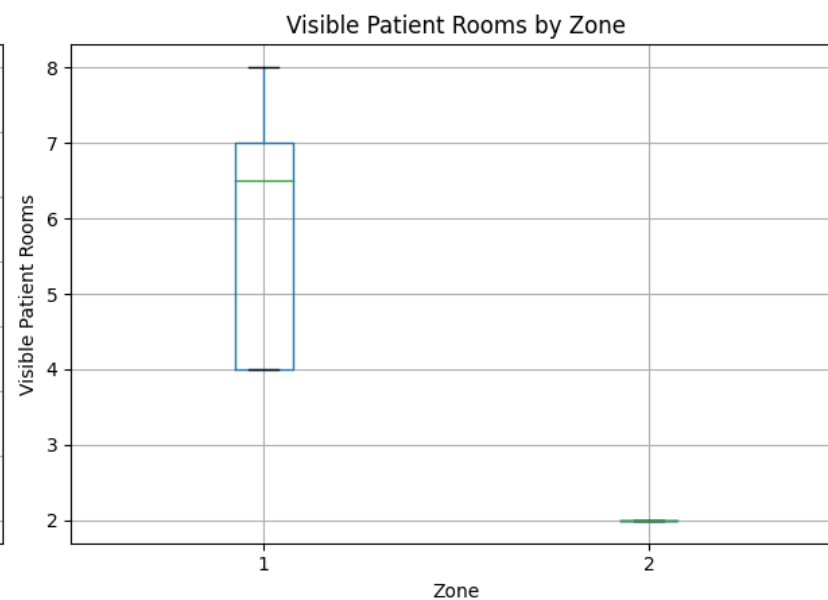
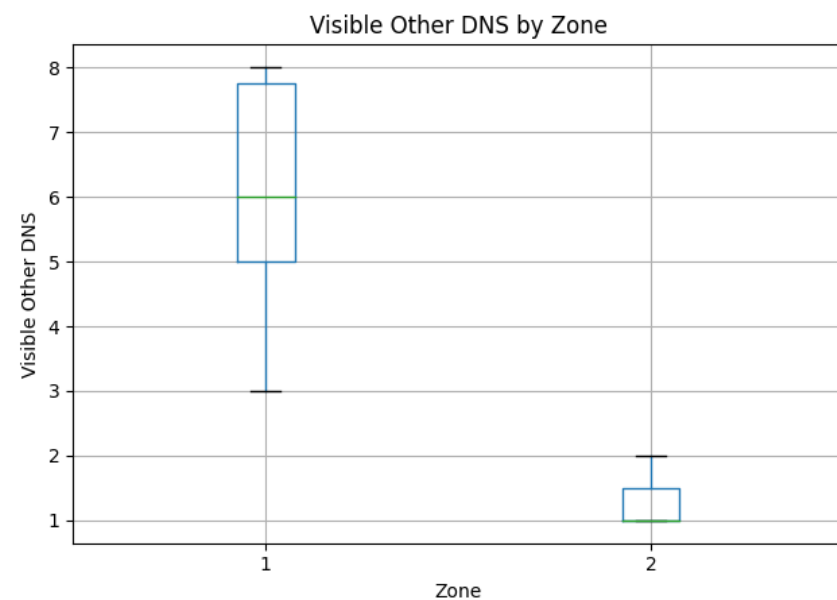
Zone 2
NA-to-NA Mutual Visibility: 1 (**100%**)
NA-Centralize Station Mutual Visibility: 2

NA-to-NA and NA-Centralized Nurse Station Mutual Visibility

- Indicates a pair of mutually visible relationship between two workstations (i.e., NA-to-NA or NA-Centralized Nurse Station), and the mutual visibility score was registered as 1.0
- ◐ Indicates one directional visibility between two workstations, with mutual visibility score registered as 0.5



SFR | NURSE ALCOVE | CENTRALIZED NURSE STATION



Designed for Satisfaction

The Impact of Single-Family Room Neonatal Intensive Care Units on Family Presence and Satisfaction

Lindsey Fay, MSArch; Zahra Daneshvar, MA; Sarah Julien-Bell, MA; Shannon Haynes, MSN, BSW, RN, CNML; Joshua E. Santiago, MA, PhD

ABSTRACT

Purpose: This study aimed to assess the extent to which single-family room (SFR) designs enhance family presence

and satisfaction and to examine onment factors such as proximity, lighting, and acoustics c

Background: The SFR neonat (NICU) presents a highly intrice design attributes. This study i onment moving from an open-family unit. **Methods:** A comp was conducted by a NICU patier researchers specializing in desig tion. Quantitative data were coll participants by electronic survey tion focused on occupancy. Qua through 7 focus groups and 1 i findings reveal that single-family

Author Affiliations: University of Ken Fay], GBBN Architects, Pittsburgh, Pen Carmel College of Nursing, Columbus, C Kentucky Children's Hospital, Lexington University of Kentucky, Lexington, Kent The authors have no funding to disclos The authors have no competing interer Ethical approval was provided by the l University of Kentucky in advance of in consent was obtained from the resean The authors have disclosed that they with, or financial interest in, any com this article.

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Examining Efficiency in Open-Bay and Single-Family Room NICU Designs

Lindsey Fay, MSArch; Kevin Real, PhD; Shannon Haynes, MSN, BSW, RN, CNML; Zahra Daneshvar, MArch

ABSTRACT

Background: There is growing awareness of the relationship between physical work environments and efficiency. Two conflicting factors shape efficiency in the neonatal intensive care unit (NICU) environment: the move to single-family rooms (SFRs) and increased demand for care, requiring growth in unit size.

Purpose: The goal of this research was to understand the impact of SFR NICUs on efficiency factors such as unit design, visibility and proximity, staff time, and workspace usage by various health professionals.

Methods: A pre/postoccupancy evaluation assessed a NICU moving from an open-bay to an SFR unit composed of 6 neighborhoods. A NICU patient care manager and researchers in design and communication implemented a multimethodological design using staff surveys, observations, and focus groups.

Results: Outcomes revealed SFR NICUs contribute to increased efficiency and overall satisfaction with design. Outside of staff time spent in patient rooms, decentralized nurse stations were the most frequented location for staff work, followed by huddle stations, medication and supply rooms, and corridors. Work at the observed locations was largely performed independently. Survey outcomes reported increased feelings of isolation, but focus groups revealed mixed opinions regarding these concerns.

Practice and Research: Design solutions found to enhance efficiency included decentralized nurse stations, increased access to medications and supplies, and proximity of supplies, patient rooms, and huddle stations. Staff work was largely performed independently. Survey outcomes reported increased feelings of isolation, but focus groups revealed mixed opinions regarding these concerns.

number of factors including multiple care practices, technological innovation, and consumer demand for an increasingly complex patient care unit (NICU).¹ In the past, neonatal care practices have changed so much that the NICU environment of 20 years ago is no longer relevant. The NICU consisted of open-bay rooms with a greater focus on efficiency and developmentally appropriate design standards that now require rooms (SFRs) to meet the needs of parents to stay with their infants. Individual rooms offer several benefits including increased privacy for parents and staff, decreased noise,

reduced risk of infection, and improved sleep among the infant. As units designed with SFRs have increased, units designed with open-bay rooms have decreased. This overall increase in unit size has required units to meet a number of needs. Numerous studies note that staff toward SFR NICUs work environment, staff and safety, some evidence suggests that SFR NICUs require increased walking by staff due to limited visibility and unfavorable factors play a role in the healthcare environment. Further examination to understand designed NICU on staff e

REVIEW OF LITERATURE

Efficiency

Increasing the efficiency of healthcare team plays a critical role in high-quality care. An efficient healthcare team is influenced by 2 internal factors: hospital environment and growing awareness of improved physical w

University of Kentucky, Lexington (Miss Fay and Real), and University of Kentucky Children's Hospital, Lexington (Shannon Haynes). The authors have no conflicts of interest. The study was approved by the Institutional Review Board of the University of Kentucky in advance of implementation. Written informed consent was obtained from the research participants. Lindsey Fay, MSArch, 117 Pence Hall, University of Kentucky 40506 (lindsey.fay@uky.edu). The National Association of Neonatal Nurses (NANN) is a not-for-profit organization. 100000000001058

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The Healthcare Workspace: Understanding the Role of Decentralized Nursing Stations, Corridors, and Huddle Spaces as Locations for Teamwork in a Neonatal Intensive Care Unit

Lindsey Fay, MSArch¹, Kevin Real, PhD², and Shannon Haynes, MSN, BSW, RN, CNML³



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Designing for Efficiency

Examining the Impact of Centralized and Decentralized Nurse Stations on Interdisciplinary Care Processes

Lindsey Fay, MSArch
Joshua E. Santiago, MA

Kevin Real, PhD
Kathy Isaacs, PhD, RN, NEA-BC

OBJECTIVE: This study examined the impact of centralized and decentralized unit designs on an interdisciplinary team's perceptions of efficiency through the use of a preoccupancy and postoccupancy evaluation of a cardiovascular unit.

BACKGROUND: During the premove study, the service line was housed across 4 separate locations, each with a centralized nurses' station. The postmove design was housed on 1 floor with decentralized stations. **METHODS:** For this qualitative study, 14 focus groups and 1 interview were conducted. Analysis of the data was guided by a developed framework for efficiency classified into 7 categories.

RESULTS: Outcomes reveal that efficiency was impacted by issues including walking, access to supplies and equipment, proximity to staff, and overall unit configuration and size.

CONCLUSIONS: Although the design of the decentralized unit positions staff members closer to patients, many feel isolated while the centralized units seemed to better promote staff proximity and access to supplies.

Healthcare delivery in acute and intensive care settings requires a high degree of multitasking and cognitive workloads. If healthcare professionals are challenged

by nonclinical inefficiencies, care quality and safety are at risk.¹ As such, the unit design and surrounding built environment play an increasingly important role in contributing to operational efficiency, a culture of safety, and the reduction of waste.² Within the healthcare industry, there is growing awareness of the relationship between improved work environments and operational efficiency. Much of the research centered on this topic is in response to the growing size of healthcare facilities. Between the years of 1980 and 2008, adult inpatient units grew by 118%.³ A primary factor contributing to this growth is the inclusion of an interdisciplinary team approach with greater involvement of specialized professions. This new model requires additional floor space and meeting spaces to adequately meet the needs of the interdisciplinary care team.

One response to the increase in physical size of the healthcare environment has been a shift from centralized to decentralized nursing stations (DNS) with the aim of improving workflow, caregiver efficiency, and patient safety by positioning nurses closer to the patient bedside to decrease response times and improve visual monitoring.⁴ The DNS can be defined as "smaller workstations and charting substations located closer to or inside patient rooms."⁵ The decentralized model has been investigated from a number of perspectives that impact efficiency, including unit design, circulation, access, visibility, proximity, timeliness, and operational considerations. However, few studies have explicitly investigated this new model's impact on healthcare professionals' efficiency.

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Patient Room Design A Qualitative Evaluation of Attributes Impacting Health Care Professionals

Lindsey Fay, MSArch; Joshua E. Santiago, MA; Kevin Real, PhD; Kathy Isaacs, PhD

The focus of this research was to identify what attributes of patient room designs are most beneficial to health care professionals and to explore whether particular professionals hold certain beliefs about patient room attributes. Acute care, progressive care, and intensive care patient room designs were analyzed through the use of pre- and postoccupancy evaluations of a cardiovascular service line. Fourteen focus groups and 1 interview among 74 health care professionals were conducted. Qualitative analysis of the data was guided by a multidimensional framework. A descriptive quantitative assessment was additionally made to reveal positive, negative, or neutral trends and determine the frequency of attributes discussed. The findings revealed outcomes in 4 primary areas: (1) clearance around the bed; (2) visibility; (3) access to the bathroom/bathroom configuration; and (4) access to daylight/views of the exterior. This study identified 8 additional categories. Outcomes illustrate perceptions from a myriad of health care professionals, but the nurses, therapists, and interdisciplinary members of the care team station offered the greatest depth of information. As patient room designs continue to evolve, building on evidence gathered as new or established models are evaluated will become increasingly important. **Key words:** access, acute care, cardiovascular unit, clearance, intensive care, patient room design, progressive care, qualitative, visibility

ADVANCEMENTS in evidence-based design and a greater focus on patient and family-centered care have led to the implementation of private patient rooms. Today, private rooms have become the industry standard in the United States and have been linked with improvements in patient care, patient sleep, satisfaction, social support, patient privacy, and control, enhanced com-

munication with patients and families, and a reduction in the risk of hospital-acquired infections.^{1,4} There is a growing list of individual components that contribute to optimum patient room configuration. Among these include factors that impact patient safety, staff efficiency, circulation, infection control, patient considerations, and family amenities.^{5,6}

Given the increasing boom in construction of both newly built and remodeled health care facilities, there is a need to identify optimal patient room design features through the development of evidence-based recommendations that consider the needs of all occupants. While patient rooms are intended to provide satisfactory healing environments for patients, these rooms also need to serve as functional and satisfactory workplaces for the multitude of people providing care. Much of the research investigating patient room de-

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The authors have disclosed that they have no significant relationships with, or financial interest in, any commercial companies pertaining to this article.

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Q&A

THANK YOU!

