EVIDENCE FOR DESIGN OF INTENSIVE CARE UNITS (ICUs)

RELEVANT CADRE RESEARCH:

Title:	**Environmental Correlates of Efficiency and Safety in Emergency Departments**
Funds:	Academy of Architecture for Health Foundation (AAHF) Research Grant and Herman Miller Grant
Period:	January 2010 to October 2012
Collaborators:	Herman Miller, Synurgy Healthcare Solutions
Location:	Four emergency departments in large US hospitals
Findings:	16 domains of physical design decisions influence safety, efficiency, or both in the ED: 1.entrance and patient waiting, 2.traffic management, 3.sub-waiting or internal waiting areas, 4.triage, 5.exam/treatment area configuration, 6.exam/treatment area centralization versus decentralization, 7.exam/treatment room standardization, 8.adequate space, 9.nurse work space, 10.physician work space, 11.adjacencies and access, 12.equipment room, 13.psych room, 14.staff de-stressing room, 15.hallway width, and 16.results waiting area.

Title:	**An Empirical Examination of the Impacts of Decentralized Nursing**
Period:	January 2011 to December 2012
Collaborator:	University of Texas MD Anderson Cancer Center
Location:	Three inpatient units of the University of Texas, MD Anderson Cancer Center
Findings:	Decentralized nursing unit and physical design models result in quality of work improvements associated with documentation, medication and supplies.

Title:	**Membrane Ceilings in Healthcare Environments Study**
Funds:	HHH Grant - 6 HFPEP070012-01-02
Period:	October 2008 to June 2009
Collaborator:	Washington Hospital Center, CCRD Partners, Fluid Dynamics Solutions, Inc.
Findings:	A membrane diffuser directed airflow ventilation strategy occupying approximately 40% to 60% of the ceiling surface and placed over the patient in a contemporary sized exam room provides a less turbulent airflow pattern and less mixing of the air between the patient and others in the room

Title:	**A Multi-Dimensional Comparative Assessment of Headwall Versus Ceiling Booms in Intensive Care Units**
Funds:	Getinge USA Grant
Period:	December 2007 to May 2008
Collaborator:	University of Texas Southwestern
Location:	Children's Medical Center Dallas
Findings:	Booms have a considerable advantage over headwalls in the case of high acuity patients and when procedures are performed inside patient rooms.

Title:	**Inpatient Unit Design: Defining the Design Characteristics of a Successful Adaptable Unit**
Funds:	AIA 2006 Research Grant and Herman Miller Grant
Period:	May 2006 to February 2007
Collaborator:	University of Texas Arlington School of Nursing
Location:	Six large US hospitals
Findings:	Physical design decisions affect 9 operational flexibility issues. Of these, 7 pertain to flexibility to adapt, and one each to flexibility to convert and expand.

Title:	**Emory University Neuro ICU Renovation Project**
Period:	2005-2006
Collaborator:	Georgia Institute of Technology, College of Architecture (PI)
Location:	Emory University Neuro ICU, Atlanta, GA
Findings:	Post-occupancy data from the unit is one indication of why the unit is considered successful.

RESEARCH ARTICLES
CADRE Publications

Evans, J. and E. Reyers (2014). "Patient room considerations in the intensive care unit: caregiver, patient, family." Critical Care Nursing Quarterly, **37**(1): 83-92.

The Patient Room is one of the most important and costly rooms in the design of an inpatient bed unit. As a result, the patient room mock-up requires knowledge of the components that inform the patient room environment. This article provides the intensive care nurse with questions about patient care processes and unit policies that should be considered in a mock-up. The mock-up outcome should align with the project's goals and objectives of the health care system, infuse the principles of evidence-based design, and ensure that the design accommodates the best workflow for the patient population that will be served. The template will serve as a guide to evaluate the various features of the patient room and for the mock-up discussion between the nurse and the architect.

Pati, D., Evans, J., Harvey, T.E., Jr., & Bauzin, D. (2012). "Factors impeding flexible inpatient unit design." Health Environments Research and Design Journal, **6**(1): 83-103.

Objective: To identify and examine factors extraneous to the design decision-making process that could impede the optimization of flexibility on inpatient units.
Background: A 2006 empirical study to identify domains of design decisions that affect flexibility on inpatient units found some indication in the context of the acuity-adaptable operational model that factors extraneous to the design process could have negatively influenced the successful implementation of the model. This raised questions regarding extraneous factors that might influence the successful optimization of flexibility.
Method: An exploratory, qualitative method was adopted to examine the question. Stakeholders from five recently built acute care inpatient units participated in the study, which involved three types of data collection: (1) verbal protocol data from a gaming session; (2) in-depth semi-structured interviews; and (3) shadowing frontline personnel. Data collection was conducted between June 2009 and November 2010.
Results: The study revealed at least nine factors extraneous to the design process that have the potential to hinder the optimization of flexibility in four domains: (1) systemic; (2) cultural; (3) human; and (4) financial.
Conclusions: Flexibility is critical to hospital operations in the new healthcare climate, where cost reduction constitutes a vital target. From this perspective, flexibility and efficiency strategies can be influenced by (1) return on investment, (2) communication, (3) culture change, and (4) problem definition. Extraneous factors identified in this study could also affect flexibility in other care settings; therefore, these findings may be viewed from the overall context of hospital design.

Pati, D., Harvey, T.E., Jr., & Cason, C. (2008). "Inpatient unit flexibility: Design characteristics of a successful flexible unit." Environment and Behavior **40**(2): 205-232.

Flexibility in health care design is typically addressed from an architectural perspective without a systematic understanding of its meaning from the end-user's viewpoint. Moreover, the architectural perspectives have been generally focused on expandability and convertibility. This study explored flexibility needs in adult medical-surgical inpatient care with the objective to understand its meaning from an end-user perspective and identify characteristics of the physical environment that promote or impede stakeholders' requirements. Semistructured interviews were conducted using a qualitative design with 48 stakeholders in nursing and nursing-support services at 6 hospitals across the United States. Data were collected during September-November 2006. Findings suggest that adaptability influences more aspects of

unit operations than convertibility or expandability. Furthermore, physical design characteristics affect 9 critical operational issues where flexibility is required, spanning nursing, environmental services, materials management, dietary services, pharmacy, and respiratory therapy.

Pati, D., Harvey, T.E., Jr., & Barach, P. (2008). "Relationships between exterior views and nurse stress: an exploratory examination." Health Environments Research and Design Journal, **1**(2): 27-38.

Objective: Examine the relationships between acute stress and alertness of nurse, and duration and content of exterior views from nurse work areas.
Background: Nursing is a stressful job, and the impacts of stress on performance are well documented. Nursing stress, however, has been typically addressed through operational interventions, although the ability of the physical environment to modulate stress in humans is well known. This study explores the outcomes of exposure to exterior views from nurse work areas.
Methods: A survey-based method was used to collect data on acute stress, chronic stress, and alertness of nurses before and after 12-hour shifts. Control measures included physical environment stressors (that is, lighting, noise, thermal, and ergonomic), organizational stressors, workload, and personal characteristics (that is, age, experience, and income). Data were collected from 32 nurses on 19 different units at two hospitals (part of Children's Healthcare of Atlanta) in November 2006.
Results: Among the variables considered in the study view duration is the second most influential factor affecting alertness and acute stress. The association between view duration and alertness and stress is conditional on the exterior view content (that is, nature view, non-nature view). Of all the nurses whose alertness level remained the same or improved, almost 60% had exposure to exterior and nature view. In contrast, of all nurses whose alertness levels deteriorated, 67% were exposed to no view or to only non-nature view. Similarly, of all nurses whose acute stress condition remained the same or reduced, 64% had exposure to views (71% of that 64% were exposed to a nature view). Of nurses whose acute stress levels increased, 56% had no view or only a non-nature view.
Conclusions: Although long working hours, overtime, and sleep deprivation are problems in healthcare operations, the physical design of units is only now beginning to be considered seriously in evaluating patient outcomes. Access to a nature view and natural light for care-giving staff could bear direct as well as indirect effects on patient outcomes.

Pati, D., Evans, J., Waggener, L., & Harvey, T.E., Jr. (2008). "An exploratory examination of medical gas booms versus traditional headwalls in intensive care unit design." Critical Care Nursing Quarterly **31**(4): 340-356.

Should power, medical gases, and monitoring and communications systems be located in a headwall or a ceiling-mounted boom in intensive care unit (ICU) rooms? Often, only the financial costs could be determined for the options, whereas data regarding its potential influence on teamwork, safety, and efficiency are lacking. Hence, purchase decisions are more arbitrary than evidence based. This study simulated care delivery in settings with a traditional headwall and a ceiling boom. Observed were the way the following elements were managed and the extent either system affected flexibility, ergonomics, and teamwork: tubing for intravenous fluids, medical gases, and suction drainage; monitoring leads and equipment power cords; and the medical equipment itself. Simulation runs involving 6 scenarios were conducted with the voluntary participation of 2 physicians, 2 nurse practitioners, 2 respiratory therapists, and 4 registered nurses at a children's tertiary care center in December 2007. Analysis suggests that booms have an advantage over headwalls in case of high-acuity ICU patients and when procedures are performed inside patient rooms. However, in case of lower-acuity ICU patients, as well as when procedures are not typically conducted in the patient room,

booms may not provide a proportionate level of advantage when compared with the additional cost involved in its procurement.

INDUSTRY PUBLICATIONS
CADRE Publications

Harvey, T. E., Jr. and D. Pati (2008). "Functional flexibility. Nine attributes of adaptable hospital spaces." Health Facilities Management, **21**(2): 29-34.

Evans, J., Pati, D. & Harvey, T.E., Jr. (2008). Rethinking acuity adaptability. Healthcare Design.

Thomas, J., Thomas, S., Pati, D., Evans, J., & Waggener, L. (2008). The Right Context to Invest in Medical Gas Ceiling Booms. Children's Hospital Today. **16:** 30-31.

RESEARCH ARTICLES
Non-CADRE Publications

Zimring, C. and H. B. Seo (2012). "Making acuity-adaptable units work: lessons from the field." Health Environments Research and Design Journal, **5**(3): 115-128.

OBJECTIVE: Because there have been no clear directions on how to implement acuity-adaptable units (AAUs), this paper describes actual tactics and strategies that have worked in multiple institutions.
BACKGROUND: AAUs have been used in hospitals for the past decade, but reports in the literature have indicated both successes and difficulties in meeting operational goals and objectives. Despite various views regarding acuity adaptability, there is little in the literature that suggests why it works in some hospitals and not in others.
METHOD: As part of a larger construction project, this project team interviewed the leaders of six hospitals to determine what was associated with the successful implementation of AAUs.
RESULTS: This paper reports on themes that emerged from these interviews, namely: choose the right specialty for medical centers; adopt the AAU model for the entire facility in community hospitals; bring in and train the right people; change culture through communication; and use acuity-adaptable unit clusters.
DISCUSSION AND CONCLUSIONS: Main themes, predictable patient progress, and culture change are further discussed and key recommendations are described.

Choi, J., et al. (2012). "Impacts of indoor daylight environments on patient average length of stay (ALOS) in a healthcare facility." Building and Environment **50**: 65-75.

This study investigates how indoor environments with lighting during the day affect patients' average length of stay (ALOS) in a hospital, by measuring and evaluating the daylight environments in patient rooms and comparing results to their ALOS. Patients' ALOS data were compiled at a general hospital in Incheon, Korea, and the physical, environmental, and daylight conditions in the building were assessed. Data gathered were analyzed using a statistical package to determine the trends in the patients' length of stay in hospital wards using 95% and 90% statistical significance levels. The data were categorized based on the orientation of each

patient's room and the positions of the heads of their beds in relation to window views. Comparisons were made between the different orientations of patient rooms in each ward of the selected hospital. The variables considered in this study were: each patient's average length of stay as an index of health outcome, and the differences in environments during daylight hours, including illuminance, luminance ratio, and diversity of illuminance in the patient rooms of the hospitals. This study considered how these components affected patients' ALOS in the hospitals. It discusses the relationship between indoor daylight environments and ALOS, as well as the seasonal weather factor effect on indoor daylight that could potentially influence the patients' length of stay. This study can serve as a basis for the development of recommendations for designing patient rooms in healthcare facilities that will result in more effective healing environments.

Grissinger, M. (2012). "Physical environments that promote safe medication use." Pharmacy &Therapeutics **37**(7): 377-378.

In 2010, the U.S. Pharmacopeia (USP) published a new chapter on environments that promote the safe use of medications.1 The chapter describes the optimal physical environment needed to promote accurate medication use and how organizations can establish a safe workplace. Standards are provided in five key areas—illumination, interruptions and distractions, sound and noise, physical design and organization, and medication safety zones. This article discusses each area as well as recommendations from the new USP chapter.

Thompson, D. R., et al. (2012). "Guidelines for intensive care unit design." Critical Care Medicine, **40**(5): 1586-1600.

OBJECTIVE: To develop a guideline to help guide healthcare professionals participate effectively in the design, construction, and occupancy of a new or renovated intensive care unit. PARTICIPANTS: A group of multidisciplinary professionals, designers, and architects with expertise in critical care, under the direction of the American College of Critical Care Medicine, met over several years, reviewed the available literature, and collated their expert opinions on recommendations for the optimal design of an intensive care unit.
SCOPE: The design of a new or renovated intensive care unit is frequently a once- or twice-in-a-lifetime occurrence for most critical care professionals. Healthcare architects have experience in this process that most healthcare professionals do not. While there are regulatory documents, such as the Guidelines for the Design and Construction of Health Care Facilities, these represent minimal guidelines. The intent was to develop recommendations for a more optimal approach for a healing environment.
DATA SOURCES AND SYNTHESIS: Relevant literature was accessed and reviewed, and expert opinion was sought from the committee members and outside experts. Evidence-based architecture is just in its beginning, which made the grading of literature difficult, and so it was not attempted. The previous designs of the winners of the American Institute of Architects, American Association of Critical Care Nurses, and Society of Critical Care Medicine Intensive Care Unit Design Award were used as a reference. Collaboratively and meeting repeatedly, both in person and by teleconference, the task force met to construct these recommendations.
CONCLUSIONS: Recommendations for the design of intensive care units, expanding on regulatory guidelines and providing the best possible healing environment, and an efficient and cost-effective workplace.

Shepley, M. M., et al. (2012). "The impact of daylight and views on ICU patients and staff." Health Environments Research and Design Journal, **5**(2): 46-60.

Objective: Using a pre-test/post-test quasi-experimental study in two New Hampshire ICUs, the impact of daylight and window views on patient pain levels, length of stay, staff errors, absenteeism, and vacancy rates were examined. One ICU was operational until 2007, the second opened in 2007. ICU patients were randomly selected from cardiac surgery,

pneumonia, and chronic obstructive pulmonary disease admissions of one or more days, 58 from the old ICU, and 52 from the new. Regular medical staff members assigned to the unit between October 2006 and September 2007 (old unit) and March 2008 and February 2009 (new unit) were included.
Results: Variables other than unit design had a more significant impact on relative pain levels in each unit. Comparing light levels independent of ICU assignment supported the hypothesis that increased light levels reduce pain perception and length of stay, but the relationship was not statistically significant. One trend, not statistically significant, suggested that view was associated with reduced pain perception. A decrease in incident filings supported the hypothesis that improved natural light and views reduced errors, but results were not statistically significant. Some subcategories demonstrated significance. Mean absenteeism per person decreased from 38 to 23 hours from the old unit to the new ($p = 0.05$). Average vacancy rates decreased by 25% (from 10.12% to 7.49% staff openings per year) in the old and new units ($p = 0.04$).
Conclusion: High levels of natural light and window views may positively affect staff absenteeism and staff vacancy. Factors such as medical errors, patient pain, and length of stay require additional research.

Olausson, S., et al. (2012). "The ICU patient room: views and meanings as experienced by the next of kin: a phenomenological hermeneutical study." Intensive Critical Care Nursing, **28**(3): 176-184.

The rooms in Intensive Care Units are considered as high-tech environments and believed to affect recovery process and wellbeing of patients. Moreover, the design and interiors affect the interplay between the patient and the next of kin.
OBJECTIVE: The aim of this study was to describe and interpret the meanings of the intensive care patient room as experienced by next of kin.
DESIGN: Next of kin (n=14) from two different intensive care units participated. Data were collected through photo-voice and analysed using a phenomenological hermeneutical method. RESULTS: Three major themes emerged; dwelling in the room and time, becoming at home and extension of the room. The results show that the room is perceived as a lived and extended place and space. The design, interiors and furnishing in the patient room are fundamental in shaping the next of kin's experiences in the room and affect wellbeing.
CONCLUSIONS: How intensive care patient rooms are designed, the place given to next of kin and the way they are received in the room are decisive for the support given to the loved one. Simple interventions can make the patient room a more healing environment.

Wunsch, H., et al. (2011). "The effect of window rooms on critically ill patients with subarachnoid hemorrhage admitted to intensive care." Critical Care, **15**(2): R81.

INTRODUCTION: Clinicians and specialty societies often emphasize the potential importance of natural light for quality care of critically ill patients, but few studies have examined patient outcomes associated with exposure to natural light. We hypothesized that receiving care in an intensive care unit (ICU) room with a window might improve outcomes for critically ill patients with acute brain injury.
METHODS: This was a secondary analysis of a prospective cohort study. Seven ICU rooms had windows, and five ICU rooms did not. Admission to a room was based solely on availability.We analyzed data from 789 patients with subarachnoid hemorrhage (SAH) admitted to the neurological ICU at our hospital from August 1997 to April 2006. Patient information was recorded prospectively at the time of admission, and patients were followed up to 1 year to assess mortality and functional status, stratified by whether care was received in an ICU room with a window.
RESULTS: Of 789 SAH patients, 455 (57.7%) received care in a window room and 334 (42.3%) received care in a nonwindow room. The two groups were balanced with regard to all patient and clinical characteristics. There was no statistical difference in modified Rankin Scale (mRS)

score at hospital discharge, 3 months or 1 year (44.8% with mRS scores of 0 to 3 with window rooms at hospital discharge versus 47.2% with the same scores in nonwindow rooms at hospital discharge; adjusted odds ratio (aOR) 1.01, 95% confidence interval (95% CI) 0.67 to 1.50, P = 0.98; 62.7% versus 63.8% at 3 months, aOR 0.85, 95% CI 0.58 to 1.26, P = 0.42; 73.6% versus 72.5% at 1 year, aOR 0.78, 95% CI 0.51 to 1.19, P = 0.25). There were also no differences in any secondary outcomes, including length of mechanical ventilation, time until the patient was able to follow commands in the ICU, need for percutaneous gastrostomy tube or tracheotomy, ICU and hospital length of stay, and hospital, 3-month and 1-year mortality.
CONCLUSIONS: The presence of a window in an ICU room did not improve outcomes for critically ill patients with SAH admitted to the ICU. Further studies are needed to determine whether other groups of critically ill patients, particularly those without acute brain injury, derive benefit from natural light.

Eriksson, T., et al. (2011). "The experiences of patients and their families of visiting whilst in an intensive care unit--a hermeneutic interview study." Intensive Critical Care Nursing, **27**(2): 60-66.

AIM: The aim of this study was to interpret and understand the meanings of the lived experiences of visiting of patients in an ICU and their families.
METHOD: The research design was hermeneutic, based on interviews. This study includes 12 interviews with seven patients and five relatives who had been in an ICU. The interview text was interpreted in a Gadamerian manner as different plays with actors and plots.
FINDINGS: Patients' narratives could be divided into two parts; recall of real life and unreal life experiences, the unreal being more common. Relatives' narratives are described as being on stage and being backstage, i.e. in the room with the patient and outside it.
CONCLUSION: The final interpretation elucidated the experience of visiting as the sudden shift between being present in real life vs. being present in the real life of unreality. It was a process whereby the patient and the family build a new understanding of life that creates a new form of interplay within the family. The pre-critical illness life is no longer there--a new life has begun. To support patients and their families in this process of change a family-centred care perspective is necessary.

Levin, P. D., et al. (2011). "Improved ICU design reduces acquisition of antibiotic-resistant bacteria: a quasi-experimental observational study." Critical Care, **15**(5): R211.

INTRODUCTION: The role of ICU design and particularly single-patient rooms in decreasing bacterial transmission between ICU patients has been debated. A recent change in our ICU allowed further investigation.
METHODS: Pre-move ICU-A and pre-move ICU-B were open-plan units. In March 2007, ICU-A moved to single-patient rooms (post-move ICU-A). ICU-B remained unchanged (post-move ICU-B). The same physicians cover both ICUs. Cultures of specified resistant organisms in surveillance or clinical cultures from consecutive patients staying >48 hours were compared for the different ICUs and periods to assess the effect of ICU design on acquisition of resistant organisms. RESULTS: Data were collected for 62, 62, 44 and 39 patients from pre-move ICU-A, post-move ICU-A, pre-move ICU-B and post-move ICU-B, respectively. Fewer post-move ICU-A patients acquired resistant organisms (3/62, 5%) compared with post-move ICU-B patients (7/39, 18%; P = 0.043, P = 0.011 using survival analysis) or pre-move ICU-A patients (14/62, 23%; P = 0.004, P = 0.012 on survival analysis). Only the admission period was significant for acquisition of resistant organisms comparing pre-move ICU-A with post-move ICU-A (hazard ratio = 5.18, 95% confidence interval = 1.03 to 16.06; P = 0.025). More antibiotic-free days were recorded in post-move ICU-A (median = 3, interquartile range = 0 to 5) versus post-move ICU-B (median = 0, interquartile range = 0 to 4; P = 0.070) or pre-move ICU-A (median = 0, interquartile range = 0 to 4; P = 0.017). Adequate hand hygiene was observed on 140/242 (58%) occasions in post-move ICU-A versus 23/66 (35%) occasions in post-move ICU-B (P < 0.001).

CONCLUSIONS: Improved ICU design, and particularly use of single-patient rooms, decreases acquisition of resistant bacteria and antibiotic use. This observation should be considered in future ICU design.

Teltsch, D. Y., et al. (2011). "Infection acquisition following intensive care unit room privatization." Archives of Internal Medicine, **171**(1): 32-38.

Background: Patients in intensive care units (ICUs) often acquire infections, which impose a heavy human and financial burden. The use of private rooms may reduce the acquisition of certain pathogens, but the limited evidence on this topic is inconsistent.
Methods: We compared the rates of acquisition of infectious organisms in an ICU before and after a change from multibed to single rooms. As a control, we used acquisition rates in the ICU of a nearby university teaching hospital, which contained both multibed and single rooms, during the study period. We used a statistical model to adjust for background time trends common to both hospitals.
Results: The adjusted rate of acquisition of Clostridium difficile, vancomycin-resistant Enterococcus species, and methicillin-resistant Staphylococcus aureus combined decreased by 54% (95% confidence interval [CI], 29%-70%) following the intervention. The methicillin-resistant S aureus acquisition rate fell by 47% (95% CI,1%-71%), the C difficile acquisition rate fell by 43% (95% CI, 7%-65%), and the yeast acquisition rate fell by 51% (95% CI, 34%-64%). Twelve common and likely exogenous organisms and exogenous/endogenous organisms had a reduction in acquisition rates after the intervention; for 6 of them, this reduction was statistically significant. No effect was observed on the acquisition rate of coagulase-negative Staphylococcus species, the most common endogenous organism, for which no change would be expected. The adjusted rate ratio of the average length of stay in the ICU was 10% (95% CI, 0%-19%) lower after the intervention.
Conclusion: Conversion to single rooms can substantially reduce the rate at which patients acquire infectious organisms while in the ICU.

Leaf, D. E., et al. (2010). "Relationship between ICU design and mortality." Ches,t **137**(5): 1022-1027.

BACKGROUND: Architectural design of health-care facilities can influence patient safety; however, it is unknown whether patient outcomes are significantly affected by ICU design.
METHODS: Six hundred sixty-four patients admitted to the medical ICU (MICU) of Columbia University Medical Center during 2008 were included in this retrospective study. Patient outcome measures, which included hospital mortality, ICU mortality, ICU length of stay (LOS), and ventilator-free days, were compared based on random room assignment. Rooms that were not visible from the MICU central nursing station were designated as low-visible rooms (LVRs), whereas the remaining rooms were designated as high-visible rooms (HVRs).
RESULTS: Overall hospital mortality did not differ among patients assigned to LVRs vs HVRs; however, severely ill patients (those with Acute Physiology and Chronic Health Evaluation II scores > 30) had significantly higher hospital mortality when admitted to an LVR than did similarly ill patients admitted to an HVR (82.1% and 64.0%, n = 39 and 75, respectively; P = .046). ICU mortality showed a similar pattern. ICU LOS and ventilator-free days did not differ significantly between groups.
CONCLUSIONS: Severely ill patients may experience higher mortality rates when assigned to ICU rooms that are poorly visualized by nursing staff and physicians.

USP-NF (2010). "Physical environments that promote safe medication use." The United States Pharmacopeia–National Formulary(Chapter1066).

Bartley, J. and A. J. Streifel (2010). "Design of the environment of care for safety of patients and personnel: does form follow function or vice versa in the intensive care unit?" Critical Care Medicine, **38**(8 Suppl): S388-398.

We review the context of the environment of care in the intensive care unit setting in relation to patient safety and quality, specifically addressing healthcare-associated infection issues and solutions involving interdisciplinary teams. Issues addressed include current and future architectural design and layout trends, construction trends affecting intensive care units, and prevention of construction-associated healthcare-associated infections related to airborne and waterborne risks and design solutions. Specific elements include single-occupancy, acuity-scalable intensive care unit rooms; environmental aspects of hand hygiene, such as water risks, sink design/location, human waste management, surface selection (floor covering, countertops, furniture, and equipment) and cleaning, antimicrobial-treated or similar materials, ultraviolet germicidal irradiation, specialized rooms (airborne infection isolation and protective environments), and water system design and strategies for safe use of potable water and mitigation of water intrusion. Effective design and operational use of the intensive care unit environment of care must engage critical care personnel from initial planning and design through occupancy of the new/renovated intensive care unit as part of the infection control risk assessment team. The interdisciplinary infection control risk assessment team can address key environment of care design features to enhance the safety of intensive care unit patients, personnel, and visitors. This perspective will ensure the environment of care supports human factors and behavioral aspects of the interaction between the environment of care and its occupants.

Gurses, A. P. and P. Carayon (2009). "Exploring performance obstacles of intensive care nurses." Applied Ergonomics. **40**(3): 509-518.

High nursing workload, poor patient safety, and poor nursing quality of working life (QWL) are major issues in intensive care units (ICUs). Characteristics of the ICU and performance obstacles may contribute to these issues. The goal of this study was to comprehensively identify the performance obstacles perceived by ICU nurses. We used a qualitative research design and conducted semi-structured interviews with 15 ICU nurses of a medical-surgical ICU. Based on this qualitative study and a previously reported quantitative study, we identified seven main types of performance obstacles experienced by ICU nurses. Obstacles related to the physical environment (e.g., noise, amount of space), family relations (e.g., distractions caused by family, lack of time to spend with family), and equipment (e.g., unavailability, misplacement) were the most frequently experienced performance obstacles. The qualitative interview data provided rich information regarding the factors contributing to the performance obstacles. Overall, ICU nurses experience a variety of performance obstacles in their work on a daily basis. Future research is needed to understand the impact of performance obstacles on nursing workload, nursing QWL, and quality and safety of care.

Hendrich, A., et al. (2009). "Unit-related factors that affect nursing time with patients: spatial analysis of the time and motion study." Health Environments Research and Design Journal. **2**(2): 5-20.

OBJECTIVE: The primary goal of this study was to test the hypothesis that nurses adopt distinct movement strategies based on features of unit topology and nurse assignments. The secondary goal was to identify aspects of unit layout or organization that influence the amount of time nurses spend in the patient room.

BACKGROUND: Previous research has demonstrated a link between nursing hours and patient outcomes. Unit layout may affect direct patient care time by determining aspects of nurse behavior, such as the amount of time nurses spend walking. The recent nurses' Time and Motion study employed multiple technologies to track the movements and activities of 767 medical-surgical nurses. With regard to unit layout, initial analysis of the data set did not detect differences between types of units and time spent in the patient room. The analysis reported here applies novel techniques to this data set to examine the relationship between unit layout and nurse behavior.

METHODS: Techniques of spatial analysis, borrowed from the architectural theory of spatial syntax, were applied to the Time and Motion data set. Motion data from radio-frequency identification tracking of nurses was combined with architectural drawings of the study units and clinical information such as nurse-patient assignment. Spatial analytic techniques were used to determine the average integration or centrality of nurse assignments for each shift.
RESULTS: Nurse assignments with greater average centrality to all assigned rooms were associated with a higher number of entries to patient rooms, as well as to the nurse station. Number of entries to patient rooms was negatively correlated with average time per visit, but positively correlated with total time spent in patient rooms. The data describe two overall strategies of nurse mobility patterns: fewer, longer visits versus more frequent, shorter visits.
CONCLUSIONS: Results suggest that the spatial qualities of nurse assignments and unit layout affect nurse strategies for moving through units and affect how frequently nurses enter patient rooms and the nurse station.

Samuels, O. (2009). "Redesigning the neurocritical care unit to enhance family participation and improve outcomes." Cleveland Clinical Journal of Medicine, **76 Suppl 2**: S70-74.

Emory University Hospital recently converted its neurocritical care unit into an environment that enhances involvement of the patient's family. Each patient room now has an adjacent family area with comfortable accommodations for daytime and nighttime use. The new unit design, which drew from evidence on the impact of the physical environment on patient outcomes, facilitates better interactions between families and the medical team, and early studies show that patient satisfaction and staff satisfaction have increased. This article describes the impetus for and process of the unit redesign, as well as initial results and lessons learned.

Wenham, T. and A. Pittard (2009). "Intensive care unit environment." Continuing Education in Anaesthesia, Critical Care & Pain, **9**(6): 178-183.

The intensive care unit (ICU) is a potentially hostile environment for the vulnerable critically ill patient. Adverse environmental factors can contribute to delirium.
Delirium is associated with an increased length of hospital stay and increased mortality.
Frequently reported stressful environmental factors are noise, ambient light, restriction of mobility, and social isolation.
Improving the ICU environment involves education of critical care staff, modification of equipment, and careful consideration to future ICU design.

Ulrich, R. S. (2009). Effects of Viewing Art on Health Outcomes. Putting Patients First: Best Practices in Patient-Centered Care. S. B. Frampton and P. A. Charmel. San Francisco, Jossey-Bass**:** 129-149.

Hathorn, K. and U. Nanda (2008). A Guide to Evidence-Based Art. Concord, CA, Center for Health Design**:** 1-24.

Cheung, W. (2008). "Design of Australasian intensive care units: time for change or time for more research?" Critical Care and Resuscitation, **10**(1): 70.

Recommendations exist to guide the design and construction of adult intensive care units, but current guidelines are hampered by the paucity of high-quality research. Much of the current literature on ICU design has focused on patient-centred outcomes, such as nosocomial infections, aspects of psychological and physiological wellbeing, and patient satisfaction, but the design of the ICU environment also affects health care workers. The literature seems to favour the use of single rooms rather than an open-plan ICU design, with the major benefits being to infection control, but this notion is controversial. For most aspects of ICU design, more research is required before definite conclusions can be drawn. This article discusses the application of evidence-based design to improve the ICU environment and reviews some of the controversial issues and concepts.

Chisholm, S., et al. (2008). Identification of intensive care unit (ICU) system integration conflicts: evaluation of two mock-up rooms using patient simulation. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, SAGE Publications.

To address increasing patient demands and acuity, the Calgary Health Region is renovating the intensive care units (ICU) at three of their adult acute care sites. Before finalizing the design plans, mock-up rooms were created at two of the sites according to several proposed room designs in order to identify potential issues during the design phase of the project. All necessary equipment was included within each of the two mock-up rooms so as to nearly replicate a functioning ICU. Evaluations of equipment, room layout and conflicts were accomplished using patient simulation of a cardiac arrest, an acutely ill patient, a palliative care patient and the admission of a new patient. Digital videos, think aloud audio tracks and extensive debriefing sessions were combined and analyzed. Specific category issues were identified including the articulating arms, visibility of the patient monitors, equipment usability, collisions with equipment, and communication issues. Elaboration of each issue and presentation of design recommendations is given.

Gallesio, A. O. (2008). "Improving quality and safety in the ICU: a challenge for the next years." Current Opinions in Critical Care. **14**(6): 700-707.

PURPOSE OF REVIEW: The objective of this review is to focus on recent developments in ICU quality improvement.
RECENT FINDINGS: Quality improvement has been subjected to an extensive discussion in the last two decades. Reasons for improving quality in the ICU cover many areas: Customer preferences have been focused as the main target for designing processes throughout the whole industry of services. New bioethics principles: patient autonomy and therapeutic limitation in the nonrecoverable patient, have changed the concept of ICU mission and quality improvement. Economical reasons: Cost of nonquality in long term vision is more expensive than investing in improving quality. Social imperatives: Equity in access to safe healthcare services is claimed everywhere in the world. Discussion about medical errors and patient safety: Errors have been visualized more as a lack of barriers in process designing than a responsibility of the health team participating in patient care.
SUMMARY: Changes described above have impacted the whole practice of intensive care. Quality improvement and offering a safer healthcare will promote deep changes in management and leadership.

Schmalenberg, C. and M. Kramer (2007). "Types of intensive care units with the healthiest, most productive work environments." American Journal of Critical Care. **16**(5): 458-468; quiz 469.

BACKGROUND: The quality of nurses' work environments in hospitals is of great concern. The American Association of Critical-Care Nurses has specified 6 standards essential to a healthy (ie, satisfying and productive) work environment. These standards are sufficiently aligned to the Essentials of Magnetism processes to make this tool suitable for measuring healthy work environments.
OBJECTIVES: To identify differences in staff nurses' perceptions of the work environment by type of intensive care unit.
METHODS: A cross-sectional descriptive design with strategic sampling was used in this secondary analysis of data from 698 staff nurses working in 34 intensive care units in 8 magnet hospitals. Intensive care units were grouped into 4 types: medical, including coronary care; surgical, including trauma and cardiovascular; neonatal and pediatric; and medical-surgical. All nurses completed the Essentials of Magnetism instrument. Analysis of variance was used to identify initial differences; multivariate analysis of variance was used to control for covariates.
RESULTS: The intensive care nurses and units scored above the National Magnet Hospital Profile mean on process variables and on the Essentials of Magnetism outcome variables.

Neonatal and pediatric units scored significantly higher than did the other types of intensive care units sampled.
CONCLUSIONS: Intensive care unit structures supported care processes and relationships that resulted in job satisfaction among nurses and high-quality care for patients in this strategic sample. Systematic study of the structures and processes present in units reporting a healthy work environment can be used to assist other clinical units in improving work environments.

Kutash, M. and L. Northrop (2007). "Family members' experiences of the intensive care unit waiting room." Journal of Advanced Nursing **60**(4): 384-388.

Aim: This paper is a report of a study to explore family members' perspectives and experiences of waiting rooms in adult intensive care units.
Background: Waiting to visit family members who are hospitalized in intensive care units can be very stressful. Although flexible and or open visiting is practised in many hospitals, family members may spend a great deal of time in the waiting room.
Method: A qualitative design using semi-structured interviews was used and the data were collected in 2004. A convenience sample of six visitors was recruited from waiting rooms of three different adult intensive care units. Data collection and analysis were concurrent.
Findings: Six categories emerged from the data that included structural and subjective aspects of waiting: 'close proximity' referred to the importance of a close physical distance to their family member; 'caring staff' captured the comfort family members felt when staff showed caring behaviours towards relative; 'need for a comfortable environment' represented the impact of the design of the waiting room on family members well-being; 'emotional support' referred to the waiting room as a place where comfort was found by sharing with others; 'rollercoaster of emotions' captured the range of emotions experienced by family members; 'information' referred to the importance of receiving information about their relative.
Conclusion: Future research should focus on the impact of the interior design of waiting rooms on the comfort and welfare of family members and on identifying needs of family members across different cultures.

Davidson, J. E., et al. (2007). "Clinical practice guidelines for support of the family in the patient-centered intensive care unit: American College of Critical Care Medicine Task Force 2004-2005." Critical Care Medicine, **35**(2): 605-622.

OBJECTIVE: To develop clinical practice guidelines for the support of the patient and family in the adult, pediatric, or neonatal patient-centered ICU.
PARTICIPANTS: A multidisciplinary task force of experts in critical care practice was convened from the membership of the American College of Critical Care Medicine (ACCM) and the Society of Critical Care Medicine (SCCM) to include representation from adult, pediatric, and neonatal intensive care units.
EVIDENCE: The task force members reviewed the published literature. The Cochrane library, Cinahl, and MedLine were queried for articles published between 1980 and 2003. Studies were scored according to Cochrane methodology. Where evidence did not exist or was of a low level, consensus was derived from expert opinion.
CONSENSUS PROCESS: The topic was divided into subheadings: decision making, family coping, staff stress related to family interactions, cultural support, spiritual/religious support, family visitation, family presence on rounds, family presence at resuscitation, family environment of care, and palliative care. Each section was led by one task force member. Each section draft was reviewed by the group and debated until consensus was achieved. The draft document was reviewed by a committee of the Board of Regents of the ACCM. After steering committee approval, the draft was approved by the SCCM Council and was again subjected to peer review by this journal.
CONCLUSIONS: More than 300 related studies were reviewed. However, the level of evidence in most cases is at Cochrane level 4 or 5, indicating the need for further research. Forty-three

recommendations are presented that include, but are not limited to, endorsement of a shared decision-making model, early and repeated care conferencing to reduce family stress and improve consistency in communication, honoring culturally appropriate requests for truth-telling and informed refusal, spiritual support, staff education and debriefing to minimize the impact of family interactions on staff health, family presence at both rounds and resuscitation, open flexible visitation, way-finding and family-friendly signage, and family support before, during, and after a death.

Chaudhury, H. P. and A. P. Mahmood (2007). The Effect of Environmental Design on Reducing Nursing and Medication Errors in Acute Care Settings. The Center for Health Design CHER. T. C. f. H. D. C. R. Committee. Concord. November 2007.

The Problem: It has been estimated that approximately 44,000 Americans die in hospitals each year as a result of preventable medical errors (Kohn et al., 2000a). The estimated national costs of adverse events in the United States is 37.6 billion dollars, while the national costs of preventable adverse events has been estimated to be 17 billion dollars (Kohn et al., 2000b). Physical environment is an important component in the acute care setting that can directly impact patient safety, nursing and medication errors, as well as contribute to staff fatigue, stress and burnout resulting in errors.

Methods: This study examines this issue in the medical-surgical units with multiple methods that include:

Literature Review and Analysis (204 empirical and 148 non-empirical journal articles, books, book chapters and reports were reviewed and analyzed. Among these 352 items, 112 were specifically on nursing and medication errors).

Survey on Nursing Staff in Four Hospitals in the Pacific Northwest

Focus Groups with Nursing, Administration and Pharmacy Staff Members

Site Visits to Three Selected Facilities that have implemented Design for Enhanced Patient Safety and Reduction of Errors

Key Findings and Conclusions: The review and analysis demonstrated that the following environmental variables contribute to work place errors: spatial design, micro-environmental design, ergonomics, noise levels, lighting, color, heating, ventilation, and air conditioning. Staffing levels, age and health of workers were among non-environmental variables associated with workplace errors. These variables contributed to errors through workers' fatigue, stress, disruptions, distractions, and other mediating factors. Ten major design recommendations are given based on the findings of the study. For example, the authors suggest finding a balance between patient accessibility and a reduction of disruptions. In addition, standardization and automation are emphasized.

Rashid, M. (2006). "A decade of adult intensive care unit design: a study of the physical design features of the best-practice examples." Critical Care Nursing Quarterly, **29**(4): 282-311.

This article reports a study of the physical design characteristics of a set of adult intensive care units (ICUs), built between 1993 and 2003. These ICUs were recognized as the best-practice examples by the Society of Critical Care Medicine, the American Association of Critical Care Nurses, and the American Institute of Architects. This study is based on a systematic analysis of the materials found on these ICUs in the booklet and videos jointly published by the above organizations in 2005. The study finds that most of these examples of best-practice adult ICUs have the following negative characteristics: (1) they are built as renovation projects with more health and safety hazards during construction; (2) most of them are mixed-service units with more safety and staffing problems; (3) the overall layout and the layout of staff work areas in these ICUs do not have any common design solutions for improved patient and staff outcomes; and (4) in these ICUs, family space is often located outside the unit, and family access to the patient room is restricted, even though family presence at the bedside may be important for improved patient outcomes. Some of these negative characteristics are offset by the following

positive characteristics in most ICUs: (1) they have only private patient rooms for improved patient care, safety, privacy, and comfort; (2) most patient beds are freestanding for easy access to patients from all sides; (3) they have handwashing sinks and waste disposal facilities in the patient room for improved safety; and (4) most patient rooms have natural light to help patients with circadian rhythms. The article discusses, in detail, the implications of its findings, and the role of the ICU design community in a very complicated design context.

Brown, K. K. and D. Gallant (2006). "Impacting patient outcomes through design: acuity adaptable care/universal room design." Critical Care Nursing Quarterly. **29**(4): 326-341.

To succeed in today's challenging healthcare environment, hospitals must examine their impact on customers--patients and families--staff and physicians. By using competitive facility design and incorporating evidence-based concepts such as the acuity adaptable care delivery model and the universal room, the hospital will realize an impact on patient satisfaction that will enhance market share, on physician satisfaction that will foster loyalty, and on staff satisfaction that will decrease turnover. At the same time, clinical outcomes such as a reduction in mortality and complications and efficiencies such as a reduction in length of stay and minimization of hospital costs through the elimination of transfers can be gained. The results achieved are dependent on the principles used in designing the patient room that should focus on maximizing patient safety and improving healing. This article will review key design elements that support the success of an acuity adaptable unit such as the use of a private room with zones dedicated to patients, families, and staff, healing environment, technology, and decentralized nursing stations that support the success of the acuity adaptable unit. Outcomes of institutions currently utilizing the acuity adaptable concept will be reviewed.

Bearman, G. M. L., et al. (2006). "Infection control and the prevention of nosocomial infections in the intensive care unit." Seminars in Respiratory and Critical Care Medicine **27**(3): 310-324.

Nosocomial infections continue to be significant causes of morbidity, mortality, and added costs in the health care setting. Half of all life-threatening nosocomial bloodstream infections and pneumonias occur in intensive care units (ICUs), despite ICUs representing only 15 to 20% of all hospital beds. Thus an efficient focus for prevention and control of life-threatening health care-associated infections should be in ICUs. Further, growing antibiotic resistance complicates the therapy of serious infections. Meticulous infection control practice with continued attention to hand hygiene is of paramount importance. Strict adherence to evidence-based catheter insertion and maintenance policies reduces nosocomial bloodstream infections. Evidence-based prevention strategies for ventilator-associated pneumonia, including management of respiratory equipment according to published guidelines and maintaining backrest elevation at 30 to 45 degrees, are effective. For greatest risk reduction, multifaceted programs ensuring maximal adherence with evidence-based infection control guidelines are needed.

Stanchina, M. L., et al. (2005). "The influence of white noise on sleep in subjects exposed to ICU noise." Sleep Medicine. **6**(5): 423-428.

Background and purpose: There is disagreement in the literature about the importance of sleep disruption from intensive care unit (ICU) environmental noise. Previous reports have assumed that sleep disruption is produced by high-peak noise. This study aimed to determine whether peak noise or the change in noise level from baseline is more important in inducing sleep disruption. We hypothesized that white noise added to the environment would reduce arousals by reducing the magnitude of changing noise levels.

Patients and methods: Four subjects underwent polysomnography under three conditions: (1) baseline, (2) exposure to recorded ICU noise and (3) exposure to ICU noise and mixed-frequency white noise, while one additional subject completed the first two conditions. Baseline and peak noise levels were recorded for each arousal from sleep.

Results: A total of 1178 arousals were recorded during these studies. Compared to the baseline night (13.3 +/- 1.8 arousals/h) the arousal index increased during the noise (48.4 +/- 7.6) but not the white noise/ICU noise night (15.7 +/- 4.5) (P < 0.004). The change in sound from baseline to peak, rather than the peak sound level, determined whether an arousal occurred and was the same for the ICU noise and white noise/ICU noise condition (17.7 +/- 0.4 versus 17.5 +/- 03 DB, P=0.65).
Conclusions: Peak noise was not the main determinant of sleep disruption from ICU noise. Mixed frequency white noise increases arousal thresholds in normal individuals exposed to recorded ICU noise by reducing the difference between background noise and peak noise.

Hendrich, A. and N. Lee (2005). "Intra-Unit Patient Transports: Time, Motion, and Cost Impact On Hospital Efficiency." Nursing Economic$, **23**(4): 157-164.

The article presents a study on the intra-hospital patient transfer. The study analyzes the process, time, personnel and cost of the transport procedure. Intrahospital transfer also causes confusion and significant stress on patients and families. Careful consideration for the three primary reasons for transfer--need for additional technology, need for higher skilled staff and need for higher hours per patient day--offer the opportunity to rethink the drivers of transfer through technology planning, staff training and staffing flexibility.

Hendrich, A., et al. (2004). "Effects of acuity-adaptable rooms on flow of patients and delivery of care." American Journal of Critical Care, **13**(1): 35-45.

McCusker, J., et al. (2004). "Nursing work environment and quality of care: differences between units at the same hospital." International Journal of Health Care Quality Assurance Inc Leadership in Health Services, **17**(6): 313-322.

The literature suggests that improvements in nurses' work environments may improve the quality of patient care. Furthermore, monitoring the work environment through staff surveys may be a feasible method of identifying opportunities for quality improvement. This study aimed to confirm five proposed sub-scales from the Nursing Work Index - Revised (NWI-R) to assess the nursing work environment and the performance of these sub-scales across different units in a hospital. Data were derived from a cross-sectional survey of 243 nurses from 13 units of a 300-bed university-affiliated hospital in Quebec, Canada, during 2001. Using confirmatory factor analysis, the five subscales were confirmed; three of the sub-scales had greater ability to discriminate between units. Using hierarchical regression models, "resource adequacy" was the sub-scale most strongly associated with the perceived quality of care at the last shift. The NWI-R sub-scales are potentially useful for comparison of work environments of different nursing units at the same hospital.

Hendrich, A. (2003). Case Study: The impact of Acuity Adaptable rooms on future designs, bottlenecks and hospital capacity. Impact Conference on optimizing the physical space for improved outcomes, satisfaction and the bottom line, Atlanta, GA, The Institute for Healthcare Improvement & The Center for Health Design.

Ulrich, R. and L. Gilpin (2003). Healing arts: Nutrition for the soul. Putting patients first: Designing and practicing patient-centered care. S. B. Frampton, L. Gilpin and P. Charmel. San Francisco, Jossey-Bass**:** 117-146.

Gabor, J. Y., et al. (2003). "Contribution of the intensive care unit environment to sleep disruption in mechanically ventilated patients and healthy subjects." American Journal of Respiratory and Critical Care Medicine **167**(5): 708-715.

Recent studies have challenged the traditional hypothesis that excessive environmental noise is central to the etiology of sleep disruption in the intensive care unit (ICU). We characterized

potentially disruptive ICU noise stimuli and patient-care activities and determined their relative contributions to sleep disruption. Furthermore, we studied the effect of noise in isolation by placing healthy subjects in the ICU in both normal and noise-reduced locations. Seven mechanically ventilated patients and six healthy subjects were studied by continuous 24-hour polysomnography with time-synchronized environmental monitoring. Sound elevations occurred 36.5 +/- 20.1 times per hour of sleep and were responsible for 20.9 +/- 11.3% of total arousals and awakenings. Patient-care activities occurred 7.8 +/- 4.2 times per hour of sleep and were responsible for 7.1 +/- 4.4% of total arousals and awakenings. Healthy subjects slept relatively well in the typically loud ICU environment and experienced a quantitative, but not qualitative, improvement in sleep in a noise-reduced, single-patient ICU room. Our data indicate that noise and patient-care activities account for less than 30% of arousals and awakenings and suggest that other elements of the critically ill patient's environment or treatment should be investigated in the pathogenesis of ICU sleep disruption.

Bartley, J. and N. B. Bjerke (2001). "Infection control considerations in critical care unit design and construction: a systematic risk assessment." Critical Care Nursing Quarterly, **24**(3): 43-58.

When contemplating major renovation or new construction of a critical care unit (CCU), the use of systematic infection control risk assessment (ICRA) provides guidance to limit infectious perils for patients and to reduce occupational hazards for employees in this environment. The nursing representative and other members of the multidisciplinary planning and design team must routinely address infection control factors throughout the project and assist administration in understanding the rationale for the floor plan, equipment, and furnishings required to support sound infection control practices. Collaborative team skills, articulate communication techniques, and frequent rounds are integral throughout the construction.

Ulrich, R. S. (2001). Effects of Healthcare Environmental Design on Medical Outcomes. Design and Health- The Therapeutic Benefits of Design. A. Dilani, Swedish Building Council Center**:** 49-59.

This book is the result of the 2nd International Conference on Design and Health organized by the Karolinska Institute in Stockholm, in June 2000. It presents the latest research findings and knowledge about new approaches in healthcare, designs that not only foster functional efficiency, but also improve and strengthen health processes.The physical environment affects our behaviour; well-designed and positively experienced environments enhance the ability to cope with stress. We react and find better ways to resolve problems if we have a good experience of our surroundings. But inappropriate designed psychosocial environments may be a source of stress and frustration, and thereby affect our well-being and health.

The diversity of papers in this book represents one voice in this ongoing discussion amongst different disciplines. Artists, designers, architects, landscape architects, clinicians, professors, researchers, psychologists, biologists, administrators, doctors and nurses are carrying a conversation between the covers of this book.

Novaes, M. F. P., et al. (1999). "Stressors in ICU: perception of the patient, relatives and health care team." Intensive Care Medicine **25**(12): 1421-1426.

Objective: To compare the evaluation of the stressors present in the intensive care unit (ICU) from the point of view of the patient, relatives and the multiprofessional team and to identify differences and similarities with regard to the perception of stressors in order to optimize patient care.

Design: Cross-sectional analytical survey.

Setting: General ICU of a private hospital.

Patients and participants: From April 1st to June 30th, 1996, 50 ICU patients during the first week of their ICU stay, 50 of their respective relatives and 50 members of the professional team directly involved in the care of these patients.

Measurements and results: The Intensive Care Unit Environmental Stressor Scale (ICUESS) was administered to all patients. The relatives and health care professionals were asked to complete

the ICUESS on the basis of their perception of the patient's stressors. Being in pain, having tubes in the nose or mouth, being restrained by tubes and being unable to sleep were considered by the patients, relatives and health care professionals as the main stressors. The professional team evaluated the intensity of the stressors higher than either the family or the patient. No statistical significance was detected between the intensity of the stressors as evaluated by the patient and the intensity evaluated by relatives and by the professional team. Conclusions: Being in pain, being unable to sleep and having tubes in the nose and/or mouth were pointed out as the major stressors by the three groups. There was no statistically significant correlation between the total stress scores of the patients and their relatives (r = 0.193), between the patients and the team (r = ±0.002), or between the total scores of the team and the relatives (r=±0.185). The results suggest that the views of the relatives and the professional team concerning the stressors have some similar points compared to the evaluation made by the patient himself, although the intensity of the evaluation for each group corresponds to its own perception.

Tanimoto, S., et al. (1999). "The psychological and physiological effects of an intensive-care unit environment on healthy individuals." Clinical Performance and Quality in Health Care, **7**(2): 77-82.

OBJECTIVE: The ideal inpatient environment would be one in which patient stress and anxiety are alleviated, but current inpatient hospital settings often do not seem to take this fact into consideration. To date, the effects of the actual hospital environment itself on patients is poorly understood. The purpose of the present study was to investigate the types of psychological and physiological changes that people undergo in response to being placed in an inpatient setting. DESIGN AND SETTING: Ten healthy volunteers were admitted to an intensive-care unit (ICU) for 4 days and 3 nights. The psychological and physiological changes before and after admission were examined. A qualitative assessment was also performed.

RESULTS: Most healthy individuals at times develop feelings of depression, which can be measured by the Profile of Mood States and the Zung Self-Rating Depression Scale (P < .05). In this study, participants' fatigue and confusion increased (P < .05) and vigor decreased (P < .01) as measured by the Profile of Mood States. There was also an increase in the General Health Questionnaire scores (P < .01). However, no significant physiological effects were apparent, as measured by peripheral lymphocyte counts, natural killer cells activity, and urinary 17-kerosteroid and 17-hydroxycorticosteroid levels. Subjects often engaged in introspection during hospitalization and often had a negative attitude towards the hospital environment. CONCLUSIONS: The findings of increased feelings of depression attributable solely to being in an ICU setting are inconsistent with the type of environment generally considered necessary to alleviate patient anxiety and tension in a critical-care-ward environment. The negative perception of this environment strongly suggests room for improvement. Efforts in this regard should focus on improving the five senses, particularly sight, sound, and taste within the ICU.

Kahn, D. M., et al. (1998). "Identification and modification of environmental noise in an ICU setting." Chest, **114**(2): 535-540.

STUDY OBJECTIVES: Noise levels in the hospital setting are exceedingly high, especially in the ICU environment. We set out to determine what caused the noises producing sound peaks > or = 80 A-weighted decibels (dBA) in our ICU settings, and attempted to reduce the number of sound peaks > or = 80 dBA through a behavior modification program.

DESIGN: The study was divided into two separate phases: noise identification and a trial of behavior modification. During the noise identification phase we simultaneously recorded sound peaks and the loudest noise heard subjectively by one observer in the medical ICU (MICU) and the respiratory ICU (RICU). During the behavior modification phase of the study we implemented a behavior modification program, geared toward noise reduction, in all of the

MICU staff. Sound levels were monitored before and at the end of the behavior modification trial.
SETTING: The MICU and RICU of a 720-bed teaching hospital in Providence, RI.
PARTICIPANTS: All ICU staff during the study period.
INTERVENTIONS: Once the noises that were determined to be amenable to behavior modification were identified, a behavior modification program was conducted during a 3-week period in our MICU. Baseline and post-behavior modification noise recordings were compared in 6-h intervals after sites were matched by number of patients in a room and Acute Physiology and Chronic Health Evaluation II (APACHE II) scores.
MEASUREMENTS AND RESULTS: We identified several causes of sound peaks > or = 80 dBA amenable to behavior modification; television and talking accounted for 49%. We also significantly reduced the 24-h mean peak noise level (p=0.0001), as well as the mean peak noise level (p=0.0001) and the number of sound peaks > or = 80 dBA (p=0.0001) in all 6-h blocks except for the 12 AM to 6 AM period.
CONCLUSIONS: We conclude that many of the noises causing sound peaks > or =80 dBA are amenable to behavior modification and that it is possible to reduce the noise levels in an ICU setting significantly through a program of behavior modification.

Su, L. L., H Bai, T (1996). "The design of air purification system and its effect on surgical ICU." [Chinese Journal of Surgery] Zhonghua Wai Ke Za Zhi, **34**(5): 291-293.

It is very important to protect air-cross infection and improve air quality in surgical intensive care unit. In the design and effect of "local air condition and purification control system", air microbe colony counter was greatly reduced to 48/m3 (control area), and 105/m3 (uncontrol area), compared to 618/m3 (untreatment), P < 0.01. This system shows stable function, sterilization effect, low cost, and is useful to protect air pollution in surgical intensive care unit.

Meyer, T. J., et al. (1994). "Adverse Environmental Conditions in the Respiratory and Medical ICU Settings." Chest, **105**(4): 1211-1216.

Sleep deprivation and fragmentation occurring in the hospital setting may have a negative impact on the respiratory system by decreasing respiratory muscle function and ventilatory response to CO2. Sleep deprivation in a patient with respiratory failure may, therefore, impair recovery and weaning from mechanical ventilation. We postulate that light, sound, and interruption levels in a weaning unit are major factors resulting in sleep disorders and possibly circadian rhythm disruption. As an initial test of this hypothesis, we sampled interruption levels and continuously monitored light and sound levels for a minimum of seven consecutive days in a medical ICU, a multiple bed respiratory care unit (RCU) room, a single-bed RCU room, and a private room. Light levels in all areas maintained a day-night rhythm, with peak levels dependent on window orientation and shading. Peak sound levels were extremely high in all areas representing values significantly higher than those recommended by the Environmental Protection Agency as acceptable for a hospital environment. The number of sound peaks greater than 80 decibels, which may result in sleep arousals, was especially high in the intensive and respiratory care areas, but did show a day-night rhythm in all settings. Patient interruptions tended to be erratic, leaving little time for condensed sleep. We conclude that the potential for environmentally induced sleep disruption is high in all areas, but especially high in the intensive and respiratory care areas where the negative consequences may be the most severe.

Wedel, S., et al. (1995). "Guidelines for intensive care unit design. Guidelines/Practice Parameters Committee of the American College of Critical Care Medicine, Society of Critical Care Medicine." Critical Care Medicine, **23**(3): 582-588.

OBJECTIVES: To develop guidelines that can serve as a reference for healthcare institutions wishing to design a new intensive care unit (ICU) or modify an existing ICU.

DATA SOURCES: Medical, nursing, and architectural/design literatures from 1975 to the present related to ICU structure and function; current regulatory standards; consensus opinion of physicians, nurses, and architects with expertise in the ICU environment.
DATA SYNTHESIS: Preference was given to regulatory standards and outcomes-based studies. If none was found, studies showing trends or preferences were combined with consensus opinion to derive models combining cost-efficiency and function.
CONCLUSIONS: ICU design should reflect a multidisciplinary team approach by physician, nursing, administrative, and technical personnel. An optimum ICU design is described herein. Acceptable variations are indicated and essential aspects are emphasized.

Balogh, D., et al. (1993). "Noise in the ICU." Intensive Care Medicine, **19**(6): 343-346.
Objective. The growing number of technical devices in ICUs makes noise exposure a major stressor. The purpose of this study was to assess noise levels during routine operation in our ICU.
Design: Our ICU is an open ward with four rooms, constructed in the 1960s. During the study period, 4 patients were in the controlled room and were treated by 4 nurses during the day and by 2 at night. A-weighted sound pressure levels (SPL) were measured continuously for 2 days and nights. Also measured were the alarms of various appliances. For gross overall evaluation it is customary to state the Leq , i.e. the energy-averaged level during measurement. The annoyance caused by noise depends more on rare events of high intensity. Therefore, the distribution of SPL values (Ln) over time was also analysed.
Results: SPL was roughly the same during the day and at night, with Leq between 60-65 dB(A) and peaks up to 96 riB(A). Most alarms reach an SPL of 60-70 riB(A), but some exceed 80 dB(A). During teaching rounds Leq exceeds 65 dB(A).
Conclusion: During the day and at night SPL always surpasses the permissible noise exposure for 24 h of 45 db(A) recommended by the US Environmental Protection Agency. Alarms cause the most irritating noise. Hospital management should pay attention to internal noise, and SPL should be measured routinely.

White, A. and M. Burgess (1992). "Strategies for reduction of noise levels in ICUs." Australian Journal of Advanced Nursing, **10**(2): 22-26.
This paper reports on a study of noise levels in an intensive care unit. The various noise sources and their sound levels were identified. Sources of noise were classified into those generated by: people, equipment and room furniture. Strategies for the reduction of noise to levels likely to be less disturbing to patients are discussed.

Wood, A. M. (1993). "A review of literature relating to sleep in hospital with emphasis on the sleep of the ICU patient." Intensive Critical Care Nursing, **9**(2): 129-136.
The subject of this literature review is the sleep of hospitalised patients, with particular emphasis on the sleep of patients in intensive care units (ICUs). Initially there is an overview of the structure of sleep and the literature related to the main theories of sleep function in order to set the subject in context. A review of some of the work related to the sleep patterns of ICU patients outlines how severely sleep-deprived many patients are. Studies of sleep patterns implicate the environment of ICUs as an important factor in preventing sleep, but factors particular to patients which have an adverse effect on sleep are also reviewed, with particular reference to a study addressing the incidence of pain and discomfort of patients. Finally the sleep patterns of patients whose environment was carefully controlled to exclude factors known to disrupt sleep are reviewed. Thus the review moves from broad issues affecting sleep to the more focused issues personal to individual patients, with implications for nursing practice addressed as each point arises. In this way the complexity of the whole issue of sleep and the lack of sleep experienced by hospitalised patients is highlighted.

Ulrich, R. S. (1984). "View through a window may influence recovery from surgery." Science, **224**(4647): 420-421.

Examined records on recovery after cholecystectomy of 46 patients admitted to a suburban hospital between 1972 and 1981 to determine whether assignment to a room with a window view of a natural setting might have restorative influences. Ss were matched in pairs according to sex, age, smoking or nonsmoking status, obese or normal weight status, year of surgery, and floor level (2nd or 3rd). Data indicate that Ss assigned to rooms with windows looking out on a natural scene had shorter postoperative hospital stays, received fewer negative evaluative comments in nurses' notes, and took fewer potent analgesics than Ss in similar rooms with windows facing a brick wall. Implications for hospital designs and therapeutic settings are discussed.

Youngner, S. J., et al. (1984). "ICU visiting policies." Critical Care Medicine, **12**(7): 606-608.

Head nurses from 78 ICUs in 37 northeast Ohio hospitals were interviewed about visiting policies. There was tremendous variation with regard to frequency and length of visits; 25% of these ICUs allowed only 2 visits/day, and 42% restricted visits to under 20 min. Most units rarely or never allowed children under 12 yr old to visit. Traditional rationales for restricted visiting are not supported by studies in the literature, nor are they consistent with current concepts of patients' rights. In an era where high technology and medicine by-the-numbers threaten to dehumanize patients, open visiting is an important part of the humanization process.

Keep, P., et al. (1980). "Windows in the intensive therapy unit." Anaesthesia, **35**(3): 257-262.

Retrospective surveys were carried out on two groups of patients who had survived a stay of at least 48 h in an Intensive Therapy Unit. One group had been kept in a unit without windows, and the other in a similar unit with translucent but not transparent windows. Survivors from the windowless unit had a less accurate memory of the length of their stay, and were less well orientated in time during their stay. The incidence of hallucinations and delusions was more than twice as high in the windowless unit. The phenomenon of depersonalisation in the face of life-threatening danger is described and discussed.

Keep, P. J. (1977). "Stimulus deprivation in windowless rooms." Anaesthesia, **32**(7): 598-602.

Enough evidence now exists to suggest that windowless environments in hospitals increase the risk to the patient for a number of reasons. These include a direct influence on his own physiological and psychological state, a lowering of the standard of care by an effect on hospital staff, and increased vulnerability to physical hazards. The psychological ill effects of the intensive therapy unit (ITU) environment on its occupants are well recognised. The aggravation of these effects by the construction of any further windowless units can no longer be regarded as acceptable.

OTHER RESOURCES

Web Links:
Guidelines for ICU design:
http://www.learnicu.org/SiteAssets/Pages/Guidelines/Guidelines%20for%20intensive%20care%20unit%20design.pdf

A summary of award winning ICUs and their distinguishing features:
http://www.worldhealthdesign.com/Critical-Care-Design-Trends-in-Award-Winning-Designs.aspx