

Innovation Series 2009

Using Evidence-Based Environmental Design to Enhance Safety and Quality

*The Institute for Healthcare Improvement thanks
The Center for Health Design, our colleagues in this
important work to improve the safety and quality of health care.*

The Institute for Healthcare Improvement (IHI) is a not-for-profit organization leading the improvement of health care throughout the world. IHI helps accelerate change by cultivating promising concepts for improving patient care and turning those ideas into action. Thousands of health care providers participate in IHI's groundbreaking work.

We have developed IHI's Innovation Series white papers as one means for advancing our mission. The ideas and findings in these white papers represent innovative work by IHI and organizations with whom we collaborate. Our white papers are designed to share the problems IHI is working to address, the ideas we are developing and testing to help organizations make breakthrough improvements, and early results where they exist.

Copyright © 2009 Institute for Healthcare Improvement

All rights reserved. Individuals may photocopy these materials for educational, not-for-profit uses, provided that the contents are not altered in any way and that proper attribution is given to IHI as the source of the content. These materials may not be reproduced for commercial, for-profit use in any form or by any means, or republished under any circumstances, without the written permission of the Institute for Healthcare Improvement.

How to cite this paper:

Sadler BL, Joseph A, Keller A, Rostenberg B. *Using Evidence-Based Environmental Design to Enhance Safety and Quality*. IHI Innovation Series white paper. Cambridge, Massachusetts: Institute for Healthcare Improvement; 2009. (Available on www.IHI.org)

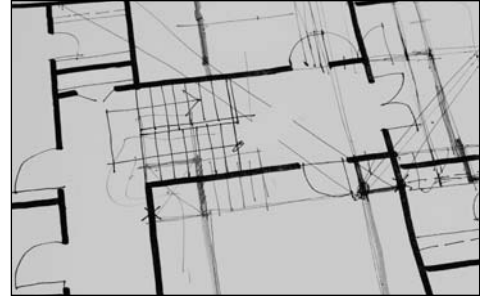
Acknowledgements:

The authors would like to thank Maureen Bisognano, Jim Conway, Pat Rutherford, Sue Gullo, Don Goldmann, and Andrea Kabcenell of the Institute for Healthcare Improvement for their generous advice and comments in the development of this paper.

The authors also thank IHI staff members Jane Roessner, PhD, and Val Weber for their editorial review and assistance with this paper.

For print requests, please contact:

Institute for Healthcare Improvement, 20 University Road, 7th Floor, Cambridge, MA 02138
Telephone (617) 301-4800, or visit our website at www.IHI.org



Innovation Series 2009

Using Evidence-Based Environmental Design to Enhance Safety and Quality

Authors:

Blair L. Sadler, JD, *Senior Fellow, Institute for Healthcare Improvement*

Anjali Joseph, PhD, *Director of Research, The Center for Health Design*

Amy Keller, MArch, *Research Associate, Pebble Design Strategist, The Center for Health Design*

Bill Rostenberg, FAIA, FACHA, *Principal and Director of Research, Anshen + Allen Architects*

Executive Summary

The Institute for Healthcare Improvement (IHI) has had a long history of looking outside, as well as inside, the health care sector for ideas and possible solutions, and has recognized the need to build bridges between different and often disconnected disciplines. One recent example is the effort to bridge the gap between the world of safety and quality, and the world of the physical environment in which care is provided. The purpose of this paper is to show health care leaders how, as part of an integrated improvement strategy, evidence-based environmental design interventions can measurably enhance the care they provide, improve the perceptions of the experience of that care by patients, families, and staff, and actually have a positive economic impact on their organizations.

The paper begins by establishing a connection between the physical environment in which patients receive their care and its safety and quality. The published literature in evidence-based environmental design, including references to two major reviews of that literature, is also described. A series of relatively low-cost recommendations are presented that virtually any health care organization should consider implementing. The paper also offers recommendations that are best addressed as part of new facility construction or major renovation. Examples of interventions for unit-specific microsystems are proposed, along with a facility checklist that any organization can use as a guide to determine whether its environment is actually helping or hindering care and the care experience.

In economic terms, the paper describes how to balance initial, one-time capital expenditures with ongoing operating cost savings and revenue enhancement through market differentiation. A suggested framework for calculating the economic return on investment of an intervention or group of interventions is included.

This paper aims to help bridge the gap between the worlds of safety and quality improvement and architectural and environmental design. Similar to experiences in safety and quality improvement, usually no single environmental design intervention will produce significant and sustainable results. Design interventions should be part of an integrated set of changes containing several components that are implemented together.

Introduction

One Person's Perspective

"I try to think of a perfectly designed hospital and it would be more reliable—fewer drop-offs, fewer mistakes. There would be more precision—promises kept. It would be peaceful, healing—a quiet place—where patients can use their limited energy to get better, instead of having to fight the environment. And, most especially, the loved ones of patients are there all the time.

There would be a sense of things in their place, a place for everything. I think it would be simpler. I think the clutter and complexity and the machines and the bells and whistles need to be managed out of the care. I think it would feel more like home probably and therefore it has to be more customized. And somehow all of this needs to rest on science because we are in a technical enterprise that has to use knowledge and machines and drugs correctly. So underneath all is a confidence that we are going to do the right thing every single time."

—Donald Berwick, MD, President and CEO, Institute for Healthcare Improvement

In: *Transforming Hospitals: Designing for Safety and Quality*. [video] Rockville, MD: Agency for Healthcare Research and Quality; September 2007.

Connecting Evidence-Based Environmental Design to Quality Improvement

Increasing evidence indicates a correlation between the physical environment in which patients receive their care and the safety and quality of that care, as well as the patient's perception of that care. Similarly, there is a growing understanding of the connection between the environments in which people work and job satisfaction and stress.

A significant body of evidence shows that the physical environment is a critical component in programs to improve safety and quality for patients and provide a safer working environment for staff.¹ As part of a comprehensive quality improvement program, the physical environment can help reduce preventable harm to patients, such as hospital-acquired infections and falls, and must be carefully considered when designing new or renovated facilities.

Patients' perceptions of their care experience should become much more important in light of the publicly available Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) data mandated by the Centers for Medicare and Medicaid Services (CMS). In an article assessing patient perception of care in American hospitals, the authors examined several domains of the patient experience. The component that received the lowest composite score (52 percent) was a quiet room.² With the baby boomer generation reaching an age where they will be consuming more

health care resources, they will be demanding quality care provided in physical environments that also help them get better and feel better.

The physical environment can also have a significant impact on revenue enhancement and operating cost avoidance, making it a sound long-term investment. As described by the research review mentioned above,¹ design interventions such as single patient rooms contribute to fewer healthcare-acquired infections, and ceiling-mounted patient lifts contribute to dramatically reduced caregiver back injuries. For example, at Peace Health in Eugene, Oregon, a 60-month study in two units where ceiling lifts were installed as part of a “no lift” policy showed an 83 percent reduction in annual work injury costs related to patient lifting. As a result, Peace Health included ceiling lifts in all 309 patient rooms in a subsequently constructed hospital in Riverbend in order to be “lift ready.” They predict that they will realize a return on this investment in 2.5 years.³

With the widespread dissemination of HCAHPS patient satisfaction scores, there could be a strong revenue incentive to make prudent evidence-based environmental design interventions that reduce errors, noise, anxiety, confusion, and stress. These are all attributes of the care experience that patients and families understand and care about. It is likely that these attributes will influence patients’ willingness to recommend a particular hospital or physician. The business case for evidence-based design should become significantly enhanced over time.

Further, many hospital facilities have simply come to the end of their useful lives, while, in several states, seismic and other safety requirements are mandating significant facility upgrades. In the US, we have entered a major hospital construction boom. It is projected that the already strong health care construction sector will have grown by 13 percent to a total of \$53.8 billion in 2008 and will continue to experience a high growth rate through 2011.⁴ In the year 2011, this figure is projected to reach \$67 billion.⁵ Despite the current national economic crisis (indeed, several health care providers have put construction projects on hold), health care construction remains more active than at any time since the federally funded Hill Burton program 50 years ago.

Evidence-Based Environmental Design: What the Literature Tells Us

Several recent studies have established the relationship between the physical design of hospitals and key outcomes. A multidisciplinary team completed a comprehensive review of the world’s literature on evidence-based environmental design.¹ After screening an extensive series of cross-referenced keyword searches, all identified literature was evaluated using two criteria: 1) the study should be empirically based and examine the influence of environmental characteristics on patient, family, or staff outcomes; and 2) the quality of each study in terms of its research design and methods, and whether the journal in which the study was published was peer-reviewed. The review team then

organized their review of approximately 1,000 articles into three categories: 1) *patient safety issues* such as infections, medical errors, and falls; 2) *other patient outcomes* such as pain, sleep, stress, depression, length of stay, spatial orientation, privacy, communication, social support, and overall patient satisfaction; and 3) *staff outcomes* such as injuries, stress, work effectiveness, and satisfaction.

Ulrich and colleagues state, “Compared to 2004, the body of evidence has grown rapidly and substantially...It is now widely recognized that well designed physical settings play an important role in making hospitals less risky and stressful, promoting more healing for patients, and providing better places for staff to work.”¹

A second comprehensive review, focused on the pediatric evidence-based design literature, assessed 320 articles individually for quality, rigor, and relevance.⁶ A majority of the articles assessed were controlled observational (cohort or case control) studies without control groups, surveys, or case studies. The authors of this review conclude, “A growing body of research shows that the physical design of pediatric health care settings contributes to positive or negative clinical, developmental, psychosocial, and safety outcomes among patients and families. The physical environment is a key component of providing patient- and family-centered care and increasing safety and overall quality of care in pediatric settings.”

In late 2008, The Joint Commission released the report, *Guiding Principles for the Development of the Hospital of the Future*. It contains a chapter on the design of the physical environment which relies on much of the same published research and includes a series of general principles that are fully consistent with the analysis and recommendations of this white paper.⁷

- Incorporate evidence-based design principles that improve patient safety, including single patient rooms, decentralized nursing stations, and noise-reducing materials, in hospital construction.
- Address high-level priorities, such as infection control and emergency preparedness, in hospital design and construction.
- Include clinicians, other staff, patients, and families in the design process to maximize opportunities to improve staff workflow and patient safety, and to create patient-centered environments.
- Design flexibility into the building to allow for better adoption to the rapid cycle of innovation in medicine and technology.
- Incorporate “green” (environmentally conscious) principles in hospital design and construction.

Similar to experience in quality improvement, frequently no single environmental design intervention will produce significant and sustainable measurable results. Interventions should be part of an integrated set of changes containing several components that, when implemented together, will lead to improvement. For example, installing alcohol-based hand gel dispensers in all patient rooms and high-volume treatment areas will not alone improve hand hygiene compliance by nurses, physicians, and other caregivers. But, when part of a comprehensive program that also includes education, competency

checks, behavioral change techniques and accountability, such dispensers can have a significant impact. Installing hydraulic ceiling-mounted lifts alone will not reduce workforce injuries but, when part of a comprehensive “no lifts” education and standards program, ceiling lifts can help to dramatically reduce patient lift injuries.³ The installation of sound-absorbing ceiling tiles in patient rooms will not alone improve a patient’s ability to sleep, but, when part of an integrated noise reduction plan, can make a measurable difference.

Similar to the debate about the rigor and type of published studies in evidence-based medicine, there is not complete consensus about the persuasive power of studies in evidence-based design in terms of their causal effects. In the two comprehensive literature reviews mentioned above,^{4,6} the authors describe the types of categories of research and their relative strengths.

In conclusion, the literature tells us that ample evidence now exists in support of many evidence-based design interventions and that they can significantly enhance the ability of hospitals to achieve safety and quality goals if implemented in an integrated way with other quality improvement and change strategies. In addition to published studies, The Center for Health Design’s research initiative, the Pebble Project, is a joint effort with several health care providers and suppliers to provide researched and documented examples of health care facilities whose physical design has made a difference in their safety, quality, and efficiency.⁸

Design Recommendations for Existing and Newly Built Facilities

We offer the following design recommendations based on the strength of the evidence in the literature,^{4,6} our opinion about their inherent reasonableness, and their impact on safety, quality, or cost. An extensive discussion regarding these design recommendations as well as the supporting references can be found in the literature reviews referenced earlier.^{4,6} Only one key reference per recommended design intervention is provided in the tables below. These recommendations can be implemented in virtually any facility undergoing minor renovations and at relatively low cost (see Table 1). Other strategies require greater financial investment and significant physical modifications; they are best implemented as part of a major renovation or a new construction project (see Table 2).

In addition, Appendix A includes a list of questions that hospital leaders should consider when evaluating new construction or renovation projects.

Table 1. Design Interventions for Existing Health Care Facilities

Design Intervention	Quality and Business-Case Benefits	Literature in Direct Support of Intervention (key references only)
1. Install alcohol-based hand gel dispensers at each patient bedside and at all points of patient care	Reduced infections, improved hand hygiene compliance	⁹ Randle J, Clarke MC, Storr J. Hand hygiene compliance in healthcare workers. <i>Journal of Hospital Infection</i> . 2006;64(3):205-209.
2. Install noise-mitigation materials such as sound-absorbing ceiling tiles as part of a noise reduction plan	Reduced patient and staff stress, reduced patient sleep deprivation, increased patient satisfaction	¹⁰ Blomkvist V, Eriksen CA, Theorell T, Ulrich RS, Rasmanis G. Acoustics and psychosocial environment in coronary intensive care. <i>Occupational and Environmental Medicine</i> . 2005;62:1-8.
3. Utilize music and art as positive distractions during procedures	Reduced patient stress, pain, medication use, and anxiety	¹¹ Walworth DD. Procedural-support music therapy in the health-care setting: A cost-effectiveness analysis. <i>Journal of Pediatric Nursing</i> . 2005;20(4):276-284. ¹² Ulrich RS, Gilpin L. Healing arts: Nutrition for the soul. In: Frampton SB, Gilpin L, Charmel P, eds. <i>Putting Patients First: Designing and Practicing Patient-Centered Care</i> . San Francisco: Jossey-Bass; 2003:117-146.
4. Include effective wayfinding systems	Reduced staff time spent giving directions, reduced patient and family stress	¹³ Carpman J, Grant M. <i>Design That Cares: Planning Health Facilities for Patients and Visitors</i> (2nd edition). Chicago: American Hospital Publishing; 1998.
5. Improve task lighting in pharmacy and medication rooms	Reduced medication errors	¹⁴ Buchanan TL, Barker KN, Gibson JT, Jiang BC, Pearson RE. Illumination and errors in dispensing. <i>American Journal of Hospital Pharmacy</i> . 1991 Oct;48(10):2137-2145.

It is difficult to provide an “average” cost estimate for each design intervention, due to a series of variables, including age of the building and utility systems if the building has been updated; degree to which the building complies with building codes and regulations; regulatory climate and codes

governing renovation; building construction (materials, structural bay spacing and construction, floor-to-floor heights, accessibility to areas not readily visible, etc.); and nature and complexity of utility systems behind walls and ceilings.

Some minor facility improvements can trigger additional seemingly unrelated work, particularly if the infrastructure is outdated. For example, an additional hand washing sink might be relatively simple to install in a new facility, but could require the plumbing system to be updated in an older one. In such circumstances, the addition of a surface-mounted dispenser for alcohol-based hand gel might provide similar benefits.

These relatively low-cost design interventions should be considered and carefully evaluated as part of any organization's improvement efforts. They have the potential to significantly improve care and raise patient satisfaction scores. Further, when undertaking new construction or major renovations, there are additional design interventions that should be considered (see Table 2).

Table 2. Design Interventions for Health Care Facilities as Part of New Construction or Major Renovation

Design Intervention	Quality and Business-Case Benefits	Literature in Direct Support of Intervention (key references only)
1. Build private patient rooms	Reduced infections, increased privacy, increased number of actual usable beds, increased patient satisfaction	¹⁵ Chaudhury H, Mahmood A, Valente M. Advantages and disadvantages of single- versus multiple-occupancy rooms in acute care environments: A review and analysis of the literature. <i>Environment and Behavior</i> . 2005;37(6):760-786.
2. Provide adequate space for families to stay overnight in patient rooms	Increased patient and family satisfaction, reduced patient and family stress	¹⁶ Rashid M. A decade of adult intensive care unit design: A study of the physical design features of the best-practice examples. <i>Critical Care Nursing Quarterly</i> . 2006;29(4):282-311.
3. Design rooms to minimize transfers and handoffs such as acuity-adaptable rooms or combining transitional care rooms with medical-surgical or ICU rooms	Reduced intra-hospital transfers, reduced errors, increased patient satisfaction, reduced unproductive staff time	¹⁷ Hendrich A, Fay J, Sorrells A. Effects of acuity-adaptable rooms on flow of patients and delivery of care. <i>American Journal of Critical Care</i> . 2004 Jan;13(1):35-45.

Design Intervention	Quality and Business-Case Benefits	Literature in Direct Support of Intervention (key references only)
4. Build larger patient bathrooms with double-door access and handrails	Reduced patient falls, reduced staff back injuries	¹⁸ Hignett S, Evans D. Spatial requirements in hospital shower and toilet rooms. <i>Nursing Standard</i> . 2006 Sep 27-Oct 3;21(3):43-48.
5. Install improved air handling systems such as HEPA filters in areas treating immunosuppressed patients	Reduced airborne-caused infections	¹⁹ Oren I, Haddad N, Finkelstein R, Rowe JM. Invasive pulmonary aspergillosis in neutropenic patients during hospital construction: Before and after chemoprophylaxis and institution of HEPA filters. <i>American Journal of Hematology</i> . 2001;66(4):257-262.
6. Install ceiling-mounted lifts in the majority of patient rooms	Reduced staff back injuries	²⁰ Miller A, Engst C, Tate RB, Yassi A. Evaluation of the effectiveness of portable ceiling lifts in a new long-term care facility. <i>Applied Ergonomics</i> . 2006 May; 37(3):377-385.
7. Provide access to natural light in patient and staff areas	Reduced patient anxiety and depression, reduced length of stay, reduced staff stress	²¹ Walch JM, Rabin BS, Day R, Williams JN, Choi K, Kang JD. The effect of sunlight on postoperative analgesic medication use: A prospective study of patients undergoing spinal surgery. <i>Psychosomatic Medicine</i> . 2005 Jan-Feb;67(1):156-163.
8. Build decentralized nursing stations	Increased staff time spent in direct patient care	²² Howard L, Malloch K. Centralized and decentralized nurse station design: An examination of caregiver communication, work activities, and technology. <i>Health Environments Research and Design Journal</i> . 2007;1(1):44-57.

Design Interventions for Specific Care Areas

Many quality improvement teams are focusing their efforts on a particular care unit in the hospital or in the medical office practice setting. Below are several recommended design interventions for six care areas which we believe will help to enhance safety and quality improvements underway.

Operating Room

Studies show that design characteristics of the operating room (OR) impact staff functioning and communication, as well as patient safety. Ventilation and filtration in the operating room environment can have an impact on surgical site infections, but various opinions abound regarding which ventilation and filtration systems are most effective. For example, numerous studies have been conducted discussing the advantages and disadvantages of the use of laminar flow (i.e., very even, smooth, low-velocity airflows that are used in clean-rooms and other settings) along with HEPA filters and automatically closing doors to reduce the incidence of surgical site infections.²³

Additional information can be found in the Centers for Disease Control and Prevention *Guidelines for Environmental Infection Control in Health-Care Facilities*.²⁴ There is a need for more research in this area.

Operating rooms tend to be crowded with a lot of equipment, monitors, carts, tables, and people over long periods of time. These environments tend to be noisy, with no access to natural light. These factors, along with the physically intense nature of the work performed, make the environment very stressful for nurses and physicians. It is important to improve working conditions for staff by reducing noise levels and by using ergonomic design of work areas. However, such design interventions must be considered within the greater context of variable design drivers. For example, most sound-absorbing materials are not easily cleaned and thus may be inappropriate for use in the surgical environment. Similarly, short-term solutions for reducing neck and back problems experienced by surgical nurses as well as guidelines for operating room design have been suggested based on an ergonomic evaluation of nursing work areas in the operating room.²⁵ Some suggestions include adjustable-height footstools, better monitor placement, and ergonomically designed instrument tables to help reduce neck and back torsion experienced by surgical nurses as they attempt to obtain an unobstructed view of the operating field and reach for instruments on instrument tables.

Intensive Care Unit

Communication and collaboration are key factors in the effective treatment of high-risk and critically ill patients. Ensuring communication and collaboration among families, patients, and the care team requires providing space for family support within the patient environment, maintaining privacy, and minimizing noise. An opportunity exists to improve outcomes by providing different levels of care without having to move patients from room to room as their acuity improves—known as an “acuity-adaptable patient room”—thus minimizing handoffs, reducing the potential for patient slips and falls

to occur, and reducing the incidence of staff injuries related to patient lifting. An acuity-adaptable room requires more than just an architectural solution; it also requires cultural and operational changes in order for caregivers to support a one-room/multiple-acuity care model. Reductions in medication errors, falls, and patient transfers have been shown using an acuity-adaptable model.¹⁷ The impact of modifying room acoustics was assessed by periodically changing sound-reflective ceiling tiles to sound-absorbing ceiling tiles within an intensive coronary care unit and revealed that patients' sleep patterns were better with sound-absorbing ceiling tiles in place.¹⁰

Having family members present during cardiopulmonary resuscitation is becoming a common practice in pediatrics. One study determined parents' perception of the effects of their presence during resuscitation efforts of their child. The findings from this study revealed that family presence during cardiopulmonary resuscitation should be encouraged and supported.²⁶ A design implication for supporting this practice is providing adequate space for families on the unit.

Emergency Department

Within an emergency department (ED) there can be an underlying conflict between the patient's need for privacy and the ED team's need to directly visualize and monitor a patient. A study conducted in a university medical center's ED found that time to initial physician assessment was higher for chest pain patients placed in rooms farther from the staff work area or placed in rooms with doors (rather than curtains).²⁷ This study suggested that visual and/or auditory barriers might impede timely intervention by physicians. On the other hand, lack of perceived privacy may impact patient trust and their ability to discuss health problems freely with their physicians. The seriousness of the problem is underscored by a study of an emergency department where five percent of the patients examined in curtained spaces reported withholding portions of their private history and refused parts of their physical examination because of lack of privacy.²⁸ It is important to optimally balance these issues of patient safety and patient privacy through design, for example, by providing enclosed treatment rooms for privacy and HIPAA compliance while also placing and configuring nurse stations to maximize room visibility.

Efforts to improve patient flow in the emergency department often focus on increasing the size of the ED, but this alone is inadequate and is not necessarily the best solution. Interventions to improve flow must look system-wide to understand how bottlenecks at different points in the care system create a "back up," which then manifests in the ED. When Virtua Health, a participating organization in The Center for Health Design's Pebble Project, started designing their new replacement facility in Voorhees, New Jersey, improving patient flow was an integral goal of their planning process. They used Lean and Six Sigma techniques to identify current problems in the system and then used future state mapping and other methods to identify the physical designs that would result in improved flow and a better patient experience in their hospital. Some environmental characteristics that they examined carefully in their quest to improve flow included the following:

- *Travel distances* and frequency of trips for different individuals in alternative designs, with a goal of minimizing non-value-added trips and reducing fatigue
- *Departmental adjacencies* that are most efficient
- *Wayfinding ease*, including getting to the hospital as well as understanding how the patient moves through it
- *Single patient rooms* to optimize use of beds to which patients could be transferred

Innovative environmental design also has the potential to reduce the frequency of patients who choose to leave the ED without being seen. A patient's fear that he or she will not receive timely care might be impacted by the ED's design. Is the environment crowded, unattractive, and noisy such that it adds to the stress of waiting and makes the waiting time seem longer? A crowded and noisy emergency waiting room conveys the wrong message to an already stressed patient. Waiting room configuration as well as positive distractions such as views to nature or artwork can help distract patients and reduce stress. A study conducted at New York City's Weill Cornell Medical College examined the relationships between the attractiveness of the physical setting and actual and perceived waiting times, quality of care, anxiety, and staff-patient interaction in seven specialty outpatient practices in Manhattan. The study found that the more attractive the environment, the higher the perceived quality of medical care, the higher reported reduction of anxiety, and the more positive the reported interaction with staff. Also, patients in more attractive physical environments perceived shorter waiting times than patients in less attractive environments.²⁹

Medical-Surgical Nursing Unit

A literature review of studies linking the physical environment of hospitals with patient and staff outcomes identified a large number of studies that point to the fact that private patient rooms are superior to semi-private patient rooms for several reasons.⁴ In addition to the infection control advantages discussed earlier, other benefits include fewer patient transfers and associated medical errors; less noise (thus improved sleep); better patient privacy and confidentiality; better communications between staff and patients; superior accommodation of family; and consistently higher satisfaction with the overall quality of care delivered.

There is also some evidence that greater family presence in single patient rooms (due to better accommodation of family needs) helps prevent patient falls and other adverse events.¹⁷ Innovations such as acuity-adaptable single patient rooms minimize patient transfers, and the time saved translates into increased caregiver time with the patient at the bedside.¹⁷ Many new health care facilities are incorporating designs based on the findings from other industries such as the aeronautical industry, where standardization has shown to significantly reduce human error. Standardization in patient room design helps to minimize unnecessary variability in design details (e.g., location of gases) between patient rooms that could potentially lead to errors. These are promising new health care design interventions that need to be validated through research.

Other design features in the patient unit—such as decentralized nursing stations and alcoves with views into patient rooms—increase visibility and access to patients, potentially improving communications and reducing adverse events. For example, reducing distances that caregivers routinely walk to access supplies and patient rooms also reduces staff fatigue and stress.

Noise is a persistent problem on most patient floors. The first step to reducing unwanted noise levels is to conduct a noise audit to determine sources, and then identify design strategies that will reduce or remove noise. Studies show that sound-absorbing ceiling tiles can help control acoustics on patient units which, in turn, results in improved speech intelligibility and reduced staff and patient stress. Several studies have shown that other design features such as access to nature and sunlight improve the perception of pain, accelerate patient recovery, and increase overall patient satisfaction with quality of care. Space for the family in the patient room and the attractiveness of the facility are linked to patient satisfaction and willingness to recommend the health care organization to others. Overall attractiveness of the facility, access to nature and sunlight, and the availability of staff respite areas are also associated with greater staff satisfaction.

Medical Office Setting

Redesigning the clinical office practice to embody many environmental design interventions can lead to increased patient and family satisfaction (e.g., minimizing noise, providing positive distractions), improved provider-to-patient communication (e.g., technology improvements, spatial organization of the room), and enhanced organizational efficiency (e.g., electronic health records, improving visual access).³⁰ Improving access to the medical office practice by addressing geographic proximity issues, establishing convenient access to the clinic from parking areas, and providing clear wayfinding systems within the facility create a more positive patient experience.³⁰ The design of waiting areas has a direct correlation to patient satisfaction. In one study, waiting areas that were considered to have higher physical attractiveness were associated with reduced patient anxiety, higher perceptions of quality care, and shorter perceived wait times.²⁹ Technology is increasingly providing additional ways to improve communications between providers and patients. The spatial organization of the exam room and orientation of computer screens that allow patients to see the information on the screen affects patient and clinician communication as well as the sense of connection experienced by the patient. Wait times can be reduced by implementing decentralized nurse stations, information kiosks, and the use of electronic medical records.³⁰

Neonatal Intensive Care Unit

Several studies focusing on environmental factors within neonatal intensive care unit (NICU) settings have been identified in a literature review published by the National Association of Children's Hospitals and Related Institutions.⁸ Among the environmental factors identified to have an effect on NICU patients were loud noise, high light levels, and infectious pathogens.

Infants exposed to excessive noise levels in the NICU have been shown to have poor auditory system development, poor auditory attention, and increased stress. Many studies show that interventions to reduce noise levels can be extremely beneficial to infants in a NICU. Altering the noise levels within the infant's incubator can be an efficient way to alter the noise environment and does not require facility renovations. Interventions that have demonstrated physiological benefits for infant development and convalescence include covering the incubator, installing a sound-absorbing panel in the incubator, and placing sound-absorbing foam next to the infant.

As in other areas of the hospital environment, sound-absorbing acoustical ceiling tiles are effective in reducing noise and reverberation and can be used in the NICU. One hospital, constructing a developmental NICU, included sound-absorbing flooring, wall panels, ceiling tiles, and privacy curtains.³¹ They also included new and more advanced equipment. The researchers found that the renovations and new equipment resulted in significant decreases in noise levels.

Infants are sensitive to light exposure and therefore the environment of the NICU impacts physiological outcomes and visual development among preterm infants. Cycled lighting (i.e., reduced light levels in the night) and providing focused lighting over incubators helps improve sleep and developmental outcomes among infants.⁶

The single family room design in the NICU provides a controlled and safe environment for the infant, and privacy and the opportunity to personalize for the family. In addition, each infant receives appropriate lighting, sound, and level of care for his/her particular developmental state.⁶ Single family rooms are also linked to fewer nosocomial infections.⁴ Several studies on staff perceptions and performance in an open bay versus a private room model suggest staff perceive that the private room model improved the quality of the physical environmental conditions, interaction with infants' families, and overall patient care. While concerns have been raised by caregivers and parents that private rooms can be visually and acoustically isolating, these issues can be addressed satisfactorily through good design.

Checklist for Providing an Optimal Healing Environment

Based on the published research and the experience of many organizations, we recommend that any health care organization use the following checklist to assess whether they are providing a physical environment that promotes optimal healing.

Table 3. Checklist of Physical Design Elements to Promote an Optimal Healing Environment

Environmental Design Element	Implemented		Comments
	Yes	No	
1. Build private patient rooms			
2. Provide adequate space for families to stay overnight in patient rooms			
3. Install alcohol-based hand gel dispensers:			
In patient rooms			
In patient care areas			
4. Meet World Health Organization recommended noise level standards: [†]			
Perform noise audit			
Develop noise reduction plan (e.g., eliminate audible paging)			
Implement noise reduction plan			
5. Optimize lighting in medication prep areas			
6. Minimize unnecessary patient transfers (e.g., acuity-adaptable rooms)			
7. Provide wider doors in patient bathrooms			
8. Install optimal air filtration systems (i.e., protect immunosuppressed patients)			
9. Install ceiling-mounted patient lifts to reduce staff injuries:			
In patient rooms			
In patient care areas			
10. Install clear, effective wayfinding systems			

[†]Berglund B, Lindvall T, Schwela DT, eds. *Guidelines for Community Noise*. Geneva: World Health Organization; 1999. Available at: <http://whqlibdoc.who.int/hq/1999/a68672.pdf>

Environmental Design Element	Implemented		Comments
	Yes	No	
11. Install “positive distractions” (to reduce patient anxiety):			
Music			
Art and interactive art			
Architectural features			
12. Provide choices for patients:			
Control lighting			
Control privacy			
Control music and visual images			

In addition to these elements of the physical environment, the materials hospitals use and the way energy is consumed also contribute to positive or negative outcomes. In October 2007, the Global Health and Safety Initiative was launched to create a social movement designed to develop synergies between “three safeties”: patient safety, worker safety, and environmental safety and sustainability. The core assumption is that these safeties can be improved, as well as health care facilities themselves, by how we build, the products we buy, and by how we operate. As part of this work, an open source searchable database of recommended best practices for evidence-based design was developed from focus groups conducted by Kaiser Permanente and others.³²

The Business Case: Balancing One-Time Capital Costs and Ongoing Operating Savings

In light of mounting pressure to improve quality and safety, and growing evidence that design of the physical environment can contribute to both, why haven’t all hospitals rushed out and implemented these evidence-based design interventions? Some have. For those that haven’t, the barriers are often perceived to be economic.

Balancing One-Time Capital Costs and Ongoing Operating Savings

Central to the business case is the need to balance one-time construction costs against ongoing operating savings and revenue enhancements. The first attempt to analyze this balance was published in 2004 by a multidisciplinary team that reviewed published research and the actual experience of health care organizations that used evidence-based design in portions of their construction projects. Many of these were pioneering hospitals, called Pebble Project partners, which were part of a collaborative learning program sponsored by The Center for Health Design.

The authors designed a hypothetical *Fable Hospital*[™]. (The name *Fable* was chosen because it had not then been built.) When they analyzed the operating cost savings that resulted from reducing infections, eliminating unnecessary patient transfers, minimizing patient falls, lowering drug costs, lessening employee turnover rates, and improving market share and philanthropy, they concluded that, with effective management and monitoring, the financial operating benefits would continue for several years, making the additional innovations a sound long-term investment. Additional initial capital investments were recovered within three years. In short, there was a compelling business case for using evidence-based design to build better, safer hospitals.³³

In addition to the reduction in worker back injuries mentioned above, Sadler, Dubose and Zimring³⁴ have described cost savings resulting from fewer infections, fewer medications errors, reduced falls, and reduced lengths of stay. Additional cost-effective interventions that improve a facility's sustainability and environmental efficiency have been described extensively and are beyond the scope of this paper. They include such areas as toxic wastes, use of mercury, and the overall carbon footprint.³⁵

The Challenge of Moving from “Light-Green” to “Dark-Green” Dollars

To fully realize the business-case impact of the costs avoided by reducing infections or patient falls, organizations must estimate, capture, and reflect these in their financial statements. Similarly, organizations must capture the costs of reduced nursing turnover that requires less recruiting and training expenditures.

The movement of theoretical savings (“light-green” dollars) to actual savings to the hospital as reflected in its financial statements (“dark-green” dollars) is a key success factor to make the business case actually accomplish its objectives. This is true of any quality improvement intervention, whether or not connected to environmental changes, and was first described by an interdisciplinary team at the Institute for Healthcare Improvement.³⁶ Documenting actual cost savings in financial forecasts can be invaluable in convincing boards of trustees that evidence-based design investments are cost effective.

Emerging pay-for-performance methodologies that reward hospitals for quality and refuse to pay hospitals for harm they cause to patients (e.g., infections and falls) will further strengthen the business case. At the same time that the costs of unnecessary harm are increasing, public and employer expectations are growing. The emerging practice of not reimbursing organizations for hospital-acquired conditions and the public reporting of comparable patient satisfaction scores adds more weight to the revenue side of the business case. While Medicare has driven much of the initial reimbursement and transparent public-reporting requirements, Medicaid and commercial payers are rapidly adopting the same or similar practices.

A suggested framework that hospitals can use to calculate the return on investment of a specific evidence-based environmental design intervention is included in Appendix B. Each organization will need to incorporate the latest relevant evidence and its best judgment about the cost and revenue impacts of the interventions being considered.

Conclusion

Hospital leaders and boards face a new reality: they can no longer tolerate allowing environmentally preventable patient hospital-acquired conditions such as infections and falls; injuries to staff; unnecessary intra-hospital patient transfers that can increase errors; or increased patient and family anxiety, stress, and length of stay caused by noisy, confusing care environments.

Leaders need to understand the clear connection between constructing well-designed healing environments and improved health care safety and quality for patients, families, and staff, as well as the compelling business case for doing so. The physical environment in which people work and patients receive their care is one of the essential elements in reducing a number of preventable hospital-acquired conditions.

As part of their management and fiduciary responsibilities, hospital leaders and boards should include cost-effective, evidence-based environmental design interventions in all their improvement programs or risk suffering the economic consequences in an increasingly competitive and transparent environment. Implemented successfully, responsible use of evidence-based design will improve patient safety and quality, enhance workforce recruitment and retention, and produce a significant multi-year return on investment.

The effectiveness of any evidence-based environmental design intervention will rarely occur in isolation from other important proven process improvements. The experience with IHI's 100,000 Lives and 5 Million Lives Campaigns has shown that effective change packages are usually an integrated set of improvements that are best implemented together. Building a new hospital or renovating an existing one also provides a unique opportunity to transform the culture and processes of the overall organizational enterprise to maximize the investment.

Imagine a health care environment where there are no needless infections, no needless falls, no needless patient transfers, no needless noise, no needless sleep deprivation, no needless lack of patient control, no needless physical barriers to communication, no needless confusion, no needless anxiety, and no needless workforce injuries, fatigue and inefficiency. Creating these environments is now within our grasp. All we need is the creativity, courage, and discipline to utilize cost-effective design interventions that work. Hospital leaders have an opportunity and an obligation to assure that, whether patients are in their care for an hour, a day, a week, or a year, they are providing care in an optimal healing environment.

Appendix A.

How to Utilize Evidence-Based Environmental Design: Ask an Additional Question

Traditionally, hospital leaders have asked five questions when considering a major building project:

1. Urgency: Is the expansion/replacement actually needed now to fulfill the hospital's mission? What is the cost, in strategic terms, of not proceeding?
2. Appropriateness: Is the proposed plan the most reasonable and prudent in light of other alternatives?
3. Cost: Is the cost per square foot appropriate in light of other projects being built in the region?
4. Financial impact: Has the financial impact of additional volume, depreciation expense, and revenue assumptions been reasonably analyzed and projected?
5. Sources of funds: Is the anticipated combination of additional operating income, reserves, borrowing, and philanthropy reasonable and enough to support the project?

Now leaders should also ask a sixth question:

6. Impact of evidence-based design interventions: How will the proposed project incorporate all relevant and proven evidence-based design interventions to optimize patient safety, quality, and satisfaction, as well as workforce safety, satisfaction, productivity, and energy efficiency?²³

Appendix B. A Proposed Framework for Calculating Return on Investment

The following four-step framework can be helpful in calculating the return on investment (ROI) of an evidence-based environmental design intervention. While healthcare-acquired infections is the example used, the framework may be applied to any intervention.

STEP 1: Identify your improvement goal (e.g., reduce healthcare-acquired infections (HAIs) to “x” number per year). Calculate the current scope of the problem in your facility to establish a baseline.

STEP 2: Estimate improvement costs. Identify the specific evidence-based environmental design strategies as well as clinical and administrative strategies needed to reach your improvement goal. Identify the associated initial and lifecycle costs for each strategy.

Design Intervention	Initial Cost	Lifecycle Cost	Calculations/Comments
Provide 100% single patient rooms		Increased square feet (SF) with associated housekeeping, energy, and replacement furnishings costs	Single patient rooms are now the standard. However, these rooms are estimated to be __SF larger resulting in an average increase of __SF for an average inpatient unit, which could increase lifecycle operational costs.
Separate sink for staff in patient room		Increased operational plumbing maintenance costs	Separate staff sinks are now standard for new hospital construction. There may be minimal increased lifecycle operational costs.
Alcohol-based hand gel dispensers in all patient rooms		Replacement and maintenance costs and gel refill costs	Initial cost = (Total number of devices per patient room) x (Number of rooms)
Clinical and administrative interventions		Training costs	Include all incremental operating costs
Total Estimated Improvement Costs			

STEP 3: Calculate revenue improvement through cost avoidance. To understand the full impact of using evidence-based environmental design strategies, incorporate the financial impact of these improvements into the hospital's annual capital and operating budgets. Using estimated costs calculated in Step 2, determine the total cost avoided if the improvement goal is achieved.

Example:

(Number of HAIs avoided per year) x (Cost of average HAI) = Total Annual Cost Avoided

Additional revenue improvements may be projected because of fewer HAIs:

- Increased capacity for more patient admissions: Reducing the number of patients with HAI and their associated longer length of stay will increase the capacity for admitting additional patients and their associated revenue.
- Avoided non-reimbursement for certain HAIs: Hospitals are no longer reimbursed for a growing list of healthcare-associated conditions that harm patients, many of which are HAIs.
- Reduced litigation and settlement costs: There may be fewer associated litigation and settlement costs for HAI patients who sue because of harm.
- Improved bond rating: A hospital's credit rating and ability to raise capital may be improved by implementing evidence-based design features that improve the safety and quality of patient care; improve the retention, satisfaction, safety and efficiency of staff; and thereby improve the organization's bottom line.³⁷

STEP 4: Calculate the ROI. Compare the total annual cost avoidance identified in Step 3 with the total initial cost of the planned interventions in Step 2 to identify the ultimate financial savings over interim points along the hospital's lifecycle. For Year 2 and 5 costs, assume that you will have the same annual costs and cost avoidance for each year or you can project costs adjusted for inflation.

Variables	Initial Year	Year 2	Year 5
Cumulative revenue improvement through cost avoidance	Annual cost avoidance	Annual cost avoidance x 2	Annual cost avoidance x 5
Cumulative cost of improvements	Initial cost	Initial cost + Annual cost	Initial cost + (Annual cost x 4)
Savings	Cost avoidance – Cost of improvements	Cost avoidance – Cost of improvements	Cost avoidance – Cost of improvements

STEP 5: Embed the business case in the fabric of the organization. While the above steps will help you create a business case for evidence-based design, to be successful in implementation the leadership team should also do the following:

- Select an architect with a proven understanding of and experience in evidence-based design, who will work with your organization to find fiscally responsible solutions that look beyond the initial capital cost.
- Communicate performance-improvement targets and progress internally to all appropriate stakeholders.
- Communicate performance-improvement targets and progress externally to increase public awareness and recognition that can differentiate the organization in the marketplace and increase market share.
- Share lessons learned and publish results. In so doing, contribute to needed knowledge about the financial and clinical impact of evidence-based design.

For a more in-depth examination of the full range of steps the leadership team and board could follow to ensure successful implementation of evidence-based design, see the article by Zimring and colleagues.³⁸

References

- ¹ Ulrich R, Zimring C, Zhu X, et al. A review of the research literature on evidence-based health-care design. *Health Environments Research and Design Journal*. 2008;1(3):61-125.
- ² Jha AK, Orav J, Zheng J, Epstein AM. Patients' perception of hospital care in the United States. *New England Journal of Medicine*. 2008;359:1928.
- ³ Joseph A, Fritz L. Ceiling lifts reduce patient-handling injuries. *Healthcare Design*. March 2006;6(1):10-13.
- ⁴ Jones H. 2008 industry forecast: Keeping pace in '08. *Construction Today*. 2007.
- ⁵ *FMI's Construction Outlook: Fourth Quarter Update*. Raleigh, NC: FMI Corporation; 2007.
- ⁶ Joseph A, Keller A, Kronick K. Transforming care in children's hospitals through environmental design: Literature review. In: *Evidence for Innovation: Transforming Children's Health Through the Physical Environment*. Alexandria, VA: National Association of Children's Hospitals and Associated Institutions; 2008:18-47.
- ⁷ *Health Care at the Crossroads: Guiding Principles for the Development of the Hospital of the Future*. Chicago: The Joint Commission; 2008:34-39. Available at: http://www.jointcommission.org/NR/rdonlyres/1C9A7079-7A29-4658-B80D-A7DF8771309B/0/Hospital_Future.pdf.
- ⁸ The Center for Health Design. The Pebble Project. Available at: <http://www.healthdesign.org/research/pebble/>.
- ⁹ Randle J, Clarke MC, Storr J. Hand hygiene compliance in healthcare workers. *Journal of Hospital Infection*. 2006;64(3):205-209.
- ¹⁰ Blomkvist V, Eriksen CA, Theorell T, Ulrich RS, Rasmanis G. Acoustics and psychosocial environment in coronary intensive care. *Occupational and Environmental Medicine*. 2005;62:1-8.
- ¹¹ Walworth DD. Procedural-support music therapy in the healthcare setting: A cost-effectiveness analysis. *Journal of Pediatric Nursing*. 2005;20(4):276-284.
- ¹² Ulrich RS, Gilpin L. Healing arts: Nutrition for the soul. In: Frampton SB, Gilpin L, Charmel P, eds. *Putting Patients First: Designing and Practicing Patient-Centered Care*. San Francisco: Jossey-Bass; 2003:117-146.
- ¹³ Carpman J, Grant M. *Design That Cares: Planning Health Facilities for Patients and Visitors* (2nd edition). Chicago: American Hospital Publishing; 1998.
- ¹⁴ Buchanan TL, Barker KN, Gibson JT, Jiang BC, Pearson RE. Illumination and errors in dispensing. *American Journal of Hospital Pharmacy*. 1991 Oct;48(10):2137-2145.

- ¹⁵ Chaudhury H, Mahmood A, Valente M. Advantages and disadvantages of single- versus multiple-occupancy rooms in acute care environments: A review and analysis of the literature. *Environment and Behavior*. 2005;37(6):760-786.
- ¹⁶ Rashid M. A decade of adult intensive care unit design: A study of the physical design features of the best-practice examples. *Critical Care Nursing Quarterly*. 2006;29(4):282-311.
- ¹⁷ Hendrich A, Fay J, Sorrells A. Effects of acuity-adaptable rooms on flow of patients and delivery of care. *American Journal of Critical Care*. 2004 Jan;13(1):35-45.
- ¹⁸ Hignett S, Evans D. Spatial requirements in hospital shower and toilet rooms. *Nursing Standard*. 2006 Sep 27-Oct 3;21(3):43-48.
- ¹⁹ Oren I, Haddad N, Finkelstein R, Rowe JM. Invasive pulmonary aspergillosis in neutropenic patients during hospital construction: Before and after chemoprophylaxis and institution of HEPA filters. *American Journal of Hematology*. 2001;66(4):257-262.
- ²⁰ Miller A, Engst C, Tate RB, Yassi A. Evaluation of the effectiveness of portable ceiling lifts in a new long-term care facility. *Applied Ergonomics*. 2006 May;37(3):377-385.
- ²¹ Walch JM, Rabin BS, Day R, Williams JN, Choi K, Kang JD. The effect of sunlight on postoperative analgesic medication use: A prospective study of patients undergoing spinal surgery. *Psychosomatic Medicine*. 2005 Jan-Feb;67(1):156-163.
- ²² Howard L, Malloch K. Centralized and decentralized nurse station design: An examination of caregiver communication, work activities, and technology. *Health Environments Research and Design Journal*. 2007;1(1):44-57.
- ²³ Yavuz S, Bicer Y, Yapici N, Kalaca S, Aydin O, Camur G. Analysis of risk factors for sternal surgical site infection: Emphasizing the appropriate ventilation of operating theaters. *Infection Control and Hospital Epidemiology*. 2006;27(9):958-963.
- ²⁴ Sehulster L, Chinn RY, Arduino M, Carpenter J, Donlan R, Ashford D. *Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)*. Chicago: American Society for Healthcare Engineering/American Hospital Association; 2004. Available at: http://www.cdc.gov/ncidod/dhqp/pdf/guidelines/enviro_guide_03.pdf.
- ²⁵ Gerbrands A, Albayrak A, Kazemier G. Ergonomic evaluation of the work area of the scrub nurse. *Minimally Invasive Therapy and Allied Technology*. 2004;13(3):142-146.
- ²⁶ Tinsley C, Hill B, Shah J, et al. Experience of families during cardiopulmonary resuscitation in a pediatric intensive care unit. *Pediatrics*. 2008 Oct;122(4):e799-e804.

- ²⁷ Hall KK, Kyriacou D, Handler JA, Adams JG. Impact of emergency department built environment on timeliness of physician assessment of patients with chest pain. *Environment and Behavior*. 2008;40(2):233-248.
- ²⁸ Barlas D, Sama AE, Ward MF, Lesser ML. Comparison of the auditory and visual privacy of emergency department treatment areas with curtains versus those with solid walls. *Annals of Emergency Medicine*. 2001 Aug;38(2):135-139.
- ²⁹ Becker F, Douglass S. The ecology of the patient visit: Physical attractiveness, waiting times, and perceived quality of care. *Healthcare Design*. 2006;6.
- ³⁰ Gulwadi G, Joseph A, Keller A. Exploring the impact of the physical environment on patient outcomes in ambulatory care settings. *Health Environments Research and Design Journal*. 2009 (in press).
- ³¹ Byers JF, Waugh WR, Lowman LB. Sound level exposure of high-risk infants in different environmental conditions. *Neonatal Network*. 2006;25(1):25-32.
- ³² The open source searchable database of recommended best practices for evidence-based design, developed by the Global Health and Safety Initiative (<http://www.globalhealthsafety.org>) and The Center for Health Design (<http://www.healthdesign.org>), is accessible at: <http://www.globalhealthsafety.org/workgroups/environment/>.
- ³³ Berry L, Parker D, Coile R, Hamilton DK, O'Neill D, Sadler B. The business case for better buildings. *Frontiers in Health Services Management*. 2004;21(1):3-21.
- ³⁴ Sadler B, DuBose J, Zimring C. The business case for building better hospitals through evidence-based design. *Health Environments Research and Design Journal*. 2008;1(3):22-39.
- ³⁵ Guenther R, Vittori G. *Sustainable Healthcare Architecture*. Hoboken, NJ: John Wiley & Sons, Inc; 2007.
- ³⁶ Nolan T, Bisognano M. Finding the balance between quality and cost. *Healthcare Financial Management Magazine*. 2006 Apr;60(4):67-72. Available at: <http://www.ihl.org/IHI/Topics/Improvement/ImprovementMethods/Literature/FindingtheBalanceBetweenQualityandCost.htm>.
- ³⁷ Houston AA, Mitchell J, Borgani M, Burnazhny A, Fuqua GM, LeBuhn J. Modern facility design and its impact on operational and capital strategies. *Fitch Ratings: Public Finance*. May 22, 2007.
- ³⁸ Zimring C, Augenbroe G, Malone EB, Sadler B. Implementing healthcare excellence: The vital role of the CEO in evidence-based design. *Health Environments Research and Design Journal*. 2008;1(3):7-21.

White Papers in IHI's Innovation Series

- 1** Move Your Dot™: Measuring, Evaluating, and Reducing Hospital Mortality Rates (Part 1)
- 2** Optimizing Patient Flow: Moving Patients Smoothly Through Acute Care Settings
- 3** The Breakthrough Series: IHI's Collaborative Model for Achieving Breakthrough Improvement
- 4** Improving the Reliability of Health Care
- 5** Transforming Care at the Bedside
- 6** Seven Leadership Leverage Points for Organization-Level Improvement in Health Care (*Second Edition*)
- 7** Going Lean in Health Care
- 8** Reducing Hospital Mortality Rates (Part 2)
- 9** Idealized Design of Perinatal Care
- 10** Innovations in Planned Care
- 11** A Framework for Spread: From Local Improvements to System-Wide Change
- 12** Leadership Guide to Patient Safety
- 13** IHI Global Trigger Tool for Measuring Adverse Events
- 14** Engaging Physicians in a Shared Quality Agenda
- 15** Execution of Strategic Improvement Initiatives to Produce System-Level Results
- 16** Whole System Measures
- 17** Planning for Scale: A Guide for Designing Large-Scale Improvement Initiatives
- 18** Using Evidence-Based Environmental Design to Enhance Safety and Quality

All white papers in IHI's Innovation Series are available online at www.ihl.org and can be downloaded at no charge.



20 University Road, 7th Floor

Cambridge, MA 02138

(617) 301-4800

www.IHI.org