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A Patient Room Prototype: Bridging Design and Research

Abstract* | *Article

Introduction

While there have been a lot of design innovations in hospital patient rooms (e.g., Malkin, 2008, Chapter 7), limited research has been conducted to empirically test these innovations. Architects repeatedly engage in designing and refining patient room concepts, yet they rarely conduct research that systematically evaluates specific outcomes in relation to their design concepts. If design intentions are not articulated in written form to accompany image-based design concepts, then it is difficult to assess design performance through research endeavors. Relationships between design and research have been explored previously (e.g., Snyder, 1984; Zeisel, 1984) and there has been a recent resurgence championed by national conferences (e.g., AIA's "Poetry and Proof" 2003 National Conference), national organizations (e.g., The Center for Health Design's Pebble Project), journals (e.g., HERD; JAE vol 61), and books (e.g., Wang and Groat, 2002 see Chapter 5).

Studies to date suggest that conditions in patient room environments can positively or negatively impact stress (Ulrich et al., 2006); staff injuries and patient safety (e.g., American Nurses Association, 2001; Carayon, 2007; Connell, 1996; Hendrich, 1995; Institute of Medicine, 2004; Reiling, 2007; Ulrich and Zimring, 2004); operational efficiency (Bobrow & Thomas, 2000; Gallant & Lanning, 2001; Hendrich, 2005; Hendrich and Sorrells, 2004), staff satisfaction and nursing turnover (e.g., Barrett & Yates, 2002; Jones, 2004; Kerzman et al., 2004; Mroczek et. al, 2005; Tumulty et al., 1994) and medical errors (Institute of Medicine, 2000, 2001). Facility design issues in patient rooms may aggravate occupational stressors for caregivers (and possibly increase errors). These issues have been linked to many factors, including inadequate lighting, absence of daylighting, noise, double occupancy rooms as opposed to single occupancy rooms, lack of standardized rooms, materials, and layout (Chaudhury and Valente, 2005; Chaudhury et al., 2006; Reiling, 2007; Ulrich et al., 2004). Additional studies show unit physical layout and interiors of the work environment affect nurse workload (Malkin, 2008; Marberry, 2006; Pinkerton and Rivers, 2001; Salyer, 1995).

While there has been a gradual but steady increase in empirical research on environmental conditions in patient rooms (e.g., Rubin, Owen & Goldin, 1998; Ulrich et al., 2004; Ulrich et al., 2008), most of the research to date is retrospective – based on environmental conditions conceived years ago. Virtually no empirical evidence exists on the performance of speculative, new design concepts for patient care environments. Architectural research, especially related to the study of new and emerging design concepts, demands a unification of the traditional gap between architectural design and research. In an effort to bridge this gap, it is important to understand the similarities and differences between these activities.

Design is often described as a problem-solving process that is intuitive, creative, generative, reflective, experiential, context-specific, holistic and multi-dimensional. The book Inquiry by Design states that designers aim to reach one acceptable design concept over time, within a range of possible solutions, by continually modifying the design concepts as information revealed through an iterative process. The design process involves visualizing an image-based idea from information given, communicating design intentions through forms of representation such as drawings and models, and then evaluating these design intentions (Zeisel, 2006).
In comparison, research is defined as an analytical process, conducted in pursuit of knowledge, which is grounded in the scientific method, with the expectation of more precise outcome measures. It is a "systematic inquiry directed toward the creation of knowledge" (Snyder, 1984, p. 2). This inquiry involves many steps, including developing concepts, formulating hypotheses, and empirical testing through observing and sampling (Zeisel, 2006, p. 34). Within the context of architectural research, Groat and Wang (2002, p.7), state that research "involves reducing lived experience or observed phenomena to chunks of information that are noted and categorized in some way."

To explore the integration of design and research related to new design concepts, the authors present a project for a Hospital Patient Room Prototype (PRP). The PRP is a concept that employs an iterative design-research process informed by both first-hand (practical) knowledge and second-hand (theoretical) knowledge. Further, it engages in an interdisciplinary participatory process infused with periodic informal and formal systematic evaluations aimed at advancing each design-research input and feedback cycle, as articulated by Zeisel (2006). A collaborative project team was formed between Clemson University, Spartanburg Regional Healthcare System (SRHS), and the SRHS innovation arm, NXT. The project scope involves the design and construction of a patient room prototype and testing of specific design attributes, first within a controlled simulated lab and then in a new hospital expected to be completed in the fall of 2008. The new hospital will become a naturally-occurring laboratory to conduct beta testing on proposed design innovations initially tested in the lab. In spring 2006, the initial design phase began as a design-build studio project. The academic team included faculty and students in the Architecture + Health (A+H) and Fine Arts at Clemson University and the School of Industrial Design at Carleton University in Ottawa, Canada. The hospital team included representatives from nursing, facilities, administration, information technology, infection control, maintenance and housekeeping. Additional formal and informal consultant collaborators were brought in from several healthcare architecture firms and healthcare equipment manufacturers.

Design-Research Leading to a Patient Room Prototype

The design of the patient room began with a rigorous, but normative, participatory design-research approach. A participatory design (PD) approach identifies the potential users of a system and actively involves them in the problem exploration, design and development stages (Namioka & Schuler, 1993). In addition to using a PD approach, a user-centered design philosophy from psychology was employed. User-centered design (UCD), also known as human-centered design, is a design philosophy that places the end user at the center of the development of items intended for human use (Gould & Lewis, 1985). While the use of the term is new, the principles and methodology have been used for decades under the labels 'human factors engineering' or 'usability engineering' (Rubin, 1994). More specifically, UCD requires that the design process specifically incorporate user input at all stages of design and evaluation. Rubin (1994) describes the three core principles of UCD as 1) an early focus on (and understanding of) the users and their tasks; 2) empirical measurement of product usage; and 3) iterative design whereby a product is designed, modified, and tested repeatedly. Variations on this methodology have also been employed to varying degrees by innovative

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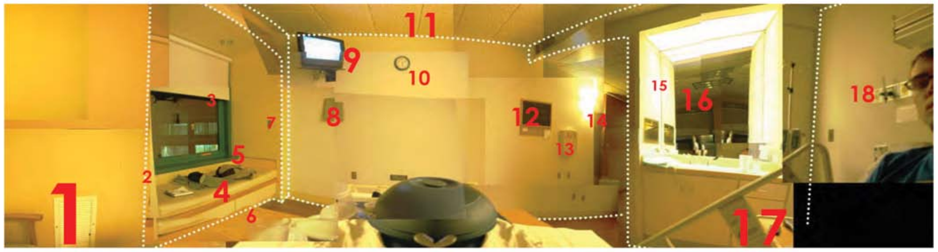
architects engaged in hospital design for over thirty years.

To begin the design process, a literature review was conducted and innovative architectural precedents, architectural products and materials, healthcare equipment, design concepts and relevant research studies were identified. Outside experts in the field were engaged to share innovative ideas in patient room design. Students and faculty in A+H were admitted as patients for an overnight stay in the hospital and kept written, drawn, and photographic journals of their stay and observations. In addition to the stay in the patient room, all participants were processed through admissions and transported to a diagnostic and treatment department to experience typical inpatient transitions into and out of the room.

The extended stay of multiple observers in a variety of room configurations yielded many astute and detailed observations that might otherwise be overlooked in a casual walkthrough. Poor finish and millwork details, the wear and tear of finishes and features, the inability to adequately clean surfaces and in corners, and the lack of functionality of certain features become particularly noticeable when encountered over an extended period of time. A significant condition evident in all observations was the overwhelming amount of visual noise or institutional clutter in constant view of the patient and family (Figure 1).



Current SRHS Footwall Clutter

1	Uncomfortable bedside chair	10	Time difficult to read
2	Peeling, yellowish wallpaper	11	Ceiling tiles stained, institutional
3	No patient control of shading	12	Noise of chalkboard painful
4	Poor insulation makes 'bed' cold	13	Sharps container in plain view
5	Window view angled, poor	14	Glove boxes tacked on wall
6	Storage too small, not secure	15	Mammoth paper towel dispenser
7	Yellow light hard on patient's eyes	16	Light off mirror intense
8	Guestbook covered with dust	17	Bed uncomfortable, stiff
9	TV small and hard to see	18	Headwall gases exposed, cluttered

Figure 1: Institutional Clutter

The entire team visited several other health facilities with innovative examples of patient room design and care practices. They reviewed the performance of these examples with the care providers and design professionals involved with the projects. The team also traveled to Hill-Rom's demonstration and mock-up facility, where initial design brainstorming began with the benefit of their facilities, equipment and expertise. This brainstorming charrette continued over two additional days at Carleton University's School of Industrial Design. The interdisciplinary design collaboration included two additional design and evaluation charrettes at Clemson, one to identify the final design concept and refine room features, and a mock-up prefabrication charrette.
The iterative process culminated in a more refined room prototype, fabricated as a full-scale mock-up in a 'black box' room within the School of Nursing on the Clemson campus. The initial mock-up was then evaluated under various use scenarios by the collaborative design-research team and a wide variety of SRHS clinical and support staff. Design refinements were made, final materials, finishes, and hardware for the room prototype were selected, and construction documents for the final prototype room were prepared in collaboration with a local architecture firm, McMillan Smith & Partners. This refined room prototype was recently completed in a warehouse on SRHS's Pelham campus, and formal research studies began during the summer of 2008.

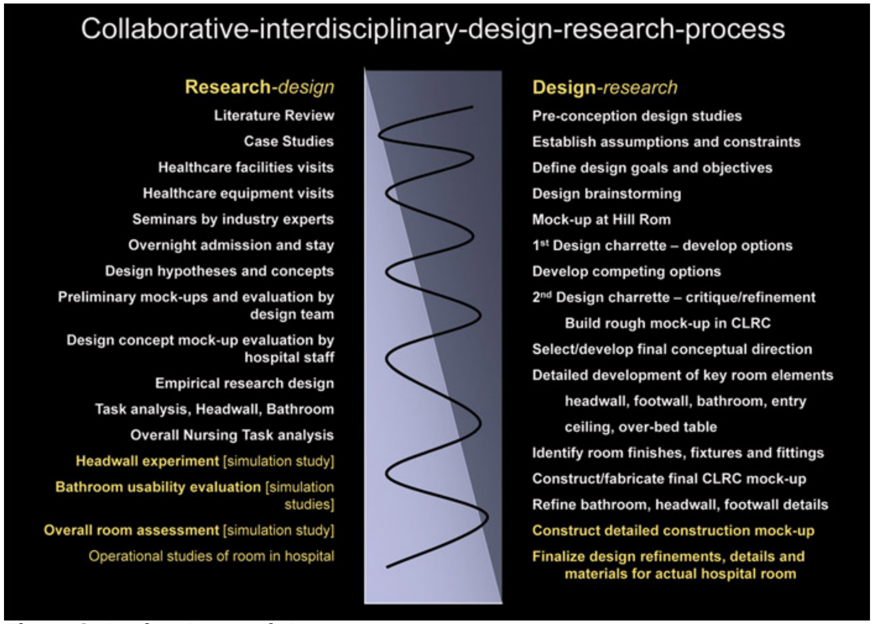


Figure 2: Design-Research Process

Design Goals for the Patient Room Prototype

A series of design objectives and assumptions for the patient room were initially established and refined based on the overall goals for the project. The design and testing of the patient room prototype was conceived to serve several purposes. It was expected to be used as an acuity-adaptable or "universal" patient room "chassis" for SRHS's new hospital in Pelham, S.C., where the initial patient population and patient profiles would transform as the hospital grew and clinical services expanded from an initial 48 beds satellite facility to a planned 150-300 bed health campus. The room prototype was also envisioned to provide transferable concepts and features for the system-wide application of patient room concepts and features in the future. The following broad design goals were established by the interdisciplinary project team for the room prototype to help guide design decisions:
Provide a setting that is functionally efficient and effective for the delivery of patient care: The room should minimize the time, motion and effort necessary for patient care. It should support patient and staff safety and be a setting that inherently optimizes direct and indirect patient care activities and tasks while helping to reduce medical errors, falls, and hospital-acquired infections. It should be a space that is easy to maintain, clean, and quickly reconfigure as needed, by minimizing the room's necessary movable furniture.
Provide a setting that is therapeutic and green: The room should support optimum health outcomes and health status for patients, families, and staff. It should provide a healthy indoor environment by employing non-toxic and green finishes, furnishings, and materials. It should maximize views and connections to nature and other demonstrated positive therapeutic distractions, while minimizing negative visual and other sensory distractions.

Provide a setting for positive patient/family/staff experiences: The room prototype should be designed to optimize individual needs for comfort and control of views, personal space, privacy, technology, lighting, entertainment, information and the thermal environment as much as possible. The room should also be organized to minimize conflicting patient, family, and staff needs, tasks, activities and events. Staff should not have to invade the family zone to provide routine patient care. Likewise, ample space should be provided and located to accommodate variable family needs and groupings, while enabling efficient and effective patient care. The room should be designed to promote overnight stays by family members and support a wide variety of positive patient and family interactions.

Provide an adaptable setting that can accommodate changing needs over time: It was understood from the start that any "ideal" solutions envisioned for the room at its initial occupancy may not satisfy the needs, acuities, patient profiles, activities, and events that may be needed to achieve the above goals in the future. Therefore the room should be designed as a flexible chassis for a wide variety of configurations, "plug and play" features. or possible adaptations over the life of the room or the life of a patient stay.
In addition to design goals, the following planning assumptions (Figure 3) were adopted, given that the prototype room design process would begin ahead of the planning and design of the overall hospital "site" for the room, in order to make the prototype transferable to as many other hospital settings and conditions as possible.

- ***A 30' x 30' structural bay was assumed as a common and economical 'minimum' area***
- ***A 15' headwall to foot wall center line dimension allowed two rooms within the 30' x 30' bay.***
- ***A 21'-deep room from centerline of exterior column to interior face of corridor wall accommodated both the room and an 8'- wide corridor within the 30' x 30' foot structural bay. Additional room depth could be gained by extending the exterior wall beyond the exterior column.***
- ***The exterior wall would be neutral so as to not dictate the design of the exterior façade. This would allow maximum flexibility to the hospital architects in determining the amount, configuration and placement of window[s] in the exterior wall. It also implied that the toilet would probably not be located in a conventional 'outboard location.'***
- ***The room width and structural module would be expanded to accommodate ADA accessible rooms, bariatric patient rooms, and executive-level rooms. This could be accomplished in specific structural bays at the end of a run of rooms, depending on the ultimate configuration of the nursing unit and floor-area footprint.***

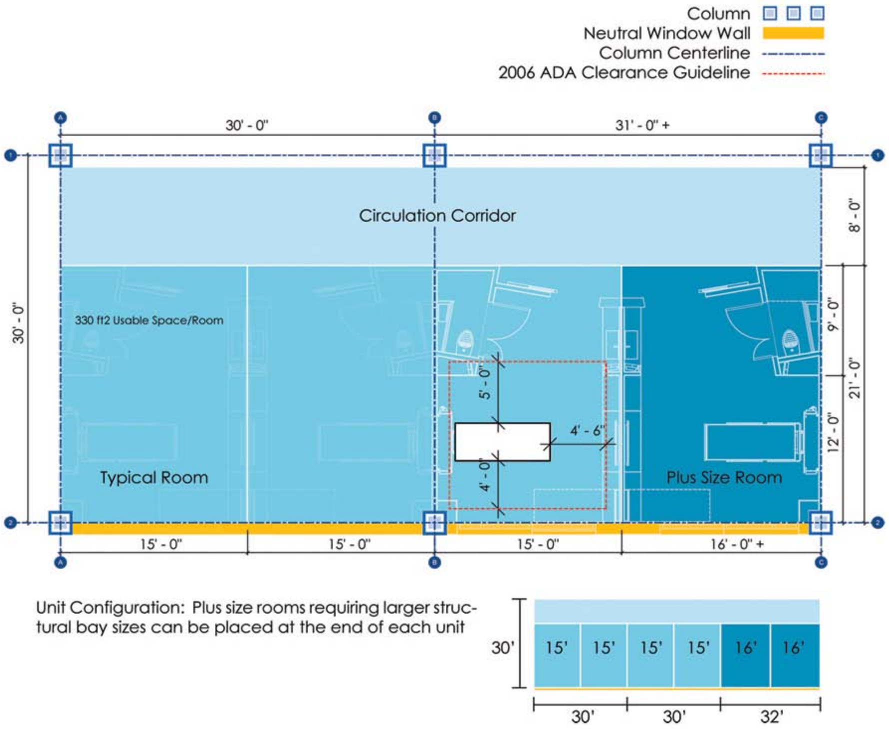


Figure 3. Planning Assumptions Diagram

Articulating Design-Based Hypotheses for a Patient Room Prototype

In order to study the built environment in relation to measurable outcomes, the design intentions, or goals, need to be articulated as testable ideas. Both design concepts and research hypotheses in the Patient Room Prototype were developed in an iterative design-research process. They were informed by the broad and project specific needs of the sponsor (SRHS), the expertise/experience/perspectives of the multidisciplinary design team and consulting experts, literature reviews and precedent research, the overnight stay observations, and site visits, as well as other factors. These hypotheses ultimately became the yard stick to assess the performance of the built environment. A subset of the original design hypotheses are identified below:

1. It is possible to create a universal and adaptable patient room "chassis" that can accommodate an appropriate patient care environment for multiple patient types and levels of patient acuity through a variety of flexible, adaptable or changeable room features and feature configurations (Figure 4).

This was achieved through several design details, including an 8'-wide throat dimension into the room from the corridor, which allows for the installation of four possible doorway configurations: a single 4'-wide door, a double-leaf 4' + 2' door, an 8' double-panel breakaway glass door, and a sliding door. The second feature involved providing several potential staff work locations within or just outside the patient room. A staff workstation can be located between the doorways to two adjacent rooms, and can also serve as a protective measures alcove or nurse server. A wet work and hand-washing area is located in the room entry area, and a dry work area is located at the bedside. The room and entry is configured for a mobile computer on wheels (COW) to be positioned so that staff can maintain eye contact with patients while in use. The bathroom and headwall features are designed for flexibility, as described below. The intent is to allow for staff to flexibly use any combination of work areas, depending on the evolving needs and tasks associated with patient care over the life of a patient stay or the life of the room itself.

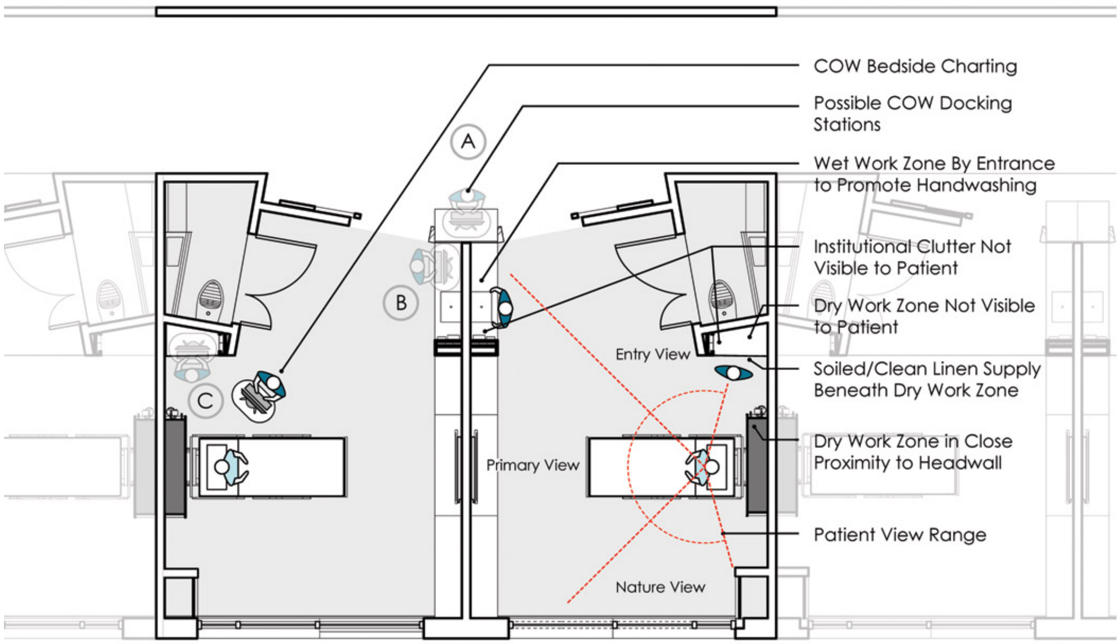


Figure 4: Patient room plan with annotations

2. An inboard headwall bathroom is the safest location from a patient toileting perspective, and the most effective and efficient location from a staffing perspective (Figure 5). The inboard headwall location provides the shortest distance from the patient bed to the bathroom for patients who can independently use the bathroom. It also minimizes the risk of oxygen and other umbilical lines connected to the headwall becoming entangled on the bed or other objects in the room. These features can minimize the risk of falls moving from the bed to the bathroom. The inboard headwall location also reduces time and motion for staff when needed for assistance, and conflicts between patient and staff bathroom access and furnishings, as well as with family members, who tend to congregate at the foot and window side of the room.

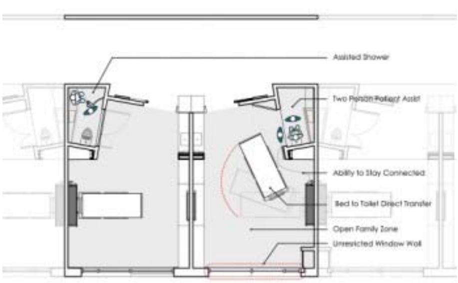


Figure 5: Patient room plan with bathroom location, access and visualization

3. It is possible to maintain the optimal staff visualization and access to patients necessary in higher acuity situations with an inboard bathroom (Figure 6). This was achieved by minimizing and optimizing the footprint and layout of the bathroom, while maintaining good sight lines and access to and from the corridor and staff work areas, both within and just outside the room. An 8' throat opening into the patient room from the corridor provides good sight lines to the patient's head from the corridor and potential nursing work areas between every two rooms.

Figure 6: Patient Room Entry

4. A small, properly-designed bathroom can provide a safe and efficient place for both patient and staff activities. A secondary hypothesis is that large ADA-compliant bathrooms are actually less safe than smaller room designs for many patients who use the bathroom independently. The bathroom was designed to minimize floor area through a customized sink and the configuration of toilet, sink, shower, door location and width. The design intent was to overlap and use the same floor area inside the door for access to the toilet, sink and shower from the doorway. The door was sized, configured and located to optimize staff-assisted toileting in a small space from the front and both sides of the toilet. The original design concept called for a double-leaf [3' + 2'] door. This was later changed to a single 4'-wide door, due to budget concerns and preliminary testing with hospital staff in the initial mock-up.

5. It is possible to minimize patient and family views of much of the institutional clutter [features necessary for basic acute inpatient care], while maintaining or improving both patient safety and outcomes as well as efficiency and efficacy of patient-care tasks and activities. The first strategy was to locate and organize the care accessories found in all patient rooms [such as soap dispensers, paper towel dispensers, alcohol wash dispensers, sharps containers, staff notes, electrical and medical outlets and devises, monitors, and miscellaneous accessories] in such a way that they would be highly usable when needed but minimally visible from the family and patient viewpoints in the room. The other strategy was to redesign the most institutional, technological and inherently visible elements so that they became positive design features, rather than adding to the institutional noise of the setting. This approach borrows from the design heritage of Apple computers and devices, as well as the dashboards of high end automobiles, etc., where inherently functional features are designed to be both usable and visually pleasing or simple. This hypothesis is manifest in two basic design features in the patient room prototype.

Footwall (Figure 7): The first issue was to recognize the footwall as essentially the hearth of the patient room, as it is the primary visual focal point for the patient. Visual clutter was reduced by minimizing the number of clinical objects mounted on the footwall, limiting sightlines for patients and family members to remaining objects, and unifying or simplifying the organization of all elements on the footwall. The footwall was designed to accommodate the flat-screen video technology commercially available today, as well as a full wall digital display that could function as a virtual window, an access point to entertainment, or video conferencing, as well as connectivity to medical information and other computing information.

Figure 7: footwall image

Headwall (Figure 8): The headwall was designed to minimize sight lines to clinical elements for patients and visitors, while maintaining optimal usability for staff in not covering medical use features with movable artwork or cabinetry. The headwall was designed to express a multifunctional technological element as a design feature. This headwall is designed for modular removable panels that enable relatively easy reconfiguration and maintenance of medical gas and electrical components. Medical gas and electrical service are located on the staff side of the projecting assembly and positioned to optimize the ergonomic use of critical elements. They can be duplicated on the other side of the headwall as needed in higher acuity rooms.

Figure 8. Patient room headwall image

It is ultimately envisioned that each of the five design hypotheses identified above would be tested through a series of research studies. Initially, two design features and the design hypotheses associated with them have been translated into research hypotheses, and these are being tested using human-factors research methodologies.

Developing and Testing Research Hypotheses Tied to Patient Room Design Concepts: Two Examples

Two design concepts for the headwall and bathroom in the PRP are being studied, using a "usability" framework common in human-factors research. The two features being tested are the bedside staff zone, including the proposed headwall configuration and side workstation and the bathroom location and design. The overall premise is that User-Centered Design (Gould & Lewis, 1985) is expected to enhance the "usability" of the patient room. Usability is defined as the ability of users to use environments, systems, or products effectively, efficiently, and with high satisfaction (Nielsen, 1993). To evaluate whether usability has been increased, environment-based variables are studied in relation to task performance in three areas. The first is effectiveness - the degree to which users can successfully complete their intended tasks. The second, efficiency, is defined as the extent to which users can achieve their tasks in a timely, safe, and error-free manner. Thirdly, satisfaction involves the users' feelings and attitudes toward the room.

This framework is applied to the evaluation of design concepts for the headwall and bathroom. In the first case, an experimental design will be used to compare the new vertical headwall with an industry-standard horizontal configuration found in many hospitals across the country. In the bathroom, a set of discrete tasks was not performed in a sequential manner; it may therefore be necessary to study changes along the way, and a human-factors usability evaluation will be used

to evaluate its design performance.

Headwall study

As the average patient acuity increases, nurses must spend more time at the bedside caring for sick patients. Current efforts are underway to increase this direct patient-care time through decentralizing nursing supplies, charting workstations, medications and patients' medical information. Greater emphasis must also be placed on making nursing tasks at the bedside more efficient, effective, safe, and positive for both patients and staff. The design of the bedside environment can affect these factors by employing human factors principles (Carayon, 2007; IOM, 2004; Tartaglia et al., 2005).

Nursing tasks at the bedside tend to be sequential tasks that rely on the accuracy of previous steps involving people, processes, technologies and environments (Perry & Potter, 2006; Potter et al., 2004). A focal point for many patient-care activities in the patient room is the headwall. The headwall functions as a control and clinical support element for both caregivers and patients. As such, it serves as an institutional umbilical cord, connecting technology and equipment in the room to the sick patient. It typically contains medical equipment (e.g., monitoring equipment), ports for various medical gasses and air, electric power, lighting (reading and ambient), IT connections, and two-way communications. These components need to be arranged to maximize functionality for various clinical uses.

Research Hypothesis.

The primary position is that a user-centered headwall design can improve "usability" for staff, while minimizing sight lines to inherently clinical elements for patients and visitors (i.e. , reduce institutional clutter). In this hypothesis, technological elements necessary for patient care delivery are expressed as design features, rather than covered with millwork, in order to ultimately improve access. The proposed headwall assembly is essentially a 4'-wide light and utility box that projects off the face of the wall and consists of a composite face panel and side utility surfaces for electrical devices, medical gas outlets and devices, as well as glove boxes on the staff side, all concentrated within an ergonomic zone. The layout of patient care features (Figure 9) was studied using ergonomic principles to prioritize the arrangement of elements for usability and safety. The face panel extends to help conceal the clutter of medical hardware and accessories from the family zone.

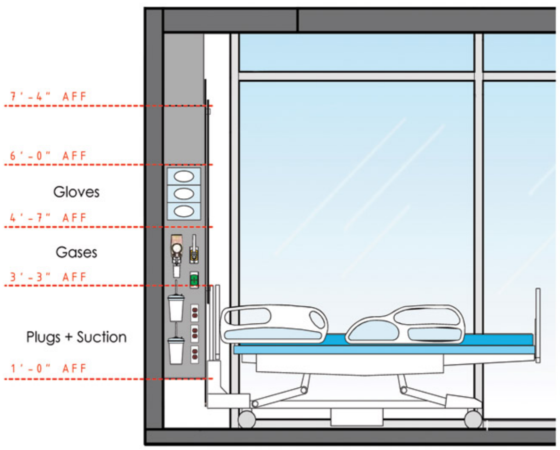


Figure 9. Insert figures here of the headwall

Experiment.

Can nursing task performance be improved through employing user-centered design principles that take into account the capabilities and limitations of nurses and nursing activities? To study this, the new headwall design will be compared to an alternative design (a typical horizontal manufactured headwall found in most acute care hospitals) using an experiment (Creswell, 1994; Cook & Campbell, 1979; Campbell and Stanley, 1966). Commonly-repeated and error-prone nursing tasks discovered in a nursing tasks analysis, described elsewhere (Battisto et al., submitted for review), will be performed and studied within two full-scale prototypes in a controlled lab, using direct patient-care staff from the hospital and a patient simulator. Nursing tasks found in the task analysis, such as administering medication, assessing patients, administering IVs, and administering oxygen therapy, will be performed using both headwall conditions. After the nurses complete the tasks, they will be interviewed about their experiences, attitudes, and adoption.

The design of the headwall will be the independent variable and will be assessed on nursing task performance employing usability measures (Nielsen, 1993) including:
(1) Nursing task completion time (how long does it take?)
(2) Nursing task error rate (how many errors are made; what kinds of errors?)
(3) Physical and cognitive workload
(4) Amount of movement required (must the nurse move back and forth and experience bending and reaching?)
(5) How satisfied are the nurses with the new design?

Human-factors usability evaluation of the bathroom design

A design objective for the Patient Room Prototype was to minimize the need for a commode chair in the patient room, as is commonly used in the existing hospital, since access to the bathroom in many rooms is difficult, and many bathrooms are not usable for many patients given their weight, age, acuity, medical conditions and inadequate staffing levels. There is inherent conflict in the design and use of many bathrooms located in patient rooms today. Patients obviously prefer to use the bathroom over a bedpan or commode chair if possible; however, the average acuity and condition of the typical patient while in the hospital today makes this task a risk-prone event. Safety is compromised in many designs, as evidenced by both patient falls and staff-related injuries due to patient transfers (Retsas and Pinikahana, 2000; Engkvist et. al., 2001).

There is an ongoing debate on the ideal location of the hospital bathroom – inboard location (close to the corridor), outboard location (on the exterior window wall), or a nested location (back to back location between patient rooms) – yet there is no empirical data documenting the best location in relation to nursing task performance (Cahnman, 2006; 2006). Similarly, there is no empirical evidence on how the bathroom is actually used, who uses it, or when and how design details of the bathroom affect usability. Since limited research is available and there are many variables and configurations, an open research process will allow for design changes to be made throughout a period of evaluation that will suggest areas for improvement.

The bathroom design goals included optimizing patient usability, both independent and staff assisted. The bathroom location reduces the amount of steps for both patients accessing the bathroom independently and staff assisting patients moving to and within the bathroom. The overall size (footprint) of the bathroom is as small as possible, in order to optimize visibility and access into the room from the corridor while providing a high level of usability for documented uses of the bathroom. The design and position of bathroom elements (e.g., sink, toilet, grab bars, shower) are intended to improve the level of usability of the bathroom when compared with larger bathrooms. A custom cast sink is designed to minimize space and both improve cleaning ability and reduce infection potential by minimizing deck-mounted plumbing fixtures and surface articulations. Finally, raised thresholds are eliminated at door and shower to reduce fall hazards for patients using wheeled supportive devices such as wheelchairs and IV poles.

Figure 10. Bathroom design

First, a redesigned bathroom layout (Figure 10), based on task and movement patterns of common bathroom tasks, will be evaluated by adapting a commonly-used human-factors procedure called heuristic evaluation, in which an expert human-factors evaluator will compare the bathroom layout with known principles of design. The challenge of this task is that there is currently no such list of principles. Second, a safety audit will be conducted to compare specific design features against an existing list of well-known principles, including examining the slipperiness of the floors, and the clearance offered at functional areas (e.g., sink, toilet, shower). Some factors suggested in the literature to improve safety include locating toilets closer to the patient, putting double doors on bathrooms, using bed exit features that notify a nurse when a patient is out of bed, decentralizing nurse stations, and locating supplies close by to reduce the amount of time the nurse is away from the patient. (Berry et al., 2004; Hendrich et. al., 2003).

In sum, the specific research strategies, techniques, methods and tactics employed to assess design concepts depend upon the nature of the research questions. Some research questions warrant a quantitative approach, some a qualitative approach, and some a combination (Creswell, 2003) employing either fixed-research designs, such as the headwall study, or flexible research designs, such as the bathroom study (Robson, 2002). A main issue however, is to connect environmental variables with measurable outcomes.

Next Steps / Conclusion

It is envisioned that additional research studies will be added to investigate other room-prototype design features and hypotheses. As the iterative design-research process evolves on the patient room prototype, additional potential studies continuously arise. Likewise, preliminary findings suggest further design refinements; these in turn lead to the potential for re-applying the methods used in the initial research studies in subsequent studies on refined design features. The real value of the prototype design-research process is the potential to simultaneous evaluate multiple dimensions of a specific patient-care space, and to better address the often competing or conflicting design objectives considered in the design of healthcare environments. This helps bridge the inherent gaps between the specificity of research activities and the general and holistic nature of architectural design. The authors envision years of study on this prototype as validated concepts are rolled out for use both at the sponsor's site and within the healthcare industry at large. This process has allowed the design research team to take creative risks that would not be feasible in more conventional design contexts. Certain features may in fact prove not to work better than existing

concepts, and the prototype design-research process allows us to better establish the efficacy of new concepts before investing in operational environments.

Editor's Note: Clinical considerations should be made to ensure appropriate patient privacy in the bathroom and the movement of the bed closer to the bathroom may not be a realistic expectation of nursing staff.

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