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Environmental Design in Acute Care Settings: A Case Study of a Neurological Rehabilitation Unit

Lindsay J. McCunn, MSc, and Robert Gifford, PhD

ABSTRACT

OBJECTIVE: The purpose of this case study was to examine environmental variables that lead to staff error in acute care settings: noise; lighting; ergonomics, furniture, and equipment; and patient room design and unit layout.

BACKGROUND: Chaudhury, Mahmood, & Valente (2009) reviewed a number of design considerations related to reducing errors by nursing staff in acute care settings. The Neurological Rehabilitation Unit (NRU) at one hospital served to further examine the design recommendations outlined by Chaudhury et al. (2009).

METHODS: Based on photographs, a site tour, interviews with the NRU manager and with the son of a patient of 5 months, comparisons were made between the NRU and the acute care setting design considerations reviewed by Chaudhury et al. (2009).

RESULTS: The NRU appeared to comply with many recommendations: enforced noise reduction was facilitated through limiting both the number of patients per room and the number of patients admitted to the unit. Distinct rooms were used for various tasks that helped to contain activity-based noise. A combination of daylighting and artificial lighting was in place, but efforts to control glare and thermal comfort were not integrated into the design. The ergonomic needs of employees were incorporated in the design of the NRU, and the layouts of patient rooms and the layout of the NRU in general also were compatible with the design recommendations reviewed by Chaudhury et al. (2009).

CONCLUSIONS: Many of the design attributes advocated by Chaudhury et al. (2009) were included in the NRU. Supplemental research should be undertaken, however, to objectively measure nursing error, efficiency, and staff satisfaction with respect to the comparisons and assumptions presented in this study.

KEYWORDS: Case study, design, hospital, satisfaction, staff

AUTHOR AFFILIATIONS: Lindsay J. McCunn, MSc, is a PhD Candidate, and Robert Gifford is a Professor, both in the Psychology Department of the University of Victoria in Victoria, British Columbia, Canada.

CORRESPONDING AUTHOR: Lindsay McCunn, Department of Psychology, University of Victoria, P.O. Box 3050 STN CSC, Victoria, BC V8W 3P5; lindsayjmccunn@gmail.com; (250) 893-0603.

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The physical environment of any workplace can influence how employees think, feel, and behave. However, flaws in design can strongly affect the attitudes and behaviors of those who work in healthcare settings. Certainly, the way in which the physical environment is organized in hospitals can impact decisions, reaction times, and the emotional well-being of medical professionals and patients (Rollins, 2004; Simmons, 2003; Spreckelmeyer, 2004). Therefore, research to develop optimal design models for hospitals and other healthcare settings is important.

A recent review summarized the effects of environmental design on nursing error and efficiency in acute care settings (Chaudhury, Mahmood, & Valente, 2009). It outlined four design attributes that the authors believe contribute most to employee error:

- Noise
- Lighting
- Ergonomics/furniture/equipment
- Patient room design and unit layout

The investigation discussed in this case study article examined the role of these attributes in one hospital's acute care unit.

The 20-bed Neurological Rehabilitation Unit (NRU) serves adult patients (17 years or older) who have suffered a stroke, head injury, or other neurological affliction. After being assigned to the NRU, patients work with a rehabilitation team to optimize their recovery for a safe and timely discharge (Vancouver Island Health Authority, 2010).

Comparisons between design attributes of the NRU and those oulined in the Chaudhury et al. (2009) review were based on two data collection methods: a guided tour of the unit, and interviews with the NRU manager and with the son of a patient with 5 months of daily experience in the setting. The tour allowed the researcher to observe the design of the unit in the attendance of a staff member with access to all areas in the NRU. Interviews also afforded the researcher informal accounts of the NRU's functionality from the perspective of both a staff member and a visitor.

How the NRU Works

Like other rehabilitation units, the NRU serves patients who suffer from single-incident neurological events, such as a head injury, stroke, subarachnoid hemorrhage, or other form of diffuse brain damage. Those who are permanently vegetative or minimally aware are typically not admitted to the NRU, and patients with tracheotomies are only admitted under exceptional circumstances (Victoria General Hospital, 2010).

The function of the NRU is to provide comprehensive, interdisciplinary rehabilitation services to patients and their families. The goal for patients is to reach

a level of independence that will enable a return to their community. To accomplish this, the unit offers a combination of rehabilitation techniques, physiotherapy, occupational therapy, speech and language pathology, social work, nutrition, and neuropsychology (Vancouver Island Health Authority, 2009).

Although certain physical and cognitive requirements for entry into a rehabilitation program must be met (e.g., stable vital signs, ability to understand and carry out instructions), the NRU also sets out rehabilitation-potential criteria, including a willingness to learn and improve (Victoria General Hospital, 2010). Once admitted, patients are expected to be alert for daily group therapy sessions and dressed for meals in the NRU dining room (Victoria General Hospital, 2010). Much emphasis is placed on practicing familiar activities (e.g., doing laundry, using a day-pass to shop at a nearby grocery store). After a regime of speech and physical therapy, and regular memory rehabilitation using computers and flashcards, patients must successfully cook a meal in the NRU kitchen in order to be discharged.

The NRU Renovation

In 2005, the fifth floor of the hospital was redesigned for the express use of the NRU. Before the renovation took place, consultations occurred between the architect and NRU employees. During an informal interview, the manager of the NRU noted that employees found the input process to be very positive and successful.

The basic structure of the floor space was not altered during the renovation (i.e., plumbing placement was not changed and walls were not moved). However, an electrician with experience working in hospitals designed lighting and electrical elements specific to the needs of the unit. In addition, an interior designer chose paint colors and other materials intended to be calming for both staff and patients.

Because the original structure of the floor was not altered, and because it had several walls on acute angles, wayfinding strategies were integrated into the unit. Distinct paint colors for different departments were chosen for hallway walls and doorframes. For example, taupe walls denote treatment space and blue walls signify patient rooms and leisure areas. Doorframe colors let patients and staff members know what was occurring in each room (e.g., yellow for physiotherapy, orange for attention process training, green for speech therapy, etc.). A listing of the colors and corresponding functions is posted near the nursing station, and is included in an orientation binder given to every patient upon arrival. This strategy not only helps with wayfinding, but also diminishes employee stress by reducing the number of direction-related questions and interruptions.

Design Attributes of the NRU

A number of design variables can help or hinder the health, safety, and job performance of staff members in a healthcare facility. This section examines the

influence of noise; lighting; and ergonomics, furniture, and equipment, as well as patient room design and unit layout on hospital employees.

Noise

Sounds can interfere with a variety of activities in any environment. They can increase stress (Donnerstein & Wilson, 1976) and decrease concentration (Cohen et al., 1991; Glass & Singer, 1972; Smith, 1989). Chaudhury et al. (2009) pointed out that although most research on noise in healthcare settings is carried out from the patient's perspective, telephone sounds, voices, moving gurneys, and paging systems can also have unproductive affects on hospital staff (Ulrich et al., 2004). Noise can also reduce the ability of staff members to communicate and concentrate during surgery (Hodge & Thompson, 1990), and the effects of high noise levels can include stress and burnout (Topf & Dillon, 1988). Such outcomes can be exacerbated when noise levels in hospitals exceed guidelines recommended by the World Health Organization (Blomkvist et al., 2005).

Chaudhury et al. (2009) suggested that sound-attenuating surfaces, such as ceiling tiles, may help combat noise in hospital settings. When traditional lightweight ceiling tiles (usually used in suspended ceilings made from wood or mineral fibers) in patient rooms are replaced with sound-absorbing tiles, patients sleep better, report lower levels of stress, and report that they receive better care from nursing staff (Blomkvist et al., 2005). However, traditional ceiling tiles and conventional laminate flooring (durable, inexpensive flooring made with a backing layer, a print layer, and a laminate wear layer on top) are present in this NRU.

Photographs (see Figures 1–8) show that the layout of the NRU is not open-plan. The various therapeutic areas are separate from each other, and some rooms have doors for further enclosure. For example, patient rooms are some distance away from the occupational therapy room, which is also separate from the dining room and kitchen. Thus, sound from activities taking place in each room is not likely to carry into other areas. This is optimal for nurses' well-being at work and for patients' privacy concerns. Figures 1 and 2 illustrate the separation between rooms in the unit.

Figure 3 shows a wide hallway linking the different areas within the NRU. Noise caused by traffic and discussions in this hallway is likely to penetrate into other areas of the unit. Although Chaudhury et al. (2009) noted that installing carpet in hallways can minimize noise (Neumann & Ruga, 1995), carpeting is not a design feature used anywhere in the NRU.

In their review, Chaudhury et al. (2009) found that reducing the number of beds per room also reduces noise levels (Hilton, 1985; Joseph & Ulrich, 2007; Ulrich et al., 2004). Accomplishing this is not always possible, given the demand for beds versus the supply of space. However, acute care units often restrict the number of patients receiving treatment in the ward at one time. According to the NRU manager, the unit limits enrollment to 20 patients (and two extra patients if necessary) at a given time, and can accommodate up to three patients per room. Compared to other units in the hospital that permit four to six patients

Figure 1. Room N518, Exercise room—note color denotation of room separation.

Figure 2. Room N517, Occupational Therapy—note color denotation of room separation.

per room, each with audible monitoring equipment and the potential for visitors and discussions with staff, the small number of beds in the NRU probably decreases excessive noise within the unit.

The only observable design element for reducing noise in the NRU is the Quiet Treatment room (used by one patient at a time, when one becomes over stimulated and needs a calm, private environment). Nevertheless, the design of the NRU appears to mitigate noise, although whether this was an intentional aspect of the unit's design or not is unclear. The lack of noise-related complaints, according to the NRU manager, is likely attributable to the combination of the layout (distinct rooms for specific tasks) and the small number of beds per room. This inference is supported by the account of the son of a NRU patient, who stated that noise was not a concern for his mother or for himself as a frequent visitor.

Lighting

Illumination affects the health, safety, and job performance of employees who work in hospital settings. Chaudhury et al. (2009) noted that as exposure to daylight increases, nurses are less likely to experience stress and dissatisfaction with their jobs (Alimoglu & Donmez, 2005), and, in contrast, artificial light can contribute to decreased energy levels for nurses and lead to less effective functioning

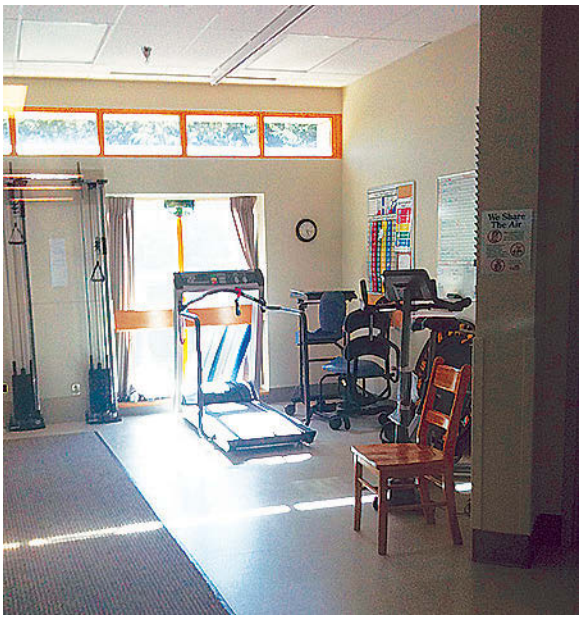
(Scott, 2004). However, it is difficult to implement an optimal combination of artificial light sources and daylighting in an environment that requires various tasks to be performed with a high degree of accuracy.

With respect to daylighting, although none of the windows in the NRU span from floor to ceiling, most are large enough for patients to see the outdoors while in bed or receiving therapy. All of the rooms along the exterior wall of the hospital building have small- to medium-sized windows. These rooms also have a row of small rectangular windows that line the top of one wall (e.g., patient rooms, the exercise room, and the kitchen/dining room—see Figures 4 and 5). Rooms with this high window arrangement that do not have other windows are equipped with more task lighting. Some rooms with this type of window structure have larger windows built into the same wall. The kitchen/dining room is an example of this type of lighting arrangement. In it, tables are situated near the larger windows to afford a view of the outdoors. However, a wooden beam is placed across these windows to signify that outdoor access is not possible. It can also serve as a safety feature, similar to a handrail. This window arrangement is common to all areas of the hospital; it is not specific to the NRU.

Figure 3. Main hallway, illustrating unit layout and distance between rooms.

Figure 4. Dining room and kitchen—note window structure.

Figure 5. Exercise room—note the window structure.



The recreation room is another example of an area in the NRU with a high row of windows near the ceiling and larger windows in the same wall (see Figures 6 and 7). This room, like the kitchen/dining room, has hanging bar light fixtures spaced evenly along the ceiling. The entire NRU uses this type of indirect, artificial lighting.

Chaudhury et al. (2009) suggested that glare-reducing surfaces should be used. The NRU has not applied glare-reducing window film, shades, tinting, or installed solar shading to permit the maximum amount of daylight into each room without the annoyance of glare or excess heat. However, larger windows have curtains for controlling the amount of light coming into the room (and any subsequent glare). The windows along the ceiling perimeter probably do not produce much glare or excess heat, given their smaller, rectangular size and height (neither variable was noted during the walk-through of the unit). This is because high windows distribute light more evenly, control for thermal load, and allow light to penetrate large buildings (Binggeli, 2010).

As is common in many hospital wards, wall-mounted fluorescent light fixtures are above each patient bed to assist nurses with medication administration and

Figure 6. Recreation room—example of window structure.

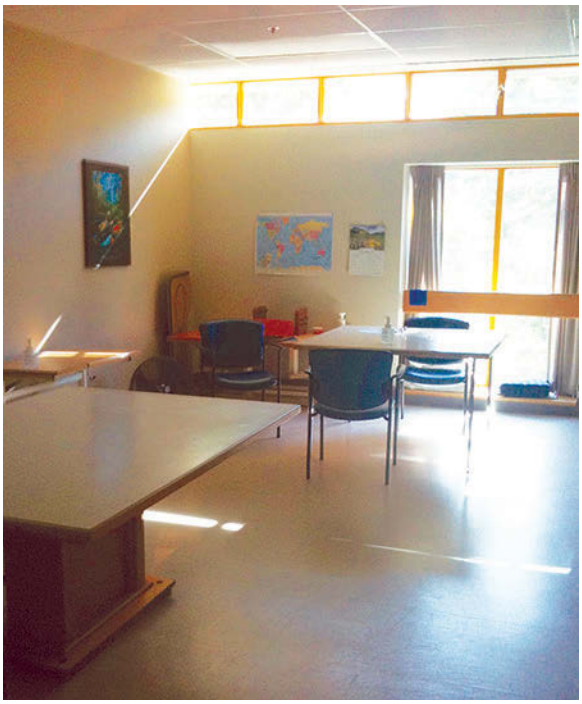


Figure 7. Recreation room—example of window structure.

instrument reading. Figure 8 illustrates how the wall-mounted lighting fixtures allow patients to turn the bottom portion on or off at their convenience (a pull-chain hangs down near the head of the bed). The top portion of the lighting fixture is controlled by nursing staff via a main switch that also controls the ceiling fixtures. Thus, patients have some degree of control over their lighting. Also, during night hours, overhead fixtures are turned off and decorative wall sconces in hallways are dimmed to signify a time for rest.

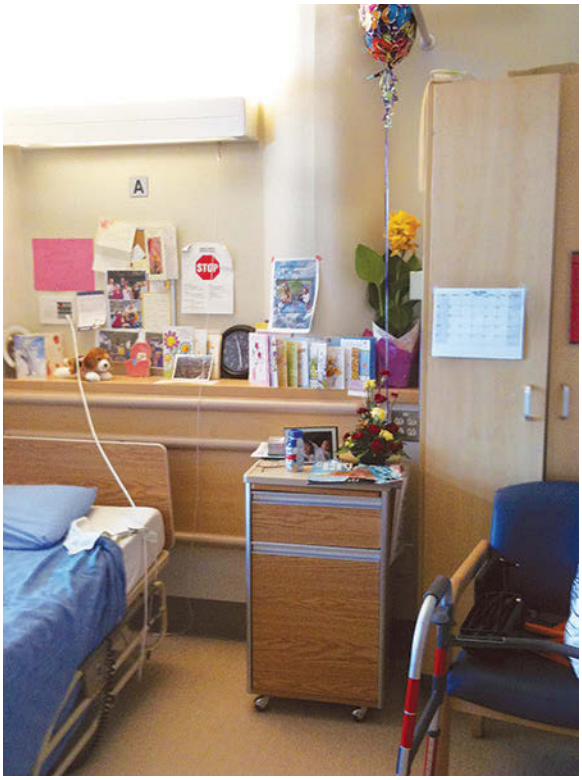
As noted by Chaudhury et al. (2009), the average age of nurses is increasing. Thus, bright illumination levels at workstations (ranging from 1500 to 2000 lux) are becoming more necessary for error reduction and employee comfort (Ulrich & Barach, 2006). Appropriate task lighting has been made available at the central nursing station via three lamps hanging over the workspace, and light fixtures have been installed under the cupboards in the charting room. Although these fixtures likely help to reduce nurse errors, none have especially high illumination levels.

Ergonomics, Furniture, and Equipment

The goals of ergonomic design are to enhance interactions between individuals and the physical elements of the workplace, and to optimize the health and productivity of people at work (Dul & Weerdmeester, 2008). Thus, ergonomic design is an important consideration when creating functional working conditions for employees in any environment. Healthcare settings often adopt ergonomic design principles to improve employee absenteeism and prevent long-term disability caused by repetitive physical stressors and lengthy time periods spent standing. In hospitals, poor ergonomics can result in nursing errors and higher absenteeism (Janowitz et al., 2006).

With respect to nurses' immediate work environments, Chaudhury et al. (2009) stated that nursing stations ought to be ergonomically designed to meet the job requirements of employees (e.g., significant amounts of standing time). Sufficient space should be provided for nurses' feet to enable movement close to counters at nursing stations (Kroemer & Kroemer, 2001). In addition, Chaudhury et al. asserted that in order to enhance working environments for nurses and other hospital employees, ergonomic nursing stations and patient rooms equipped with mechanical (i.e., easily moveable and height adjustable) furniture and equipment should be standard in acute care settings. This would, for example, allow a patient to remain in bed for an x-ray, rather than requring transfer to a different table (Chaudhury et al., 2009)

Figure 8. Patient room—denotation of patient controllability of overhead lighting.



The ergonomic needs of employees have been accounted for in the design of the NRU. The central nursing station has a sufficient number of seats for several staff to sit down and write, talk on the telephone, or work at the computer between rounds. All chairs in the unit are of ergonomic design, following the hospital's recent mandate to reduce physical stress on staff (e.g., all chairs are adjustable in height, and offer lumbar support).

Chaudhury et al. (2009) pointed out that to minimize the need for physical strength of employees, mechanized devices ought to be used, such as beds that do not require patients to be moved for various procedures. The NRU does not use beds that are appropriate for different procedures (e.g., x-rays); however, ceiling lifts with waist belts to assist employees with moving individuals in and out of bed are installed in some patient rooms (not all patient rooms have ceiling lifts because part of the NRU's purpose is to ensure patients become able to enter and exit their beds without mechanical assistance).

Patient Room Design and Unit Layout

Chaudhury et al. (2009) stated that patient room design and acute care unit layout ought to be convenient and accessible to both patients and staff. With respect to patient room design, single-occupancy rooms have been associated with better communication among staff, fewer medication errors, and decreased infection rates (Chaudhury et al., 2009).

The layout of patient rooms in the NRU is standardized in terms of where beds, cabinets, chairs, and privacy curtains are stationed. Thus, nurses who move from room to room are not at a disadvantage with respect to efficiency. The layout of the patient rooms is standardized in part because of the wall-mounted computer fixtures between beds and the size of the rooms.

In addition, Chaudhury et al. (2009) noted the positive role en suite bathrooms play in a successful acute care unit (focus group participants stated that close proximity between bathroom and bed is optimal for reasons of comfort and safety). Patient rooms in the NRU are equipped with en suite bathrooms in close proximity to beds. Each room also affords seating for visitors, controllability of privacy by way of curtains separating each bed, and controllability of temperature by way of access to extra blankets or an electric fan upon verbal request.

The NRU utilizes two supply rooms and one centralized medication room. Members of the focus groups in the review by Chaudhury et al. (2009) stated that decentralized supply rooms are more efficient than a single supply storage area. Another important aspect of the layout of an acute care unit is clear lines of sight between nursing stations and patient rooms. This design goal is difficult to execute in units with several types of rooms, like the NRU. The NRU affords limited visibility of patients by staff because the central nurses' station has sight lines to only a few patient rooms, not to all beds or patients.

Patient rooms in the NRU are also designed to enable patients to receive numerous forms of acute care in one room, regardless of acuity level. Acuity-adaptable

rooms accommodate patients and family members, as well as nurses and staff, by providing ease of use and increased storage for equipment (Chaudhury et al., 2009). Fewer medication errors, patient falls, and procedural errors, as well as shorter lengths of stay, all occur in acuity-adaptable rooms (Hill-Rom, 2002). The combination of acuity-adaptable rooms and decentralized nursing stations has resulted in improved operational and cost efficiency, and satisfaction for patients and staff (Hendrich, Fay, & Sorrells, 2004). Future studies of the NRU should measure whether the unit's combination of a centralized nursing station and acuity-adaptable rooms have a similar positive influence on employee satisfaction levels and procedural errors.

Conclusion

This case study was based on the review by Chaudhury et al. (2009) of the physical aspects of acute care settings that can lead to reductions in nursing staff error. Evidence suggests that nursing staff efficiency and engagement can suffer from common workplace stressors such as distractions due to noise, artificial lighting, poor ergonomics, and disorienting layouts. The NRU at the hospital serves as an appropriate setting for examining the design goals concerning noise, lighting, ergonomics, and unit layout presented in Chaudhury et al. (2009).

Based on a site tour and photographs of the unit, an interview with the NRU manager, and the account of the son of a patient of 5 months, informative comparisons were made between the NRU's design and the acute care setting design guidelines outlined by Chaudhury et al. (2009). In terms of noise, no formal (i.e., structural) attempts to reduce excess sound have been integrated into the design of the NRU. However, the layout of the unit and the limitation on the number of beds per room provide natural barriers to noise. The NRU uses a combination of artificial and natural light in each room, along with task lighting at the nursing station and in the charting room. In addition, the unit uses specialized seats at the nursing station and affords adequate foot space for nurses to comfortably stand at the station for lengthy periods. Ceiling lifts in some patient rooms also decrease physical requirements for nurses. Finally, all patient rooms have a standard layout. The NRU's centralized nursing station, decentralized supply rooms, and acuity-adaptable patient rooms creates a satisfactory working environment for staff.

The NRU includes many of the design attributes advocated by Chaudhury et al. (2009). However, supplemental research should be undertaken to objectively measure nursing error, efficiency, and staff satisfaction with respect to the comparisons and assumptions presented in this study.

Implications for Practice

- No formal attempts to attenuate excess sound were integrated into the NRU's design. However, the layout of the unit and the limitation on the number of beds per room provided natural barriers to noise.

- The NRU used a combination of artificial and natural light in each room, along with task lighting at the nursing station and in the charting room.
- The unit accounted for ergonomics by using specialized seats at the nursing station and afforded adequate foot space for nurses to comfortably stand at the station for lengthy periods. Ceiling lifts in some patient rooms also decreased physical requirements for nurses.
- All patient rooms had a standard layout. The NRU's centralized nursing station, decentralized supply rooms, and acuity-adaptable patient rooms created an apparently satisfactory working environment for staff.

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