

# Nursing Unit Configuration and Its Relationship to Noise and Nurse Walking Behavior: An AIDS/HIV Unit Case Study

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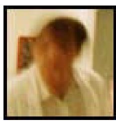

**Introduction**

While empirical studies have addressed the appropriate design of healthcare facilities in general, there is very little research-based information regarding the design of supportive facilities for persons with AIDS. HIV/AIDS environment studies have been limited to a few postoccupancy evaluations (e.g., Shepley and Wilson 1999), case studies (e.g., Chambers and Guerin 1993), and research on the appropriateness of AIDS-dedicated facilities (e.g., Rothman and Tynan 1990). Another topic that has not been thoroughly addressed is nursing unit size and configuration as well as related decisions based on staffing ratios and recent precedent. Although the average number of beds on a typical unit is 25 to 30 beds (Velsey and Egbert 1994), unit size may range widely-from as few as six beds in intensive care to as many as 48 in a general medical unit. In addition, the overall physical dimensions of units are wide-ranging due to the impact of patient density (single-, double-, or multiple-bed rooms). AIDS units tend to have more single-bed rooms (to support infection control). The increased area per patient results in a larger nursing unit and, potentially, decreased staff efficiency. Even if two-bed rooms meet the social and medical needs of some patients, these rooms lack the room assignment flexibility and infection control efficiency of single-bed rooms.

The objective of this study was to compare two nursing unit designs in facilities for persons with AIDS. The two dependent variables were noise level and distance walked by nurses. There were two hypotheses. The first was that nursing staff would walk more in the large rectangular units. This has been suggested in previous studies (e.g., Trites et al. 1970). The second hypothesis was that noise levels would be lower in the more compact radial design because this design would use fewer staff. In addition, because patients are visible from the nursing station, they might be less likely to create noise by using the nurse call system. Although studies have measured noise levels on nursing units, these levels have not been compared for differing unit configurations. If both the hypotheses are supported, radial plans can be presumed more effective in these ways.

**Walking**

Nurses spend a lot of time walking. A study of 17 nurses participating in 37 shifts indicated that the average nurse in a general ward walked approximately 6,260 meters (3.89 miles) and 8,260 meters (5.13 miles) in an intensive care ward (Bauer and Knoblich 1978). In a nursing home study, Burgio et al. (1990) noted that almost 28.9 percent of nursing staff time was spent walking. This came second to patient-care activities, which accounted for 56.9 percent of observed behavior. It follows that if less time is spent walking, more time will be available to spend with patients or on activities that would improve patient care. Seelye (1982) noted that travel distance and patient contact are the two most important issues affecting nursing care.

In addition to the anecdotal reports of reduced walking in cluster units (e.g., Fisher 1982), there are related studies on the relationship between unit design and walking. A study at Rochester Methodist Hospital in Minnesota (Sturdavant 1960) compared two intensive care units, one with a radial design and the other with a single-corridor design. Sturdavant found that fewer trips were made to patient rooms in the cluster units due to the increased visual supervision of the patient from the nursing station, while the average time spent with patients was equivalent (39 percent to 40 percent). Increased patient visibility also enabled the head nurse to participate more in patient care in the radial unit than in the rectangular unit. Staff expressed greater satisfaction with the radial unit as well.

**Noise**

Several studies have found links between noise and stress-related physiological changes (e.g., Glass, Singer, and Friedman 1969). In healthcare environments, inappropriately high noise levels can adversely affect patients and staff (Falk and Woods 1973). More specifically, increased noise level is a stressor for immunocompromised patients (Griffin 1986). Although the maximum sound level recommended for a hospital is 45 decibels, Hilton (1985) recorded levels that range from 50 to 80 decibels in an acute nursing unit. Lack of noise control has been identified as an element that contributes to a patient's sense of helplessness. In addition, noise levels may contribute to the occurrence of medication and charting errors by the staff in a patient unit.

Sources of noise in an inpatient unit include the movement of people and equipment, computer printers, telephones, staff and patient conversations, patient noises, public address system messages, and alarms. Haslam (1970) listed the following primary sources of noise, in order of their level of irritation to patients: conversations between staff, visitors, and patients; sounds from patients in distress; noises from mechanical devices; and sounds from television and radio. One of the most disturbing noises to patients has been identified as talking in the hallway (Topf 1985). Redding, Hargest, and Minsky (1977) noted that three physicians talking in the hallway generated 68 dB. High noise levels in the corridors may be a result of long corridors and increased distance from the nurses' station. Staff may tend to have miniconferences in the hallways instead of walking all the way back to the nurses' station. Also, the staff cannot see patients (as is common in rectangular designs), patients make noise to get staff attention. Bells and the rattling side rails generate 78 dB and 80 dB at 10 feet, respectively (Redding, Hargest, and Minsky 1977).

Relationships have also been found between noise and physiological responses. Kryter (1985) identified the following six responses:

1. Vasoconstriction of the peripheral blood vessels
2. Altered breathing rate
3. A modification in galvanic skin response
4. Skeletal and muscular tension
5. Gastrointestinal motility changes
6. Blood and urine chemical modifications.

Relative to hospital populations, Marshall (1972) identified a correlation between acoustical stimulation and pulse rate in a critical care unit. In addition, Minckley (1968) found that patients exposed to higher noise levels are more likely to perceive higher pain levels as measured by requests for pain medication.

Many inpatients complain that it is difficult to sleep. This is likely due to the number of loud noises in a nursing unit as well as the impact of being in an unfamiliar environment. Helton, Gordon, and Nunnery (1980) found a correlation between interrupted sleep and negative psychological status such as hallucinations, combativeness, and disorientation in an intensive care unit. Snyder-Halpern (1985) also reported evidence of physical and psychological alterations when noise interferes with patients' sleep.

Cluster or radial units are usually smaller than corridor units. If smaller units are associated with less noise and increased staff efficiency, better patient care may be provided when the number of beds per unit is limited. In the case of general diagnosis patients, better patient care may result in shorter hospital stays and perhaps reduced medical costs. In the case of AIDS/hospice facilities, where length of stay is less of a consideration because many patients die on the unit, less noise and increased efficiency may increase staff productivity and enhance the patient's sense of well-being.

Linear Corridor versus Radial Configuration

A thorough study regarding nursing unit configuration was undertaken in 1970 by Trites et al. This study compared three unit designs: radial, double-corridor (racetrack), and single-corridor (L-shaped). The main finding was that radial designs were more successful from the perspective of functionality and staff preference. Nurses traveled significantly less, and the time was converted into more time spent with patients. Double-corridor designs were rated second and single-corridor designs were rated last in terms of both these variables. Most of the medical staff preferred the radial units and felt that configuration enhanced the quality of patient care. In addition, it was noted that staff members had relatively more accidents on single-corridor units. Preference for radial designs has also been demonstrated elsewhere (Macdonald et al. 1981).

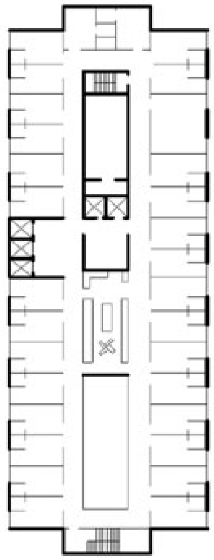
Figure 1

**Methodology**
The two nursing unit sites selected for comparison had the following characteristics in common: location within a few miles of one another in the same large city, management by the same health organization, and a focus on care for HIV/AIDS patients. Although the units had much in common, they differed dramatically in plan configuration. One unit had a double-corridor rectangular floor plan with the nurses' station/support spaces in the core and patient rooms on the perimeter wall (see Figure 1). The other unit was circular in configuration with the patient rooms radiating around the circumference and the nurses' station at the center (see Figure 2).

The rectangular unit accommodated 24 beds and was approximately 18,500 square feet including support areas. The radial unit was one of five 10-bed units and approximately 8,100 square feet. The number of staff per square foot in each nursing unit was comparable. Staffing on the rectangular unit ranged between five and 10 nurses on a single shift, while staffing on the radial unit was typically two nurses.

**Measurement Apparatus**
Sound levels were measured using a noise-logging dosimeter with an operating range of 30 dB to 125 dB. The dosimeter was downloaded every 36 hours, producing noise-level histograms and other data, including thresholds (the percentage of time that sound exceeded a specified level), peak levels, and averages. The apparatus consisted of the measurement device and a small microphone.

Walking was measured using electronic (battery-operated) pedometers that logged the number of steps taken. These pedometers were attached to the back of the nursing staff's belts. The effectiveness of the pedometers was pretested on a running track to confirm their intradevice mechanical accuracy, which was found to be between 97.7 percent and 99.7 percent.

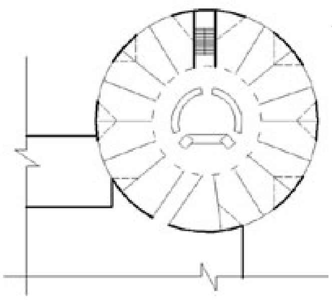
Figure 2

**Procedure**
A survey of the physical characteristics of the nursing stations identified variables that might significantly affect noise measurement data. While the ceilings were of comparable height and finish (acoustical tile), the floor finishes were not (see Figures 3 and 4). The radial unit was carpeted, while the rectangular unit had resilient flooring. The carpet had sound reduction indices of .03 to .08 at 125 Hz and .72 to .80 for 4000 Hz (Templeton 1993). On the other hand, the radial unit also had a low-volume radio turned on throughout most of the study. (A soft-volume radio has an average decibel level of 35 dB [Waterfall 1929].) Although these two characteristics of the radial unit may have been self-canceling, it was decided that only highly significant differences in sound level would reliably indicate variability in noise levels.

In each case, the dosimeter was located near the core of the nurses' station on vertical casework. Ten- to 30-minute gaps occurred in the data when the dosimeter was reset every 36 hours. These gaps were staggered to avoid the repeated absence of data during the same time interval. The dosimeter recorded decibel levels every minute, and the levels were averaged for every five minutes. The starting and ending times were recorded to allow the data to be entered by time of day. This method reduced the data to 288 points while also allowing for analysis by time and day of the week. The data retrieval spanned from 00:00 (midnight) to 23:55 (11:55 p.m.).

Noise data were collected at the rectangular and radial units for 174 and 140 hours, respectively, and recorded on consecutive weeks. Walking measures were obtained during the same period that noise measurements were made. Nursing staff were pretrained in the use of the pedometers. When the study period began, each nurse set his or her pedometer and recorded the start time. The pedometers were removed at the end of the work shift, and the time that they were returned was also recorded.


Figure 3

**Results**
**Walking Behavior**
Steps per minute per work shift were calculated for each subject. The data were broken down to steps per minute rather than steps per work shift because shifts varied in duration from one hour to 16 hours and 40 minutes. Nurses working in the rectangular configuration took an average of 7.9 steps per minute, and those in the radial configuration took an average of 4.7 steps per minute. Using a conversion factor of 2.6 feet per step, the nurses traveled an average of 20.5 feet per minute and 12.22 feet per minute, respectively. The maximum distance walked per segment was approximately 6.87 miles (33 feet per minute) in the rectangular design and 1.97 miles (9.66 feet per minute) in the radial design. A t-test showed the difference in walking distance between the two units to be statistically significant ($p<.01$). Tables 1 and 2 demonstrate the different patterns between the two units.


Figure 4

**Noise Levels**
The five-minute totals were averaged over the duration of the study. For example, the average decibel level at 6 a.m. over seven consecutive days was approximately 58 dBs. Each entry on Table 3 represents averages at five-minute intervals over six to seven days. The total average, combining all data entries, was 60.98 dB for the rectangular design and 60.65 dB for the radial design. A t-test assuming unequal variances indicated no significant difference between the two units. Commonalities in noise patterns were observed, however. Noise level tended to drop at night (9 p.m. to 6 a.m.) relative to the day (9 a.m. to 6 p.m.). The average noise level at night was 60.25 dB on the radial unit and 59.63 dB on the rectangular unit, and the average day levels were 62.56 dB on the radial unit and 62.02 dB on the rectangular unit. Saturday peaks were also noted on both units (79 dB in the radial unit and 86 dB in the rectangular unit).

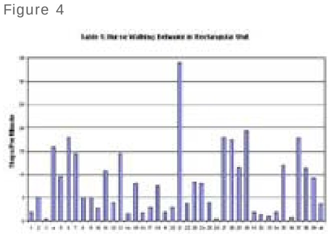
Table 1

**Discussion**
Nursing staff in the radial unit walked significantly less than staff in the rectangular unit. This has been confirmed by other studies (Trites et al. 1970). The Trites study and this study were also similar in that they both found a large variance between individuals. The extreme variation in the data is likely a result of job descriptions. Differences in walking distance have been identified in previous studies (Burgio et al. 1990), where it was found that LPNs (licensed practical nurses) spent 15.8 percent of their day walking, whereas RNs (registered nurses) spent 24.1 percent of their day walking. The Trites findings suggest that a decrease in the percentage of time spent walking correlated to an increase in the percentage of time spent in patient care activities.

Regarding noise levels, the lack of significant variation between the two designs might be misleading. Possible confounding variables in the field study included differences in staffing levels and nursing station size; variations in acoustical finishes of the nursing stations; the presence of a radio in one unit; and possibly, the amount of time nurses spent in the nurses' station.

The range of approximately 52 dB to 67 dB recorded in this project is consistent with findings by Hilton (1985), who reported levels ranging from 50 dB to 80 dB. The fact that the noise levels in the rectangular and radial units proved similar may suggest another hypothesis-that the noise levels in most nursing units will fall into that range, regardless of unit size, due to any of the following factors:

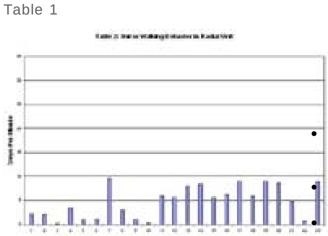
Table 2

- Relative increase in time spent in the nursing station as patient rooms become more proximate. Although small units would have fewer staff, the staff could spend more time in the station because they wouldn't be walking as much, and they would have less reason to leave the station as patients would be more readily seen.
- Increased size of the nursing station as the unit gets larger. Larger nursing stations will provide acoustical distribution of noise.
- Social stimulation requirements. The use of the radio in the radial unit may have been a result of increased need for stimulation due to the decrease in staff numbers in the station.
- Community size. Observers in this study noted that the smaller radial unit had a much less formal ambience than the rectangular unit, which may have accounted for increased talking among staff.

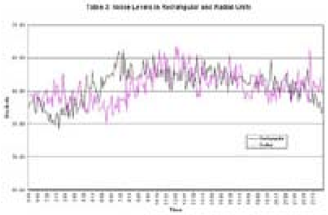
Table 3

**Conclusions**
The intention of this study was to examine noise levels and walking behavior in radial and rectangular AIDS/HIV facility designs. The data from this research support previous studies that indicate that a dense radial nursing unit design requires less walking on the part of staff. If less walking is required, staff may be able to spend more time directly caring for or supervising patients. Noise levels, on the other hand, were similar for the two designs. In future studies, noise levels for other unit densities should be compared to verify the relationship between nursing unit size and noise levels. If noise levels are comparable between units, they may be relatively stable across nursing unit configurations, and efforts to reduce noise should therefore focus on operational issues and acoustical finishes.

Although the relatively small size of radial units may reduce staffing assignment flexibility, the decrease in walking would help to support both direct and indirect patient supervision. If the trend in increased patient acuity in inpatient care continues, it is likely that fewer patients will be assigned to each nurse, thus justifying clustered/radial units.

Staff that had worked in both types of units and participated in this project indicated that security (relative to theft and control of intruders) on the dense radial unit was greater than on large rectangular units and expressed a strong preference for the radial unit. Data from previous studies suggest that nursing staff and patients prefer the radial units.

The obvious limitations of the smaller units are increased construction and staffing costs. Another shortcoming of radial units may be problems with regard to wayfinding. Although standard rectangular units are also confusing, their unidirectional symmetry is less difficult to interpret than the bidirectional symmetry of the radial units. This lack of wayfinding support could be easily rectified by providing a window view. All the radial units surveyed in this study lacked windows from the nurses' station to the outside. Although the use of exterior walls for unit windows rather than for patient rooms would decrease the number of beds around a nursing station, the window space could be multifunctional and be used as a small lounge area.

In conclusion, this study suggests that radial units require less walking. If radial/cluster units are to be recommended for hospitals, however, efforts must be undertaken to enhance their wayfinding characteristics, and acoustical finishes and staffing costs need to be balanced against the need for improved care environments.

**References**
Bauer, H., and K. Knoblich. 1978. Ein beitrag zur erfassung der laufleistung stationar tatiger krandenschwestern (Recording of walking performance of nurse working in hospitals). Zum Gesellschaft Hygiene 24 (7):539-540.

Burgio, L., B. Engel, A. Hawkins, K. McCorick, and A. Scheve. 1990. A descriptive analysis of nursing staff behaviors in a teaching nursing home: Differences among NAs, LPNs and RNs. The Gerontologist 30:107-112.

Chambers, S., and D.A. Guerin. 1993. AIDS hospice unit: Design criteria and prototypes. Journal of Interior Design 19 (2):41-50.

Falk, S., and N. Woods. 1973. Hospital noise levels and potential health hazards. The New England Journal of Medicine 215:774-781.

Fisher, S. 1982. Design reduces nurses' walking, encourages patients to visit with each other. Journal - American Health Care Association 8 (March):40-43.

Glass, D., J. Singer, and I. Friedman. 1969. Psychic cost of adaptation to an environmental stressor. Journal of Personality and Social Psychology 12:200-210.

Haslam, P. 1970. Noise in hospitals: Its effect on the patient. The Nursing Clinics of North America 5 (4):715-724.

Helton, M., S. Gordon, and S. Nunnery. 1980. The correlation between sleep deprivation and the intensive care unit syndrome. Heart and Lung 9 (3):646-648.

Hilton, B. 1985. Noise in acute patient care areas. Research in Nursing and Health 8:283-291.

Kryter, K. D. 1985. The effects of noise on man. 2d ed. Orlando, Fla.: Academic Press.

Macdonald, M. R., J. J. Schentag, W. B. Ackerman, and M. A. Walsh. 1981. ICU nurses rate their work places. Hospitals 55 (2):115-116, 118.

Marshall, L. 1972. Patient reaction to sound in an intensive coronary care unit. Community Nursing Research 5:81-92.

Minckley, B. 1968. A study of noise and its relationship to patient discomfort in the recovery room. Nursing Research 17:247-250.

Redding, J. S., T. S. Hargest, and S. H. Minsky. 1977. How noisy is intensive care? Critical Care Medicine 5 (6):275-276.

Rothman, D. J. and E. A. Tynan. 1990. Advantages and disadvantages of special hospitals for patients with HIV infection. The New England Journal of Medicine 323:764-768.

Seelye, A. 1982. Hospital ward layout and nurse staffing. Journal of Advanced Nursing 7:195-201.

Shepley, M. M., and P. Wilson. 1999. Designing for persons with AIDS: A postoccupancy study at the Bailey-Boushay House. Journal of Architectural and Planning Research 16 (1):17-32.

Snyder-Halpern, R. 1985. The effect of critical care unit noise on patient sleep cycles. Critical Care Quarterly 7 (4):41-51.

Sturdavant, M. 1960. Intensive nursing service in circular and rectangular units. Hospitals, JAHA. 34:46-48, 71-78.

Templeton, D. 1993. Design acoustics. In Acoustics in the Built Environment, edited by D. Templeton. Oxford: Butterworth-Heinemann.

Topf, M. 1985. Personal and environmental predictors of patient disturbance due to hospital noise. Journal of Applied Psychology 21 (6):717-733.

Trites, D., F. Galbraith, M. Sturdavant, and J. Leckwart. 1970. Influence of nursing-unit design on the activities and subjective feelings of nursing personnel. Environment and Behavior 2 (3):303-334.

Velsey, D. W., and C. F. D. Egbert. 1994. Healthcare facilities. In Architectural Graphic Standards, edited by J. R. Hoke. New York: John Wiley, 827-830.

Waterfall, W. 1929. A loudness scale. Engineering News Record 102:60-62.

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