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Clin Nurs Res 2008; 17; 74

DOI: 10.1177/1054773807312769

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Effect of a Noise Reduction Program on a Medical–Surgical Unit

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This quasi-experimental study tested an intervention to reduce sound levels in an acute care hospital. A parallel pre- and posttest design with control group was used; patients and employees completed the Topf Adapted Sound Disturbance Scales, and environmental sound levels were recorded on a Quest 2900 Sound Level Meter. Treatment interventions included an educational PowerPoint presentation for employees, minor environmental acoustical alterations, and the use of a Quest 261 Sound Detector/Controller for behavioral modification. None of these interventions produced statistically significant changes in sound levels. Patients and employees reported slightly less disturbance due to noise postintervention on the treatment unit. The findings of this study support Philbin and Gray's suggestion that the use of sound-absorbing materials in the hospital's physical structure may be the most effective measure to reduce sound levels in the hospital setting.

Keywords: *clinical research; hospitals; noise; sound levels*

Reducing sound levels can improve the hospital environment. Both patients and staff can benefit from a quieter environment, which will ultimately enhance quality of care. Patient satisfaction is said to go up when the unit is less noisy and sleep is improved. The work environment for employees can

Authors' Note: Dr. Margaret Topf, Dr. Kathleen Philbin, Dawn Gould, MSN, Dr. Jerome Minkoff, Wendy Gong, RN, BSN, Katy Bayless, RN, Lucinda Hammond, MSPH, and Quest Technologies were helpful in the creation of this study.

also be improved by less noise-induced distraction, which may promote patient safety. The purpose of this study was to test whether interventions based on current literature would be effective in reducing recorded sound levels and sound-related disturbance in a medical–surgical hospital unit.

Problem and Literature Review

The negative effect of excessive sound levels in various hospital settings and among a variety of patient populations has been well documented. The sound level recommended by the Environmental Protection Agency to allow for rest in hospitals is 45dB (A). Sound levels exceeding this have been shown to impair sleep, increase stress, delay post-illness rehabilitation, and exacerbate agitation and psychiatric symptoms in hospitalized clients (Holmberg & Coon, 1999; Ragneskog, Gerdner, Josefsson, & Kihlgren, 1998; Simpson, Lee, & Cameron, 1996; Topf, 1983, 1992; Topf, Bookman, & Arand, 1996). Experimental research designs with rat models found association between excessively noisy environments and altered sleep–wakefulness cycles and delayed wound healing (Rabat et al., 2004; Wysocki, 1996). Sleep disturbance due to noise has been well documented in recent literature, although results have proven somewhat inconsistent. Corser (1996) found that noise and other external environmental stimuli in the pediatric intensive care setting altered sleep states and increased nighttime awakening even after discharge from the hospital. Topf and colleagues (1996) found that sound levels in a simulated critical care setting negatively affected subjective qualities of sleep. Topf and Thompson (2001) reported that noise-induced stress interacts with other stress to predict poorer sleep quality in hospitalized patients. Conversely, other research has shown that environmental noise in intensive care settings is only responsible for a small portion of sleep disruption (Freedman, Gazendam, Levan, Pack, & Schwab, 2001; Gabor et al., 2003). Nivison and Endresen (1993) found no evidence of a detrimental relationship among environmental noise, health, and sleep in a sample of people living near areas of heavy traffic.

High sound levels may also have an effect on hospital employees. Morrison, Haas, Shaffner, Garrett, and Fackler (2003) found that high average sound levels were predictive of increases in heart rate, subjective stress, and annoyance in hospital nurses. Sound levels have been shown to increase when more staff are present on the unit (Christensen, 2005). Although there is no research at this time to demonstrate a relationship between high sound levels and medical errors, one can infer that noise-related disturbance has the potential to jeopardize patient safety.

Despite the wealth of literature suggesting the negative effect of noise on patients and staff, studies have suggested that hospital sound levels have risen in recent decades from 52dB to 72dB during daytime hours and from 42dB to 60dB at night (Busch-Vishniac et al., 2005). Several studies have examined the effects of noise-reduction strategies in the hospital milieu, especially within intensive care units and neonatal nurseries. Kahn and colleagues (1998) found that an intensive behavior modification program related to noise reduction strategies for staff significantly reduced mean peak noise levels in an intensive care setting. Walder, Francioli, Meyer, Lancon, and Romand (2000) implemented guidelines to reduce noise and light levels in an intensive care unit during the nighttime hours, which significantly lowered the noise level equivalent as well as peak noise levels. Cmiel, Karr, Gasser, Oliphant, and Neveau (2004) were able to reduce average noise levels on a surgical unit by using a group of registered nurses, deemed the "sleep promotion team," to teach staff simple noise-reducing techniques. Similar reductions in noise levels were observed in neonatal and pediatric units after providing staff with education related to noise abatement (Elander & Hellstrom, 1995; Johnson, 2003). Nagamia, Nasseh, Ouslander, and Schnelle (2003) were not able to significantly reduce noise at night in a nursing home setting after establishing a noise-abatement policy, as staff compliance with the policy was inconsistent, which may signify that more intense training and feedback modules are needed when attempting to create a quiet nighttime environment.

In addition to behavioral modification programs and staff education, the physical environment and acoustical characteristics of hospital spaces have been shown to affect noise levels (Cmiel et al., 2004; Philbin, 2000; Philbin & Gray, 2002; Topf, 2000). Interventions to reduce reverberation and sound intensity, such as the use of sound-absorbing materials in patient rooms and other unit spaces, can significantly reduce noise levels (Philbin & Gray, 2002). Topf (1983) found a significant relationship between reports of exercised control over noise by using earplugs and reports of disturbance due to hospital noise in postoperative patients. A related study by Topf (1992) did not show a significant relationship between instruction in personal control over noise and sleep quality as measured by polysomnograph equipment and self-report. A study that exposed participants to simulated noise of an intensive care unit during sleep found that those wearing earplugs demonstrated a decrease in rapid eye movement latency and an increase in the percentage of rapid eye movement sleep (Wallace, Robins, Alvord, & Walker, 1999). On a related note, Topf (1985) found that sensitivity to noise is a personal characteristic that is predictive of level of disturbance due to noise and reactions to environments irrespective of the amount of objective noise imposed.

Research Question and Design

Will a noise reduction program lessen sound levels as recorded by a Quest 2900 Sound Level Meter and disturbance due to sound as perceived by employees and patients?

This study used a quasi-experimental design with parallel groups and a pretest–intervention–posttest model. There was a control group on a matched unit that did not experience the intervention. A total population sample was attempted on each of the two units and, thus, randomization was not sought.

Purpose

The purpose of this study is to test the following hypotheses:

Hypothesis 1: The use of a noise reduction program will have an effect on the outcome of the Topf adapted tools to measure sound disturbances for patients and employees on a designated medical–surgical hospital unit as evidenced by a statistically significant difference between these postintervention scores and scores on a matched control unit.

Hypothesis 2: The use of a noise reduction program will have an effect on the decibel measured sound levels on a designated medical–surgical hospital unit as evidenced by a statistically significant difference after the program between the treatment unit and matched control unit.

Operational Definitions

Sound measurement is defined as the sound levels measured in A-weighted decibels using a slow response setting. The decibel weighting network determines the measured frequencies and can be either A, B, C, D, or linear (Gray & Philbin, 2000). The A-weighted network will be used and measurements recorded as dB (A), as the A-weighted sound-pressure levels are electronically shaped to simulate human ear responses to soft sounds (Gray & Philbin, 2000).

L Levels

L_{eq} is the level of sound that represents the total amount of acoustic energy of changing pressures over a specified interval.

L_{min} is the lowest level of sound that is recorded each hour.

L_{max} is the highest level of sound that is recorded in any of the recorded intervals.

L_{10} is the level of sound exceeded 10% of the recorded time interval.

L_{90} is the level of sound exceeded 90% of the recorded time interval.

Sound level reduction is defined as a reduction in the recorded L levels described.

Sample

All patients hospitalized during the preintervention and postintervention phases on the treatment and control units were invited to participate. Qualifying criteria included the ability to speak or read English sufficiently to fill out the survey and give informed consent. Per Cohen's power analysis, 63 participants were needed in each group to prove effect at $p < .05$ at 50% certainty.

All Patient Care Services (PCS) employees (nurses, nurses' assistants, and unit assistants) working during the preintervention and postintervention phases on the treatment and control units were invited to participate. The total population of unit PCS staff was surveyed.

Method

Preintervention

After obtaining IRB approval, three measurements took place on both the treatment and control units:

1. A Quest 2900 Sound Level Meter was used for a 6-day period and six readings per hour were recorded. The research team was careful to follow recommendations from the literature related to proper placement of the sound level meter, such as suspending the microphone on a cord from the ceiling to prevent surface vibrations from transmitting to the meter as sound. The sound level meter was placed in the nursing station, out of sight from staff. The meter was placed in the same spot on both the treatment and control units, which were confirmed by measurements from the engineering department. Data from the noise level meters were downloaded into the Quest Technologies Quest Suite computer program every 24 hours. A common method of sound recording is to measure the L_{eq} (equivalent sound level). More distinct sound levels, such as the L_{min} , L_{max} , L_{10} , and L_{90} , were also measured.
2. Patients during the preintervention time frame were asked to fill out the Topf Adapted Sound Disturbance Survey.
3. All PCS employees on all shifts during this same preintervention time frame were asked to fill out the Topf Adapted Sound Disturbance Survey for Employees.

Intervention on the Treatment Unit

1. An educational PowerPoint presentation created by the research team based on the literature and consultant recommendations was shown to PCS employees on the treatment unit over a 2-week period. The PowerPoint presentation included a simple overview of the complex subject of sound reduction, the current literature related to the detrimental effects of high sound levels in health care settings, and simple methods to reduce noise, such as wearing soft-soled shoes, closing doors and curtains softly to prevent unwanted sound from traveling into patient rooms, and turning off televisions when not in use (i.e., after a patient falls asleep). The program was administered by the primary investigator and questions were encouraged by the staff members. The average length of the presentation was 15 minutes. Although employees were not required to attend the session, it was encouraged by the unit management and employees were paid for 15 minutes of overtime. More than 95% of employees attended. A copy of the educational PowerPoint presentation was also available on the unit for employees to read or review in their own time. No intervention took place on the control unit.
2. For behavioral modification, a Quest 261 Sound Detector/Controller was placed on the treatment unit (in the nurses' station) for a 1-month period, which notified the staff when the noise decibel level rose above a certain preset decibel. The Quest 261 Sound Detector/Controller is an instrument created to show a lighted "Quiet Please" sign when the noise level reaches a certain preset decibel level. This flashing light was intended to influence staff to lessen their noise creations. The initial "trigger decibel," or the decibel at which the lighted sign would flash, was set at 70 decibels for the first 3 days of the intervention phase, then turned down to 65 decibels for the next 3 days, and then reduced to 60 decibels for the remainder of the intervention phase. The levels were chosen by the researchers based on preliminary noise level meter readings that were taken when the unit was quiet and also from input from the staff who wished to slowly transition into a low preset decibel trigger. The machine was not placed on the control unit.
3. Environmental alterations, as recommended by the literature, were implemented by the engineering department on the treatment unit including repair/replacement of hydraulics and rubber stripping in doorways; repair/adjustment of patient furniture (nightstands) to eliminate unnecessary noise; turning alarms on mobile equipment away from patients' heads; reducing volumes on patient and nursing station telephones; and padding the pneumatic tube system. Nursing staff distributed earplugs to patients who were deemed coherent. No environmental alterations took place on the control unit. Earplugs were not available on the control unit.

Postintervention

1. A Quest 2900 Sound Level Meter recorded noise levels (as described above) for a 6-day period following the 1-month intervention phase on the treatment and control units.
2. Patients on both of these units following the month-long intervention phase were asked to fill out the Topf Adapted Sound Disturbance Survey for Patients.
3. All PCS employees on all shifts on both the treatment and control units following the month-long intervention were asked to fill out the Topf Adapted Sound Disturbance Survey for Employees.

Validity and Reliability

The two survey instruments used (the Topf Adapted Sound Disturbance Survey for Patients and the Topf Adapted Sound Disturbance Survey for Employees) were based on the work of Dr. Margaret Topf (1985). Validity of the initial instrument had previously been established by Dr. Topf. Per her suggestion, the researchers also included modern sounds found in a hospital unit (i.e., floor polisher). To establish reliability for these minor changes made to the instrument, a test–retest and alternate forms piloting of the adapted instruments was completed on a unit not participating in the study. Dr. Topf approved of the adapted version.

The Quest 2900 Sound Level Meter was used in accordance with the manufacturer's directions and those given by Philbin and Gray in publication. The device was calibrated by the manufacturers, Quest Technologies, and daily calibration was verified by the researchers, and two fresh 9-volt batteries per device were inserted daily to ensure that the entire 24-hour cycle would be captured. The validity of the educational program was established by two nurse educators who frequently develop material for employee education and by a PhD nurse who advises on health education.

Data Analysis

The pre- and postintervention surveys were analyzed using Wilcoxon Rank Sums after means and medians were identified. The decibel levels, which were obtained via the Quest Suite computer program and converted to Microsoft Excel format, were plotted on visual displays, entered into histograms, and analyzed using Wilcoxon Rank Sums.

Findings

Survey Data: Patients

A total of 64 patients on the control unit and 63 patients on the treatment unit completed the Topf Adapted Sound Disturbance Survey for Patients during the preintervention phase, making a total of 121 completed surveys preintervention. There were no patients who refused to participate in the study; those not participating were deemed too ill or confused by the data collectors. After the month-long intervention, 47 patients on the control unit and 50 patients on the treatment unit completed the Topf Adapted Sound Disturbance Survey for Patients, making a total of 97 completed surveys postintervention. Again, this included all patients on the two units who were not too ill or confused. The possible scores ranged between 30, indicating no sound disturbance, and 150, indicating severe sound disturbances. The difference in Wilcoxon Rank Sum means and medians on the sound disturbance scores between the two units was not significant ($p = .16$), and the difference between the pre and post scores on the treatment unit was not significant ($p = .67$).

Survey Data: Staff

A total of 44 PCS employees on the control unit and 41 PCS employees on the treatment unit completed the Topf Adapted Sound Disturbance Survey for Employees during the preintervention phase. A total of 30 PCS employees on the control unit and 43 PCS employees on the treatment unit completed the Topf Adapted Sound Disturbance Survey for Employees during the postintervention phase. In both instances, more than 90% of the PCS staff participated. The difference in Wilcoxon Rank Sum means and medians on the sound disturbance scores between the staff on the two units was not significant ($p = .99$), and the difference between the pre and post scores for the staff on the treatment unit was not significant ($p = .82$). Employees reported a higher level of sound disturbances ($M = 63-64$) than the patients ($M = 39-47$).

Individual Sources of Sounds: Patients

Specific questions indicated a trend toward differences in responses between treatment and control groups. Tables 1 and 2 delineate specific questions in which the noise disturbance seems to have lessened after the intervention, although not statistically significantly.

Table 1
Comparison of Patient and Employee Treatment and Control Groups, Postintervention

Patient Treatment & Control Groups, Postintervention		% of Participants Reporting Disturbance Due to Sound, Postintervention	
Question #	Subject	Treatment	Control
3	Talking in hallway	48.00	57.45
4	Doors opening, closing, slamming	40.00	46.81
5	Falling objects such as equipment, patient charts	26.00	40.43
6	Socializing at nurses' station	36.61	48.94
9	People talking on cell phones	20.41	40.43
13	Telephones in patient rooms	16.70	33.04
14	Construction noise in hospital	24.00	34.78
16	Intercom and call lights	36.73	44.68
27	Visitors	29.17	42.55

Employee Treatment & Control Groups, Postintervention		% of Participants Reporting Disturbance Due to Sound, Postintervention	
Question #	Subject	Treatment	Control
1	Loud talking in hallway at night	67.65	91.3
3	Talking in hallway	81.40	93.33
4	Doors opening, closing, slamming	74.42	90.00
5	Falling objects such as equipment, patient charts	76.74	90.00
7	Squeaking parts on beds or equipment	65.12	83.33
9	People talking on cell phones	57.14	80.00
20	Televisions	65.12	83.33

Individual Sources of Sounds: Employees

Specific questions showed differences in responses between treatment and control groups after the intervention. The number of employees reporting disturbance due to sounds was lower on the treatment unit, suggesting reduced levels of noise disturbance on the treatment unit in the specific areas after the intervention. In comparing the pre- and postintervention employee survey data on the treatment unit, specific questions also showed differences, although not statistically significant.

Table 2
Comparison of Patient and Employee Treatment
Groups, Pre- and Postintervention

Question #	Subject	Patient Treatment Group, Pre- and Postintervention		% of Participants Reporting Disturbance Due to Sound	
		Preintervention	Postintervention	Preintervention	Postintervention
1	Loud talking in hallway at night	60.00	54.00		
7	Squeaking parts on beds or equipment	36.07	30.61		
13	Telephones in patient rooms	24.59	16.67		
20	Televisions	31.15	28.00		

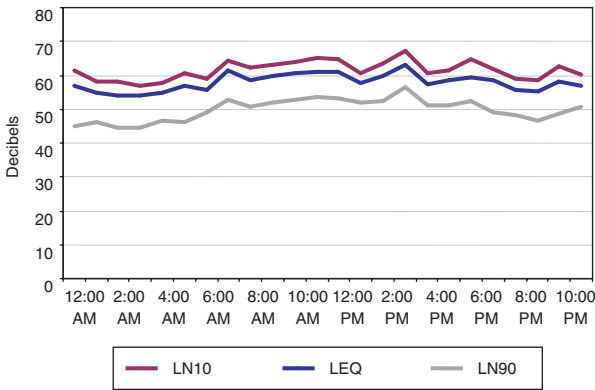
Question #	Subject	Employee Treatment Group, Pre- and Postintervention		% of Participants Reporting Disturbance Due to Sound	
		Preintervention	Postintervention	Preintervention	Postintervention
1	Loud talking in hallway at night	80.65	67.65		
2	Patient sounds such as coughing, snoring, gagging, moaning	90.00	69.77		
4	Doors opening, closing, slamming	85.00	74.43		
5	Falling objects such as equipment, patient charts	85.00	76.74		
6	Socializing at the nurses' station	97.44	86.05		
17	Paging system	78.05	69.05		
18	Radios	52.50	27.91		
22	Telephones outside patient rooms	73.17	53.49		

Sound Level Data

A Quest 2900 Sound Level Meter recorded sound levels in A-weighted decibels for the L_{eq} , L_{max} , L_{min} , L_{10} , and L_{90} on both the treatment and control units for 6 days both pre- and postintervention. Data were analyzed using interval data analysis techniques, visual plotting, and histogram comparison. In comparing pre- and postintervention sound levels for the L_{eq} , L_{max} , L_{min} , L_{10} , and L_{90} , no statistically significant differences were found between control and treatment groups.

The 45 dB (A) sound level recommended by the Environmental Protection Agency was rarely achieved in our study units. The L_{eq} daily means ranged from 44.9 to 69.2 throughout the length of the study.

Figure 1
Illustration of Sound Level Histogram, 15:00 Decibel Spike



Note: L_{max} and L_{min} levels have been omitted for clearer visualization of the data.

Although not statistically significant, a histogram of the L_{90} , the level of sound exceeded 90% of the time, did show lower sound levels after the intervention. An additional finding was the fairly consistent spike in noise levels around 15:00, which coincides with change of shift times. The spike in decibels during this time was found to be between 65 dB and 75 dB (see Figure 1). There were also higher recorded levels of noise during daytime hours in general.

Limitations

Survey. The patients on the medical–surgical floors had more hearing deficits than anticipated. Although not revealed in the pilot study, many patients neither heard nor complained about noise. The data collectors often found themselves on a unit with telemetry alarms going off, IV pumps alarming, overhead paging, and telephones ringing, and several patients on this same unit would state that they heard no noise. Despite the facility’s Picker scores (Picker Institute, 2007) identifying noise as an area in need of improvement, the patient surveys in this study did not verify those results. One third of all patient participants reported no sound disturbances at all (scores < 31 on the survey).

Patients were also found to be more acutely ill during the postintervention stage (in November) and fewer were able to participate due to illness

or confusion. In addition, several patients who were more alert stated, "I am getting great care," and did not wish to offer any complaints.

Joint Commission requirements. There are standards required by the Joint Commission on Accreditation of Healthcare Organizations, which require very clear monitor alarm levels that must be audible by all staff members from all areas on the units. Thus, telemetry alarm levels were not alterable and created sound levels above 70 decibels, which caused the Quest 261 Sound Detector/Controller to illuminate whenever the telemetry alarms rang. Nurses may have become habituated to the flashing of the Quest 261 Sound Detector/Controller associated with the telemetry alarms.

Quest 261 Sound Detector/Controller. This piece of equipment was placed in the nurses' station where manipulation by staff was noted on four occasions. Staff members turned up the triggering decibel level so that the lighted "Quiet Please" sign would not illuminate despite high sound levels.

Discussion

Anecdotally, the staff members on the treatment unit verbalized willingness and eagerness to reduce unit noise levels during the completion of the educational program. Many reported being distracted by noise in the course of their workday and described feelings of helplessness in taking steps to lessen sound levels on the unit. Several reported not wanting "to be the one that shushes everyone." Despite these reports, the researchers noted that the Quest 261 Sound Detector/Controller was occasionally manipulated by staff members 2 weeks into the intervention phase. There were instances when the device was found to be unplugged or altered so that the trigger decibel was set higher, causing the machine to light up less frequently despite loud noises. Staff on the treatment unit reported becoming accustomed to the device, suggesting that the flashing sign may have been ignored after several weeks on the unit. Other studies have also reported staff members' resistance to noise reduction programs or manipulation of sound reduction tools (Bailey & Timmons, 2005; Schnelle, Alessi, Al-Samarrai, Fricker, & Ouslander, 1999). This is a factor that must be seriously considered in future sound reduction research and programs. If the Quest 261 Sound Detector/Controller is to be used as a modification device, it would be important for the device to have the ability to be locked so as to deter such manipulation by staff.

A successful part of the intervention program was the use of earplugs. Both staff and patients reported satisfaction with the earplugs for the patients. Employees verbalized to the research team that they liked being able to offer their patients something nonpharmacological to help them rest and reduce unwanted noise.

The survey data were suggestive of lessened noise on the treatment unit in the postintervention phase, so it is possible that the nurses were altering their behaviors to some degree. Overall, this study was not able to support the hypotheses. A replication of this study with a larger sample size may have more power to show an effect.

Application

From the aforementioned information and lack of statistically significant findings, it appears that the intervention described in this study had limited effect on disturbance due to hospital noise in patient or employee groups and did not significantly alter the measured sound levels. This is an important finding from both financial and outcomes perspectives. Many hospitals are attempting to reduce noise levels through educational programs and the use of behavioral modification instruments similar to the Quest 261 Sound Detector/Controller. These interventions can be costly considering employee wages for training and the purchasing of sound level instruments. Because staffing dynamics can change frequently in acute care settings, educational and behavioral modifications aimed at reducing sound levels would require rigorous oversight. Even then, the degree of enduring sound level reduction that is possible from such interventions in a busy and hectic hospital environment remains ambiguous. Interventions that may be more useful in permanently reducing sound levels in the hospital setting include changing elements of the physical space as suggested by Evans and Philbin (2000) and Philbin and Gray (2002), such as installation of sound-absorbing tiles in patient care settings. Because both patients and staff have been shown to benefit in many ways from a quiet environment, it is worthwhile for administrators and nursing leaders to continue to explore sound level reduction strategies in their respective practice settings.

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