Noise, stress, and annoyance in a pediatric intensive care unit

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Objective: To measure and describe hospital noise and determine whether noise can be correlated with nursing stress measured by questionnaire, salivary amylase, and heart rate.

Design: Cohort observational study.

Setting: Tertiary care center pediatric intensive care unit.

Subjects: Registered nurses working in the unit.

Interventions: None.

Measurements and Main Results: Eleven nurse volunteers were recruited. An audiogram, questionnaire data, salivary amylase, and heart rate were collected in a quiet room. Each nurse was observed for a 3-hr period during patient care. Heart rate and sound level were recorded continuously; saliva samples and stress/annoyance ratings were collected every 30 mins. Variables assessed as potential confounders were years of nursing experience, caffeine intake, patients' Pediatric Risk of Mortality Score, shift assignment, and room assignment. Data were analyzed by random effects multiple linear regression using Stata 6.0. The average daytime sound level was 61 dB(A), nighttime 59 dB(A). Higher average sound levels significantly predicted higher heart rates ($p = .014$). Other significant predictors of tachycardia were higher caffeine intake, less nursing experience, and daytime shift. Ninety percent of the variability in heart rate was explained by the regression equation. Amylase measurements showed a large variability and were not significantly affected by noise levels. Higher average sound levels were also predictive of greater subjective stress ($p = .021$) and annoyance ($p = .016$).

Conclusions: In this small study, noise was shown to correlate with several measures of stress including tachycardia and annoyance ratings. Further studies of interventions to reduce noise are essential. (Crit Care Med 2003; 31:113–119)

KEY WORDS: noise; stress; heart rate; saliva; catecholamines; nursing

T he World Health Organization (1) and Environmental Protection Agency (EPA) (2) recommend that hospital noise levels not exceed 40–45 dB(A) during the day and 35 dB(A) at night. Sound levels above 50 dB(A) are sufficient to cause sleep disturbance, and sustained levels above 85 dB(A) can damage hearing. Excess noise is correlated with patient annoyance, abnormal sleep patterns (3), increased length of stay, intensive care "psychosis" (4), and delayed wound healing (5). Noise in hospitals, particularly in intensive care units, often exceeds the recommended levels (6–10).

The effects of noise on hospital staff have not been studied as extensively as have the effects on patients. We are aware of no studies of the effect of noise on physiologic measures of stress in hospital staff and none using subjective stress and annoyance scales administered in the workplace itself. We hypothesize that the pediatric intensive care unit (PICU) is noisier than recommended and that noise contributes to staff stress and annoyance.

There is no true "gold standard" in the measurement of stress; we therefore used several parameters to measure stress, in part to identify which would be useful measurements for future studies. We measured heart rate (HR), salivary amylase, and subjective ratings of stress and annoyance.

Many cardiovascular measurements, including HR, blood pressure, ectopy, ST changes, and HR variability have been used in studies of stress. Studies of the effects of noise on HR have shown variable results, with some animal studies showing higher HRs (11) with chronic noise exposure. Studies in humans of acute changes in HR with noise have shown the greatest impact from uncontrollable noise (12) and with certain personality types (13). Others have shown that HR changes are associated with noise if the subject is evaluated while trying to perform a task (14).

Salivary hormone analysis has been used as a surrogate for blood hormone concentrations in many research studies. Saliva analysis has the advantage of avoiding stress that might be caused by venipuncture itself (15) and also causes minimal interference with the normal activities of the subject being studied. Some authors have even suggested that salivary hormones may be a better marker of adrenal function than plasma concentrations (16). A recent study in critical care nurses and physicians (17) used salivary cortisol as a measure of stress. Salivary amylase has also been used in the study of stress and has been found to correlate with serum norepinephrine concentrations (18, 19), thus providing a measure of the catecholamine, rather than the adrenocortical, response to stress. Salivary amylase concentrations have been used predominantly in studies of stress in army recruits, firefighters (20), and skydivers (21). In one study of stress associated with skydiving, serum norepinephrine was shown to increase within 10–20 mins of the stressful event and normalize within 1 hr (22). We chose to analyze salivary amylase as a stress measure in

this study because we wanted a measure that would have a fairly rapid response to a stress, since we were performing multiple measurements within a several-hour period.

MATERIALS AND METHODS

Eleven registered nurses working in the PICU at Johns Hopkins Hospital were recruited as volunteers for the study. Informed consent was obtained. At the beginning of the study period, each nurse was taken to a quiet room where an audiogram was performed and baseline data on demographics, medical history, and nursing experience were obtained. In addition, a Holter monitor was placed, a saliva specimen was obtained for determination of baseline salivary amylase, blood pressure and HR were recorded, and baseline stress and annoyance ratings were obtained. Each nurse then returned to normal patient care activities.

During each 3-hr study period, the nurse was observed at routine patient care. The shift, number of patients in the room, census of the entire unit, and Pediatric Risk of Mortality Score (PRISM) (23) of the nurse's patients were recorded. Sound pressure levels were recorded continuously by using a calibrated Quest Advanced 1900 precision integrating logging sound level meter (Quest Technologies, Oconomowoc, WI). Sound pressure levels are measured in decibels (dB), which is a logarithmic scale such that a 6-dB increase in sound level correlates to a doubling in perceived loudness. The dB(A) scale is a frequency weighted adjustment such that higher frequencies, which cause more hearing damage in humans, are weighted more heavily. The weighted average sound pressure level (L_{eq}) was determined for every half-hour period. Maximum and minimum sound levels and peak sound level, an instantaneous non-frequency-weighted peak measured in dB, were also recorded. Auditory events including alarms, telephone noises, conversation, and overhead pages were noted whenever they occurred, and their sound pressure levels were recorded in dB(A). The sound level meter was positioned 2–5 feet from the bed of a patient for whom the study nurse was caring.

The nurse's HR and episodes of ectopy were recorded continuously by using a portable cassette battery-driven Holter monitor (GE Marquette 8500 series, Milwaukee, WI). Recordings were analyzed to obtain the average HR for every half-hour period, the maximum and minimum HR for each half hour, the percent of time in tachycardia (HR > 100) for each half-hour period, and the number of episodes of ectopy. The half-hour subdivisions were chosen to allow comparison with the half-hour interval sound measurements, stress scales, and amylase measurements.

Salivary amylase was obtained by the nurse chewing a citric acid (0.1 mL of a 200 mg/mL solution) impregnated cellulose sponge for 1 min. The saliva produced was collected, placed on ice, and frozen to −20°C within 3 hrs. Later, the samples were thawed to room temperature, and 50 μL of saliva was then added to 2.5 mL of phosphate-buffered saline. Fifty microliters of this diluted saliva was then added to 1 mL of a reagent containing 4,6-ethylidene-protected polysaccharide. The amylase in the saliva hydrolyzes this reagent to p-nitrophenol, which has a yellow color. The time until the color change is equivalent to a reference yellow preparation is recorded; comparison to a standardized chart then allows determination of the salivary amylase concentration. Salivary amylase field test kits were provided by Dr. Robert Chatterton at Northwestern University, Chicago, IL.

Self-reported stress and annoyance ratings were obtained using the Specific Rating of Events Scale (20). This tool was designed for the U.S. Army Research Laboratory stress program in which the participants rate (on a scale of 0 for "not at all stressful" or "not at all annoyed" to 100 for "most stress possible" or "most annoyance possible") how stressed or annoyed they feel "right now." The nurses rated their levels of stress and annoyance on this scale in the quiet room and then at half-hour intervals during the study period.

At the end of each study period, the nurses returned to the quiet room, where they completed a poststudy questionnaire concerning their perceptions of noises in the unit.

The study was approved by the institutional review board of the Johns Hopkins Hospital.

Data concerning the contribution of noise to stress were analyzed by using random effects multiple linear regression, accounting for multiple observations being made on each subject. All data were analyzed by using Stata 6.0 (Stata Corporation, College Station, TX). The effect of the weighted L_{eq} on the salivary amylase, HR, and stress and annoyance ratings was the primary relationship of interest. Years of nursing experience, shift worked, caffeine intake, size of the patient room, and PRISM of the patients were included as potential confounders. To analyze how sound levels were affected by dichotomous factors, a two-tailed Student's t-test was used. For comparison of the relationship between sound levels and census or PRISM, simple linear regression analysis was used. Throughout, a cutoff of $p < .05$ was considered statistically significant.

RESULTS

The audiograms revealed that all of the nurses enrolled in the study had normal hearing. All nurses had normal blood pressure, and only one nurse reported

taking a medication (a sedative-hypnotic that was not taken before working) which could affect HR.

The L_{eq} in the PICU was 60.6 dB(A), with the daytime average 61.2 dB(A) (7 am–7 pm) and the nighttime average 58.8 dB(A) (7 pm–7 am) ($p = .0005$ for the difference between day and night). The PICU is divided into four two-patient rooms and two larger four-patient rooms, allowing a maximum census of 16 patients. The two-patient rooms were slightly louder with an average L_{eq} of 61.6 dB(A) vs. 60 dB(A) for the four-patient rooms ($p = .02$). The minimum sound pressure level recorded during the entire study period was 43 dB(A), and the maximum recorded was 96 dB(A). No half-hour period, even at night, had a maximum sound pressure level <76 dB(A). Shorter, non-frequency-weighted sound spikes ranged from 93–122 dB during the study.

The number of patients assigned to the nurse being studied was not associated with the average sound level in the room ($p = .37$), and caring for patients with higher PRISM was associated with a less noisy room ($p = .019$). A higher overall census in the unit was associated with higher average sound levels ($p = .001$).

On Holter monitoring, baseline HR for the nurses in the quiet room ranged from 63 to 107 bpm. In the regression analyses, we examined both change in HR from baseline and HR itself. The model that used the actual values of HR had a far better fit, perhaps because two nurses reported being made nervous by the questionnaires and therefore had higher HRs in the quiet room. Results reported subsequently therefore reflect actual measured HR rather than change from baseline.

The average HR, as well as the percentage of time spent in tachycardia, directly correlated with the years of nursing experience; the less experienced nurses had significantly higher HRs and more tachycardia ($p < .001$; Fig. 1). This relationship held true for all nurses except for one nurse who was pregnant: Although she had several years of nursing experience, she was tachycardic for >95% of the study period. As pregnancy is known to cause tachycardia, this nurse was excluded from the remaining analyses.

In random effects linear regression analysis, higher L_{eq} was found to predict a higher mean HR with $p = .014$ (Fig. 2).

Potential confounders for which the analysis was adjusted included caffeine intake, years of nursing experience, shift (am vs. pm) worked, size of patient room (two-patient vs. four-patient), and sum of PRISM of the nurse's patients. The coefficients for all regression equations are shown in Table 1. In addition to average sound levels, factors that also significantly predicted increased HRs were higher caffeine intake ($p = .002$), fewer years of nursing experience ($p < .001$), and day shift ($p = .018$; $r^2 = .9$ for the regression).

A regression analysis that used the same variables as predictors, with the percentage of time spent in tachycardia (HR >100) as the outcome, showed that higher L_{eq} ($p = .02$), less nursing experience ($p < .001$), and higher caffeine intake ($p = .048$) were predictive of a greater percentage of time spent in tachycardia ($r^2 = .85$).

The number of ectopic beats present on the HR recordings was also noted. Only one subject had ectopic beats (rare premature atrial complexes); the number of ectopic beats was insufficient to allow correlation with any stressors. No ST segment changes were noted on the recordings from any of the nurses.

Salivary amylase concentrations were extremely variable, ranging from 0 to 888 units/mL, with a mean and SD of 121 ± 125 units/mL. Nineteen of 69 samples collected had minimal or no amylase detected. The L_{eq} did not show a significant correlation with the amylase measurements, even when the outlying salivary amylase measurement at 888 units/mL was excluded ($p = .3$). Greater caffeine intake ($p = .02$) was the only statistically significant predictor of higher salivary amylase.

Linear regression analysis was also performed for the results of the subjective ratings of stress and annoyance (Specific Rating of Events scale). The stress ratings ranged from 0 to 88, with a median of 9.5. The annoyance ratings ranged from 0 to 65, with a median of 3. In regression analysis, L_{eq} was associated with higher stress ratings ($p = .021$). Lower caffeine intake ($p = .004$) and day shift ($p = .03$) also predicted higher stress ratings (overall $r^2 = .55$). Higher annoyance ratings were significantly predicted by higher L_{eq} ($p = .016$) and by lower caffeine intake ($p = .005$) when all of the variables were included in the model ($r^2 = .48$). Because there were many zero ratings for stress and annoy-
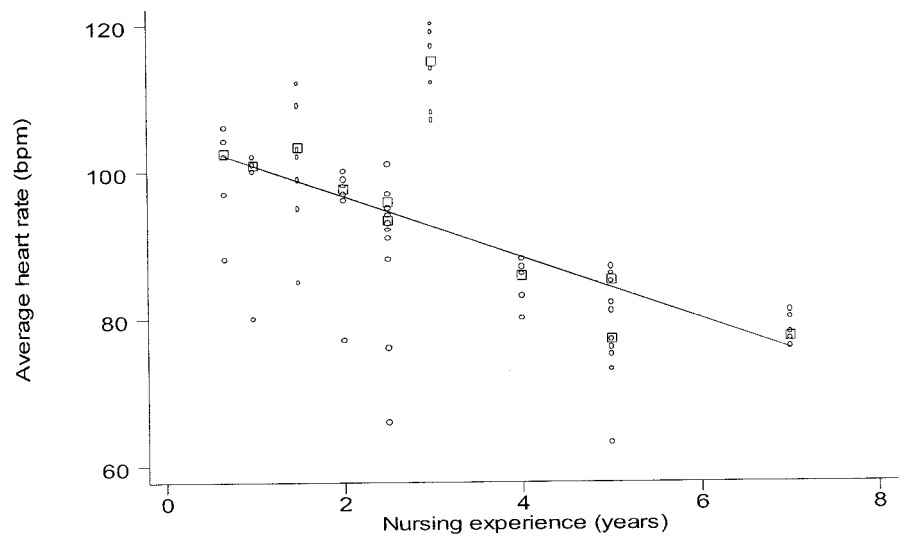

Figure 1. Nurses' heart rates (*HR*) plotted against years of nursing experience with fitted regression line. *Circles*, average heart rate for each 1/2-hr period; *squares*, each nurse's heart rate average over the entire 3-hr study period. The pregnant nurse is the outlier on the graph: Her overall average heart rate was 114 bpm.
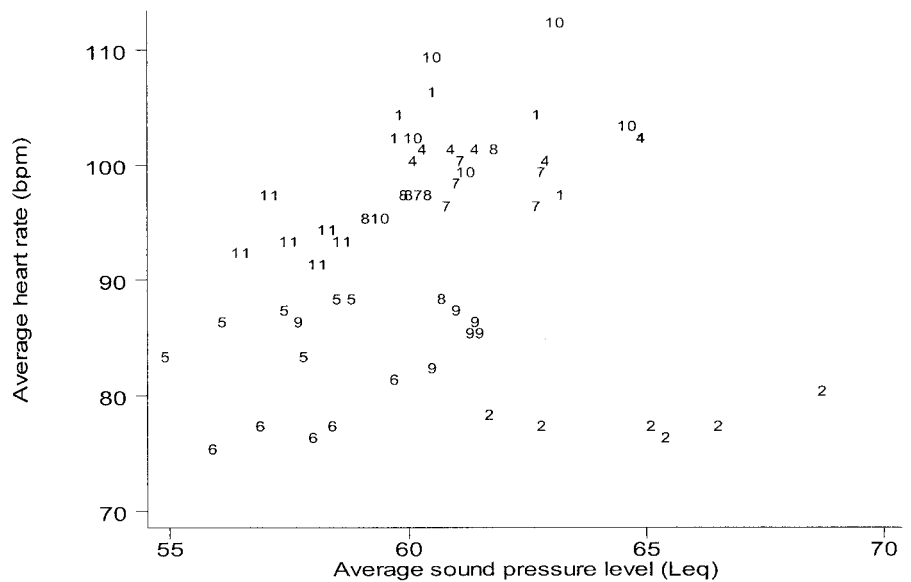

Figure 2. Average heart rate plotted against average sound pressure level (*Leq*). Each heart rate plot is represented by the subject number, to show which measurements were made on the same nurse. Subject 2, whose heart rate did not vary with sound level, was the most experienced nurse in the study.

ance, the linear regression analyses were confirmed with ordinal logistic regression, and levels of significance were, in fact, very similar; the linear regression coefficients are presented in Table 1.

DISCUSSION

Concern over noise pollution in hospitals has grown over the past few decades as noise is increasingly being recognized as an environmental hazard of our modern tech-

nological age (7, 24). Table 2 summarizes some of sound pressure levels measured in various studies; not since 1977 have any of the units in published studies met the EPA recommended average sound pressure level of 45 dB(A).

Most studies of hospital noise have measured sound levels and focused on how noise affects patients. Excess noise in hospitals has been shown to correlate with increased patient annoyance, abnor-

Table 1. Linear regression coefficients (95% confidence interval) for stress analysis

	Outcomes				
	Average Heart Rate	Percent of Time in Tachycardia	Amylase, units/mL	Stress Rating	Annoyance Rating
Average sound level (L_{eq}) in dB(A)	0.61 (0.15, 1.1)[a]	2.1 (0.4, 3.7)[a]	12.2 (−12.0, 36.6)	2.7 (0.5, 4.8)[a]	2.9 (0.7, 5.1)[a]
Nursing experience, yrs	−4.4 (−5.1, −3.8)[a]	−13 (−14, −11)[a]	−8.2 (−29.3, 12.9)	−1.3 (−4.6, 2.0)	−1.2 (−4.1, 1.7)
Caffeine intake, cups	1.2 (0.6, 1.9)[a]	2.4 (0.02, 4.8)[a]	41.3 (7.5, 75)[a]	−9 (−14, −3.6)[a]	−7.9 (−12.8, −3.0)[a]
Room size, 2 pt = 0; 4 pt = 1	1.4 (−1.8, 4.8)	−3.2 (−13, 6.3)	99.5 (−19, 218)	−9.4 (−32, 14)	−11.0 (−36, 14)
Shift worked, day = 0; night = 1	3.2 (0.7, 5.8)[a]	3.5 (−3.5, 10)	93 (−23, 209)	−18.7 (−35, −1.8)[a]	−13.8 (−30.4, 2.7)
PRISM score	0.02 (−0.1, 0.2)	−0.1 (−0.4, 0.2)	2.4 (−4.7, 9.5)	0.39 (−0.55, 1.3)	0.61 (−0.3, 1.5)
r^2 for equation	.90	.85	.32	.56	.48

pt, patients; PRISM, Pediatric Risk of Mortality Score.

[a]$p < .05$. Coefficients represent the change in the outcome of interest per unit change in the predictor variable (units shown next to variable), equivalent to the slope of a line. A positive number, therefore, indicates a higher result on the stress measure for higher values of predictors; a negative number means a higher value of the predictor is associated with less measured stress.

Table 2. Summary of hospital noise in prior studies

Study	Setting/Yr	Noise Levels	Notes
Bentley et al. (53)	ICU/1977	Average 42–53 dB(A) Peaks >70 dB(A)	
Redding et al. (54)	ICU/1977	Average 74 dB(A)	ICU noise comparable with boiler room and cafeteria at noon
Meyer et al. (6)	ICU/1994	Peaks 83.6 dB(A)	
Meyer-Falcke et al. (55)	SICU/1994	Average >65 dB(A) Peaks >110 dB(A)	
McLaughlin et al. (56)	CSICU/1996	Average 58–77 dB(A) Peak 101 dB(A)	Recordings made in secret
Tsiou et al. (8)	6-bed ICU/1998	Average 60–67 dB(A) Peak 83–90 dB(A)	
Keipert (57)	Peds ward/1985	Peaks 80–88 dB(A)	Peaks from infants crying
Couper et al. (9)	Peds ward/1994	65 dB(A)	Noise correlated with number of visitors and staff present

ICU, intensive care unit; SICU, surgical ICU; CSICU, cardiac surgical ICU; Peds, pediatrics.

mal patient sleep patterns (25), increased length of stay (26), intensive care unit "psychosis" (4), delayed wound healing (5), and increased sensitivity to pain (27). Patients have often identified noise as one of the most severe stressors experienced during their hospital stay (10, 28).

Several investigators have suggested noise reduction interventions: soft-soled shoes for staff, abolishing multiple-patient rooms, quieter alarms. Few have documented noise before and after interventions. Moore et al. (10) studied the effects of staff education and closing doors to patient rooms as noise-reduction interventions. They counseled staff to keep pagers on vibrate, reduce overhead pages, and limit conversations in patient rooms; these interventions had little impact. Closing the doors to the patient rooms, at least in the intensive care unit, actually increased the noise in the room.

There have been few studies of the effects of noise on hospital staff. Topf and Dillon (29) surveyed critical care nurses with a battery of stress and burnout scales that the nurses completed at home. Reported stress due to noise was closely correlated with predictors of burnout in these nurses. Murthy et al. (30) tested anesthesia residents in a controlled setting with recorded operating room noise averaging 77 dB(A). The residents exhibited reduced mental efficiency and poorer short-term memory under the noisy conditions in this controlled study.

The effects of noise on human performance have been studied much more extensively in the laboratory setting and in nonhealthcare workplaces such as factories. In the controlled laboratory setting, noise has been associated with poor task performance (31), poor concentration (32), decreased test-taking efficiency (14, 33), and greater anxiety among subjects (34). The ability to perform complex, problem-solving tasks may be particularly affected (35), and a lack of personal control over noise worsens the effects (36). It is easy to imagine that in the intensive care unit, uncontrollable noise

might be associated with an increased number of medical errors due to such interference with task performance.

Several large studies have focused on how noise affects factory workers. Noise has been associated with job dissatisfaction, irritability, fatigue, and employee illnesses and injuries (37–39). Distraction and stress due to noise, leading to such problems, are surely not unique to the factory environment.

Our analysis is based on a small number of subjects as part of a pilot to assess our methods of evaluating stress; however, despite the small numbers, the regression equations were still able to explain a large proportion of the variability in our stress outcomes. It was no surprise that the average sound level of 60.6 dB(A) in the PICU was louder than the average 45 dB(A) recommended by the EPA (2). Of note, however, the environment in the unit actually seemed quieter than usual during our study period to the investigator who normally works there. There were no emergencies (e.g., intubations,

resuscitations) in the PICU during our observation and no patients on high-frequency ventilation—the high-frequency ventilator most commonly used in our unit has been shown to produce constant noise in the 70 dB(A) range (40). The maximum sound levels of 96 dB(A) recorded in the PICU, although not sustained, are above the 85 dB(A) level at which hearing protection is recommended. One obvious conclusion that must be drawn from these data is that interventions to reduce noise in the PICU are necessary; however, it could be additionally true that the sound levels recommended in 1974 by the EPA are unattainable in the intensive care setting. The 1999 World Health Organization recommendations actually suggest a maximum hospital sound level of 45 dB(A).

Some of the patterns of the noise in the PICU are also interesting. It is not surprising the PICU is louder during the day than at night. We were initially surprised that the two-patient rooms were slightly louder than the four-patient rooms; this finding makes sense, however, when one considers that the two-patient rooms are smaller and more often have the doors closed, which does not allow equipment noise to disperse as easily. We also noted that lower patient PRISM scores were correlated with more noise. The explanation may be that a crying, fairly well infant is relatively loud compared with a sedated, paralyzed, and intubated acutely ill child. This difference may also partly explain the two-patient rooms being louder, as in our unit the most acutely ill patients are usually placed in the four-patient rooms. Table 3 lists the sound pressure levels of some particular auditory events in the PICU.

We also identified positive correlations of noise with measures of stress. The regression equation for average HR showed that for every 10 dB(A) increase in the average sound level, the nurses' average HR increased by 6 bpm. For each additional year of nursing experience, the average HRs decreased by 4 bpm. When all variables were included in the model, 90% of variability in the average HR was explained.

A regression with percentage of time spent in tachycardia as the outcome showed that each 10 dB(A) increase in sound levels led to 20% more time in tachycardia, and each additional year of nursing experience led to 12% less time in tachycardia.

A striking pattern unrelated to the noise in the unit was noted between the years of nursing experience and the nurses' HRs (Fig. 1). The average HRs decreased steadily as the nurses obtained more experience; in fact, the HR of the nurse with the most experience hardly varied. A larger study of this factor alone might be worthwhile.

The levels of stress and annoyance self-reported by the nurses were, overall, not very high. More stress and annoyance were noted on the day shift as well as in the four-patient rooms. There was also a slight increase in reported stress and annoyance with higher patient PRISM. When all variables were included in the linear regression model, each 10-dB(A) increase in average sound levels was associated with a 27-point increase in stress ratings. A higher average sound level was also a significant predictor of higher annoyance ratings, with a 10-dB(A) increase associated with a 30-point increase in annoyance ratings.

The regression equations for salivary amylase did not show a significant association of higher average sound level with higher salivary amylase ($p = .3$). The only significant predictor of higher salivary amylase was higher caffeine intake. Although caffeine has been shown to affect serum cortisol (41, 42) and epinephrine (43), a relationship between caffeine intake and salivary amylase has not been shown. Higher salivary amylase values were found on the night shift and in the four-patient rooms, but these associations were not significant when all of the variables were included in the model. In prior studies of skydivers and exercise subjects, salivary amylase values have ranged from 150 to 900 units/mL (18, 21). In U.S. Army research, concentrations >600 units/mL are considered "high stress" and 400–600 units/mL are considered "moderate stress" (personal communication, Linda Fatkin, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD). The concentrations of salivary amylase obtained in all but one sample in this study would be consistent with little or low stress.

It is possible that salivary amylase was not the appropriate hormonal measure of stress for this study, as it may be true that noise causes more chronic tension than a "fight-or-flight" catecholamine response (44). The nurses could also easily have become habituated to the amount of noise present in the PICU, altering their stress responses (45, 46). Animal and human studies have shown quite variable results when researchers assess whether catecholamines or cortisol is more affected by noise (33, 47–51). It is possible that salivary amylase was not significantly associated with average sound pressure levels simply because of the small study size; however, consideration should be given to assessing the usefulness of salivary cortisol as well in future studies.

The greatest limitation of our study is the inclusion of few subjects; yet even with a limited study size, some of the associations of sound levels with stress suggest that a larger study is worthwhile. It is also true that although we have shown a relationship between higher sound levels with higher HRs, more stress, and more annoyance, we cannot prove that this is a causal relationship. More noise could, for instance, be associated with a greater number of alarms requiring nursing intervention, thus leading to higher HRs. A possibility for future studies would be to include an activity level monitor to determine whether the relationship between noise and stress can be explained by nursing activity/motion as a potential confounder. Another issue is that this study could not be blinded—the nurses were aware that the investigators were present and that they were being monitored. Such awareness could have had subtle effects on their routines of patient care and the amount of noise produced. The nurses recruited for the study were also volunteers; it is therefore possible nurses who were more annoyed by noise at baseline would be more likely to volunteer for the study. One last concern is that higher sound levels do not necessarily define greater "noise" because there is a subjective context as to what sounds qualify as "noise" that we were obviously unable to measure (52). There have also been many studies showing that unpredictable noise

Table 3. Typical sound pressure levels of various events in the Johns Hopkins pediatric intensive care unit

Event	Sound Pressure Level, dB(A)
Trauma phone	73
Overhead pages	59–84
Monitor alarms	62–74
Ventilator alarms	Up to 79
Medication pump alarms	55–56
Conversations	Up to 73
Infants crying	78
Cleaning crew/equipment	Up to 96

> *I*n this small study, we showed that noise is potentially a significant contributor to higher heart rates and tachycardia among nurses, as well as to nurses' stress and annoyance.

is associated with much greater stress and cardiovascular changes; we did not attempt to assess this factor in this study, although one would assume that most intensive care unit noises are unpredictable.

Some interventions that might reduce noise are currently being made in our intensive care unit. Trauma phone calls that are for information only are no longer ringing in the unit. A system to replace the current overhead pages is being evaluated; it would be useful to study the sound levels and changes in nursing stress if this source of noise is replaced. Cleaning equipment and staff conversations were also associated with high noise levels (Table 3); these areas should be a particular focus on intervention.

CONCLUSIONS

In this small study, we showed that noise is potentially a significant contributor to higher HRs and tachycardia among nurses, as well as to nurses' stress and annoyance. It is certainly possible that noise could have long-term health consequences for healthcare workers. Because of the association of noise with poor task performance and job frustration in other settings, noise in the healthcare environment should be evaluated as a potential contributor to increased medical errors and poor staff retention.

ACKNOWLEDGMENTS

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