Noise Levels in a Hospital

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Abstract: Noise measurements were performed in eight patients' rooms, three intensive care units (ICUs) and one operating theatre at a large hospital (1300 beds). Daytime and nighttime LAeq in patients' rooms and in ICUs were higher than the recommended standards. The measured noise levels could interfere with normal sleep and could be dangerous for patients at greatest risk. The laminar flow ventilation system was the main source of noise in the operating room. The LAeq recorded during a surgical procedure was sufficiently high to mask speech communication.

The measurement of A-weighted sound pressure levels disclosed that staff activities were responsible for the loudest noises. Air-conditioning systems and electro-mechanical instruments were also important contributors to noise pollution in the hospital.

Key words: Patients' rooms—Intensive care units—Operating theatre—LAeq—Extraauditory effects of noise

INTRODUCTION

Many hospitals are located in residential areas often unprotected from external noise sources such as traffic, railroads, airports, etc. Nevertheless many investigators report that much of noise in the hospital comes from within more than outside the premises. The most annoying noises inside the hospital are produced by internal sources such as telephone, air-conditioning, electrical and mechanical equipments, personnel activity (movement, conversation, etc.). In fact high noise levels have been measured in wards and also in intensive care unit where quiet is an essential requirement for patients' comfort and recovery.

The aim of this paper was to study noise pollution at a 1300 bed hospital (Trieste, Italy) and for this purpose we have measured noise levels in eight patients' rooms, three intensive care units (ICUs) and one operating theatre.
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MATERIALS AND METHODS

This hospital is a four-sided building, five stories high, with a garden in the middle. Typical rooms are 5.5 m high with wall thickness of 1.2 m and contain from 6 to 10 beds. Each room has two double glazed windows and one or two doors.

Of the eight bed rooms chosen for this study, six were in medical departments and two in surgical departments. The ICUs were a coronary care unit (5 beds), a postoperative cardiac care unit (3 beds) and a general intensive therapy unit (8 beds). Air-conditioning systems were present only in ICUs. For aseptic purposes, the operating theatre, designed for open heart surgery, was ventilated by laminar air-flow.

Sound pressure levels were measured by a Brüel & Kjaer 1/2” microphone (B&K type 4165) and a preamplifier (B&K type 2619) connected by a cable to a noise level analyzer (B&K type 4426). A flexible extension rod placed between the preamplifier and the transducer was taped on the wall of the room 1.5 m above the floor near a patient’s bed. The noise level sampling period was adjusted to 0.1 s (36000 samples per hour) and the following acoustic parameters were recorded: “A-weighted” equivalent continuous sound level (L_{Aeq}), levels exceeded for 1%, 10%, 50% and 90% of the sampling period (L_{1}, L_{10}, L_{50}, L_{90}), probability distribution in % with 2 dB(A) resolution. The data were printed out at intervals of 1 hour by an alphanumeric printer (B&K type 2312) connected directly to the noise analyzer. The analyzer was programmed to reset at the end of each hour and to sample for the next hour. Sound pressure levels were measured for seven consecutive 24-hr periods in each patients’ room and ICU.

In the operating theatre noise levels were recorded during a surgical procedure. Frequency analysis of the noise generated by the laminar flow ventilation system in the above mention operation room when it was not in use was also performed by an octave filter set (B&K type 1613) in combination with a sound level meter (B&K type 2209).

RESULTS

The mean (±SD) L_{Aeq} measured in the patients’ rooms and in the ICUs are reported in Fig. 1. The noise pattern throughout the 24-hr periods was similar in the surgical and medical departments. The noisiest parts of the day were during the morning and early evening when Leq of 55.3–60.9 dB(A) were recorded. During nighttime the quietest period was between 0200 and 0400 (Leq = 40.2–45.1 dB(A)). In the ICUs mean Leq of 56.9–61.2 dB(A) were measured during the day and the noise levels lowered to 53.5–57.7 dB(A) during the night. The cumulative distribution of sound pressure levels over the weekly
period (Fig. 2) confirms that the difference between day (from 0700 to 2200) and night (from 2200 to 0700) levels was smaller in ICUs than in patients' rooms.

In the course of this survey we observed the occurrence of many impulsive noises. Fig. 3 shows the number of sound samples >70 dB(A) recorded in two patients' rooms and in the coronary care unit of the Cardiology Division.

In the operating theatre the noise levels were measured under three different conditions. The background noise in the unoccupied operating room with the laminar flow system off was 35 dB(A) Leq. When the laminar flow ventilation circuit was switched on, the Leq increased to 63.2 dB(A). The 1/1 octave band spectra of these noises are plotted in Fig. 4. The noise generated by the laminar flow system may be classified as stationary with main components in the low frequency range (31.5–250 Hz). Finally Leq of 64.8 dB(A) was recorded during a four-hr surgical procedure (aortocoronary bypass graft). L1, L10, L50 and L90 were 73.1 dB(A), 66.1 dB(A), 63.4 dB(A) and 62.6 dB(A) respectively.

Fig. 1. "A-weighted" equivalent continuous noise levels (mean ± S.D.) over seven consecutive 24-hr periods in two surgical bed rooms (A), six medical bed rooms (B) and three intensive care units (C).
The "extraauditory" effects of noise on laboratory animals and on human beings are well documented. Noise can affect cardiovascular, gastrointestinal and neuroendocrine systems. Peripheral vasoconstriction, changes in gastrointestinal motility and activation of the hypothalamic-pituitary-adrenal axis are the main features of excessive noise stimulation. These physiological alterations may be uncomfortable for a healthy person and dangerous for a sick one. Clinicians agree that quiet conditions have a beneficial effect on the patient's recovery. It was found that noise levels of 40–50 dB(A) interfered with the normal stages of sleep as evidenced on the electroencephalogram and levels above 70 dB(A) awakened most people. In this study the Leq measured at nighttime was 40.2–55.7 dB(A) in the bed rooms and 53.5–57.7 in the ICUs. This means that patients' sleep is seriously disturbed by nighttime noise.

For the reasons given above, some authors and Institutions have proposed...
threshold value limits for noise in hospital.\textsuperscript{15-17} Maximum permissible $\text{Leq}$ of 20–35 dB(A) in patients' rooms at night and 30–45 dB(A) during daytime have been suggested. In our country the Ministry of Health recommends 40 dB(A)$\text{Leq}$ at day and 30 dB(A)$\text{Leq}$ at night.\textsuperscript{18}

Several authors have studied noise pollution in patients' rooms. De Camp\textsuperscript{19} measured nighttime $\text{Leq}$ between 28 and 54 dB(A)impulse in eight hospitals in West Berlin. Average noise levels of 47–53 dB(A) were found by Sorensen and Schultz\textsuperscript{20} in six hospitals in USA. In a modern British hospital Aitken\textsuperscript{2} recorded daytime $\text{Leq}$ of 50–60 dB(A) and nighttime $\text{Leq}$ of 40–45 dB(A). These noise measurements are not different from those reported in this study.

Few investigations exist for acute care units.\textsuperscript{21} Bentley et al.\textsuperscript{1} measured average noise levels of 53 dB(A) during the day in an intensive therapy unit in London. During the quietest period of the night, 42.5 dB(A) was recorded. The mean $\text{Leq}$ in our three ICUs were about 8–11 dB(A) higher than those reported
by the English researchers. The Leq variations over the 24-hr periods were found to be larger in ICUs than in patients' room. It may be due to various factors such as the number of acute patients present in the ICUs, the number of functioning instruments (monitors, respirators), emergency situations, etc.

Shapiro and Berland\textsuperscript{22} have measured noise in a general operating room during a surgical procedure. They reported A-weighted sound pressure levels between 55 and 86 dB(A). Our data show that the laminar air-flow system was the major source of noise in the operating theatre. Deleterious effects such as irritability of the staff and masking of speech communication may come from exposure to the equivalent noise level of 64.8 dB(A) recorded during the cardiac surgical procedure.\textsuperscript{23}

In our opinion personnel activities were the most important sources of noise. The following A-weighted sound pressure levels were often measured: conversation 50–65 dB(A), nurses' footsteps (clogs!) 45–48 dB(A), movement of the stretchers 50–70 dB(A), delivery of meals 60–70 dB(A), closing of the doors 60–75 dB(A).

Many peak levels exceeding 70 dB(A) were recorded during noise measurements in the Cardiology Division. 70 dB(A) is considered the threshold for peripheral
vasoconstriction and this response is undesirable for patients with cardiovascular disease.

In conclusion the results of this study suggest that noise pollution in our hospital is ubiquitous. The measured noise levels are annoying for most the patients and dangerous for those at great risk.

Noise attenuation may be attempted by using acoustic engineering techniques such as installation of sound absorbent panels or other porous layers. The manufacturers of air-conditioning systems and electro-mechanical equipments have to be encouraged to design less noisy devices. Nevertheless we think that one of the most effective action to prevent noise pollution in the hospital would be to insist on personnel compliance with the recommended noise limits.

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