RESEARCH PAPER

Noise levels in an Australian emergency department

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Summary Elevated hospital noise levels potentially affect communication, stress levels, aggressive behaviour and sleep during treatment. However, few studies have measured noise in the emergency department (ED). In an Australian context, study investigators aimed to assess noise levels in multiple clinical care areas of the ED. Data was collected in decibels (dB) in six ED patient locations over 24 hours. Recorded data was analysed and compared across locations and over time, in the light of World Health Organization (WHO) and Australian noise standards. The 24-hour average sound levels varied between 64.0 and 55.8 dB, with some diurnal variation in noise levels, thereby consistently exceeding recommended levels. Such high noise levels could potentially affect patient care and well-being whilst in the ED.

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Introduction

Creating a healing environment is crucial to nursing care1 and increasing attention is being paid to the ambient physical healthcare environment, including the impact of sensory stimuli such as sound and light.1,2 Undesirable sound becomes noise, and high noise levels are known to have a detrimental effect on health and healing. Stemming from clinicians’ anecdotal reports, this project measured noise levels in the emergency department (ED) with a view to assessing current noise levels and discussing potential effects and implications of such noise levels on patient care.

Hospitals are intrinsically noisy places with noise emanating from many sources including alarms and monitors; human chatter from workers, patients and visitors; movement of beds and equipment; and public address systems. The level of noise is further affected by building design and acoustics,1 which typically includes door mechanisms, open-plan work areas and the lack of sound absorption materials. The effect of exposure to continuous excessive environmental noise can have deleterious affects on patients including altered memory, increased agitation, less tolerance for pain, and can contribute to falls and confusion especially in the elderly. Excessive environmental noise can
What is known about the topic?

- Hospitals worldwide have noise levels higher than established standards. This potentially affects communication, stress levels, aggressive behaviour and sleep during treatment. Scant evidence exists about noise levels in the emergency department (ED), and none in Australia. Addressing noise levels in the ED and resultant changes can promote improved patient care.

What this paper adds or contributes?

- This paper presents new data from a uniquely Australian perspective and context to add to the discourse about hospital noise levels. It links physical noise measures with the fundamental implications of existing noise standards. Data is gathered from a major urban emergency department, and implications for patient care are discussed.

Noise has many negative effects including sleep disturbance, aggressive behaviour and difficulties with hearing and comprehending speech.3–7 It has been identified that sudden increases in noise can elicit specific physiological responses such as hypertension, tachypnoea, tachycardia and vasoconstriction.8 There is also some evidence that working in continuously noisy environments has an impact on staff with increased exhaustion, burnout, depression, and irritability reported in workers in other noisy workplaces.9 Noise is also a potential contributory risk factor in medical and nursing errors.10–12

Noise is measured via sound pressure levels using the logarithmic decibel (dB) scale. In order to approximate the subjective human perception of sound, which varies at different frequencies and volumes, a standardised frequency A-weighting curve, dB(A) is used in sound measurement.13 Functionally, 20–30 dB(A) are equivalent the ticking of a watch, 50–60 dB(A) are produced by a normal conversation in a room, 80 dB(A) are perceived as very loud, and 120 dB(A) result in pain.14 An average healthy human ear will notice a change of 1 dB(A) or more. There is a need for a signal-to-noise ratio of 15 dB(A), therefore noise over 35 dB(A) interferes with quiet speech in small rooms. An increase of 3 dB(A) indicates double the sound intensity while an increase of 10 dB(A) means that the human ear perceives the sound as twice as loud. Note that dB(A) is the acknowledged standard and hence all further references to dB in this paper imply dB(A).

Due to the fluctuating and intermittent nature of noise events, the equivalent average sound level is calculated using a standard A-weighted ‘energy equivalent level’ (L_{Aeq}).15 World Health Organization (WHO) hospital noise guidelines recommend acceptable sound levels for patient treatment areas (L_{Aeq} ≤ 35 dB), night time background noise (L_{Aeq} ≤ 30 dB), and individual noise events (L_{Aeq} ≤ 40 dB).15 Australian Standards have similar guidelines for hospital wards (L_{Aeq} ≤ 35 dB).16 Levels greater than L_{Aeq} 50 are associated with noise annoyance and noise stress, while levels ≥ 80 dB may contribute to aggressive behaviour.15

A literature search of relevant databases (MEDLINE, CINAHL, PsychINFO, Google Scholar) using appropriate search terms (emergency care, emergency department, acute care, intensive care, loudness, sound, noise, noise stress) indicated that the problem of elevated noise in hospitals is worldwide, with reports from diverse countries such as Brazil, Turkey, India, Greece, Taiwan, and the United Kingdom.7,17–20 Hospital noise levels frequently exceed WHO levels, with one research team reporting mean hospital-wide levels of 65–70 dB(A).20 An ICU in Greece reported sound levels of 59 dB,19 and an acute surgical area in the United Kingdom reported approximately 58 dB.17

Studies in the United States measuring noise levels in the emergency department (ED) have demonstrated average noise levels between 50 and 60 dB21, and 60–65 dB,22 with individual peaks of 94–117 dB occurring every minute.23 An emergency care area in Brazil was also measured as 64.2 dB.18 Noise has been cited as a main reason for patients choosing to leave the ED before appropriate hospital placement.24 Scant hospital noise research exists in Australia, and we could find no literature relating to noise levels in Australian EDs. Results of an Australian intensive care unit (ICU) study showed averages of 56 to 58 dB with individual peaks to 95 dB.25 However, the ICU is a substantially different context to the ED in terms of patient flow, staffing levels, and sheer numbers of people present in the clinical context.

It is unclear to what extent and in which ways the Australian ED setting may differ from overseas locations such as the UK or the USA. Potential factors include the nature of demand in the typically public (government-funded) hospital system,26 disparities in insurance coverage,27 and the layout of the ED as open-plan or with physical barriers for staff and consumer protection (locked doors/bullet proof glass) to compartmentalize the ED due to security considerations (Heather Austin, personal communication, 2010 April 27). Therefore, the aim of the current study was to assess the noise levels in a range of patient areas of a large urban emergency department (ED) in an Australian context. By doing so, this foundational study sought to provide beginning evidence about current noise levels, from which further intervention studies aimed at reducing noise and noise stress may proceed.

Method

Site

This project took place in a large urban tertiary ED with approximately 60,000 presentations per year and an admission rate of 35%. It featured separate but linked patient care areas: triage, paediatrics, acute, resuscitation, short stay and cubicles.4 Physically, the recently redesigned and refur-
blished Emergency Department consists of large open-plan spaces, linoleum-covered concrete floors, major access corridors through patient care areas, two ambulance entrances, a central staff write-up area (accommodating 12 seated and 4 standing staff members), and regular use of an overhead paging system with multiple ceiling-mounted speakers. During the research study, noise levels were measured in selected patient locations for 24 hour time periods. The study was approved by the relevant Area Health Service Ethics committee.

Materials

An AS 1259 compliant noise monitoring device was placed in a small and unobtrusive unmarked box (28 cm × 19.5 cm × 11 cm). The device comprised three main components: a battery operated commercial sound level meter (Digitech model QM 1588); linked to a purpose-built micro-controller logging device; and a 24-hour rechargeable battery. The sound level meter outputs a voltage proportional to the sound level reading in dB(A). This voltage is automatically scaled and recorded by the microcontroller as dB level. The sound level meter was operating with a 0.125 sec response time and a sensitivity range of 30 to 100 dB. The microcontroller sampled and recorded 8 times a second the sound level during the 24-hour time segments. Before and after each run, the device was checked against the internal calibration on the sound level meter.

Procedure

The noise level monitor was placed in six selected areas (triage, acute, short stay, resuscitation, paediatrics and cubicles) on a 1.4 m high shelf located at the head end of a patient bed space. Placement was chosen to most closely approximate the experience of the patient. Noise levels were automatically recorded at each location for 24 hours according to a predetermined weekday sampling plan. This resulted in approximately 600,000 sounds samples (data points) at each location.

Analysis

Noise monitor data was downloaded electronically and analysed with routines written in LabView v7.0 software, which was needed to process the very large data-sets. Average sound pressure levels (LAeq dB(A)) during each measurement were calculated as the equivalent continuous sound pressure level defined according to the WHO standard. The LAeq for each whole 24 hour period and at standard 15 minute intervals were calculated. The maximum (Lamax) and minimum (Lamin) sound levels were also calculated for 24 hour and standard 15 minute intervals. Levels for selected one-hour time periods were further graphed to investigate instantaneous sound peaks.

Results

The average sound levels in all six clinical areas were greater than 55 dB(A) with the highest levels in the acute and resuscitation areas (64.0 dB and 57.4 dB respectively). Across the entire 24-hour time period, all areas showed averages above 50 dB, with instantaneous sound level peaking (Lamax) about 90 dB and the quietest sound recorded (Lamin) occurring below 40 dB in only two areas: cubicles and short stay (see Fig. 1).

The proportion of time that the sound level exceeded specific dB levels is illustrated in Fig. 2. In all clinical areas, sound levels exceeded 50 dB for significant periods of time during the 24 hour measurement, varying from 20% in the cubicles and 23% in short stay areas, to 65% and 76% in the resuscitation and acute areas respectively.

Noise levels varied over time in all clinical areas, with quieter periods between 10 pm and 6 am. Peak noise levels occurred typically in the middle of the day, including instantaneous sound peaks to 90 dB. However, even during the quietest period sound levels were frequently >40 dB, with spikes of up to 80 dB. Fig. 3 demonstrates this diurnal variation in average, minimum and maximum sound levels in the acute area.
ED Noise levels

Figure 3  Diurnal variation in noise levels for the Acute area, using $L_{Aeq}$, $L_{Amin}$ and $L_{Amax}$ for each 15-minute interval.

Closer examination of noise fluctuations using the 8/sec measurements demonstrated that very loud sounds were typically of short duration. A one-hour snapshot of noise fluctuations during the middle of the day in the acute area is illustrated in Fig. 4. Although readings frequently exceeded 75 dB, this was generally for very short periods of time. This one-hour fragment of data is indicative of the nature of data taken in all areas.

Discussion

Results of this study show that sound levels monitored over 24 hours in each of six locations within an Australian urban tertiary ED consistently exceeded established recommendations. These recommendations of a maximum sound level of 35 dB for patient areas/hospital wards were exceeded at all times in all locations. Additionally, single peak noise events exceeding WHO recommendations of 40 dB occurred on many occasions in all areas. Our data indicated that noise levels exceeded 50 dB approximately 20% of the time in cubicles and short stay and nearly 80% of the time in acute area, suggesting significant levels of noise annoyance and stress throughout the ED. Given that a signal-to-noise ratio of 15 dB is required for speech intelligibility, a background level of 50 dB in effect means a further increase in sound levels to 65 dB is necessary in order to maintain a conversation between patient and clinician.

In all clinical areas there were multiple short noise peaks in excess of 80 dB, which equates to the perception of ‘very loud’. Variable and unexpectedly changing sound pressure levels indicative of a wide range of auditory events in the busiest (acute) areas of the ED suggest that, above a fairly constant minimum sound level, many sounds were loud but of short duration, which could indicate sudden-onset sounds such as scratches, bangs, beeps and loud speech.

Such high levels of noise in the ED environment have a number of implications for clinical care. Due to signal-to-noise requirements, both clinician-patient and staff communication may be affected, each having an effect on direct patient care. The patients themselves may experience the psychological effects of noise stress during their stay in the ED due to the high noise levels. Occasional instantaneous spikes of very high noise levels ($\geq 80$ dB) may promote aggressive behaviour, which has implications for patient and staff safety and may be particularly pertinent for mental health and older disoriented patients.

The capacity to achieve necessary sleep in the patient’s illness and recovery period is clearly affected by high noise levels. Whilst ideally patients should not remain in the ED for prolonged periods, access block is prevalent across Australia forcing many patients to stay in the ED for more than eight hours, often across their usual sleep period. Access block is defined as “the situation where a patient in an emergency department requires inpatient care but is unable to gain access to an appropriate hospital bed within a reasonable time-frame”. Although we observed that noise levels tended to be lower during the night, noise levels were still consistently well above the WHO recommended night time level of 30 dB, and thus sleep disturbance was very likely.

Our results showed highest sound levels in the acute and resuscitation areas (64.0 dB and 57.4 dB respectively) with an average greater than 55 dB in all six clinical areas across a 24-hour time period. Instantaneous sound levels peaked at about 90 dB and minimum levels of less than 40 dB were recorded in only two areas: cubicles and short stay. These results were similar to those from emergency care or similar areas in Brazil (64.2 dB), Greece (59 dB), the United Kingdom (approx. 58 dB), and the USA (52.9 dB and 60—65 dB). Nevertheless, reported ED average noise levels were lower than a large Indian hospital (58—71 dB). Our individual noise peaks, at or in excess of 90 dB, were similar to those found elsewhere in the world. Looking at the minimum sound levels ($L_{Amin}$), whilst our study levels were higher than recommended, at around 40 dB, they were still less extreme than levels reported in the USA (50 dB) and India (59 dB). Regardless of how the Australian ED context may vary in comparison to other emergency care clinical areas around the world, noise levels in this particular ED in Australia were still higher than established recommendations.

The nature of the sounds

It was beyond the scope of the current study to identify the nature of the actual sounds experienced in the ED, or investigate the reflected sound within the broader acoustic environment. The variable and suddenly changing sound pressure levels are indicative of a wide range of auditory events occurring in the ED. Investigators in this study did not explore the types or sources of the many different sounds recorded and further studies could explore the nature of the sounds experienced in the ED and their potential for reduc-
tion. Other studies, such as those by Topf\textsuperscript{31} have found that hospital sounds may include alarms on equipment, staff, visitors, other patients, doors opening and closing and the public address system.

**Building factors**

The scope of this study was not sufficient to assess the physical ED structural design. However, we observed that high levels of sound reflection may well have contributed to the high baseline levels of noise in the ED. Sound propagation via the air conditioning system, announcements from the public address system, and the lack of sound absorptive materials due to infection control design requirements resulting in multiple sound-reflecting surfaces may well be factors contributing to high noise levels within the department. Recent studies have suggested that sound-absorbing materials may be effective in reducing noise levels in acute clinical areas,\textsuperscript{34} and if redesign and refurbishment of a clinical area is being planned, these should be considered.

**Individual factors**

We also did not have the capacity to look at variability in perception of and response to sound, including differences in foreground and background perception by staff and patients. Noise sensitivity\textsuperscript{35} should be further explored in order to more fully understand the clinical context and an individually tailored appropriate environment for each patient.

An evaluation of further steps which may potentially be taken in addressing noise in the ED is beyond the scope of this current paper. However, this foundational study provides a clear assessment of noise levels, as a basis for the building of further interventions. Existing literature suggests that such interventions may focus on 1) the nature of the sound, e.g. alarms on equipment and staff talking, 2) building design (e.g. use of absorbing materials), and 3) patient stress reduction via appropriate interventions (e.g. music to reduce noise stress, see Topf\textsuperscript{31}). In addressing the latter, a pilot study has been further undertaken, aimed at reducing noise stress via use of headphones and music\textsuperscript{36} and other noise reduction strategies are planned.

**Conclusions**

Ambient sound in the physical healthcare environment may manifest as high noise levels, which in turn have an effect on the healing environment for patients. Therefore, clinical staff should be encouraged to be aware of the impact of these auditory stimuli on their patients. The current study has documented and validated previous anecdotal evidence from clinicians that high noise levels exist in the emergency department. Such an environment has the capacity to affect patient care in terms of communication, noise annoyance/stress, behavioural problems and sleep disturbance. Further follow-up studies are needed to explore noise sources and exacerbating factors within the ED, with a view to reducing noise to recommended levels in order to improve patient care and healthcare delivery.

**Conflict of interests**

There are no competing interests or conflicts of interest in this study.

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