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Acoustic environments of patient room in a typical geriatric ward

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ABSTRACT

This study aims to investigate background noise levels and noise sources in geriatric ward, and to examine the sound fields of the patient room. Acoustic measurements were carried out over 24-h period in five typical rooms in a geriatric ward in the UK. Based on these measurements, noise levels and sources were analysed in terms of the A-weighted equivalent (L_{Aeq}) and maximum Fast time-weighted sound pressure levels (L_{AFmax}) over three different periods of time during the day. It was found that the measured noise levels of the rooms exceeded the World Health Organisation's guide levels by at least 25 dBA of average levels and at least 10 dBA of the maximum noise level. The most common noise sources in the geriatric ward were talking/voices, door closing/squeaking and general activity. Noise events most frequently occurred during daytime and the majority were talking/voices emanating from patients, staff and visitors. It was also observed that talking/voices produced the highest median value of maximum noise levels, followed by general activity and then door closing/squeaking. Measured reverberation time (T_{20}) at high frequencies in an empty six-bedded room was less than 0.8 s, whereas T_{20} at low frequencies was greater than 1.2 s. Computer simulations showed that absorptive treatments in the ceiling contributed to significant changes in reverberation time and sound pressure level.

1. Introduction

Noise is considered a threat to public health and well-being [1]. Previous studies [2–4] have reported that noise in healthcare facilities negatively influences staff as well as patients. For example, high background noise disrupts patients' sleep at night [2] and greater noise levels can lead to elevated heart rates amongst nurses [3]. The World Health Organisation (WHO) includes guidelines for hospitals in its 'Guidelines for Community Noise' published in 1995. The WHO guidelines [1] recommend noise levels for daytime, evenings and night-time in terms of the A-weighted equivalent (L_{Aeq}) and maximum Fast time-weighted sound pressure levels (L_{AFmax}). According to these guidelines, the background noise level (L_{Aeq}) in a patient's hospital room should not exceed 35 dBA during the day and 30 dBA at night. These guidelines further suggest a L_{AFmax} of no more than 40 dBA at night when measured on the fast setting.

Many studies have conducted noise level measurements in hospitals and, unfortunately, most [5–8] have shown that hospital background noise levels are considerably above the recommended values. Furthermore, since 1960, noise levels in hospitals have increased at an average of 0.38 dB per year during daytime and 0.42 dB during the night [5]. More specifically, the noise levels in intensive care units (ICUs) have varied from 50 dBA to 75 dBA and peak levels at night have reached almost 100 dBA [6]. Busch-Vishniac et al. [5] suggested that the large variation in noise levels across rooms in the hospital was due to the different forms of activity taking place in patient's rooms. However, most research has focused on ICUs: higher and varied sources of noise across different types of patient rooms are therefore rarely investigated. In particular, there has been little investigation into noise exposure in geriatric wards occupied by a high number of elderly patients.

The proportion of elderly patients in hospitals has been increasing in line with an aging population. In the UK, more than 60% of hospital beds are occupied by older patients aged 65 or over [9], while older people account for one-third of all hospitalisations in the USA [10]. The geriatric wards accommodate elderly people who suffer from a range of diseases and disabilities, with dementia being one of the most common medical problems presented in geriatric admission [11]. Older people in hospital often require help with activities of daily living, this requires increasing support and patient contact time. Care on geriatric medicine wards is often provided by a large multi-disciplinary team, this results in increased frequency of staff visits per patient. People with dementia or delirium can often exhibit symptoms of agitation which can include shouting out. These activities might cause an increase in background noise levels; however, noise exposure levels in geriatric wards and the

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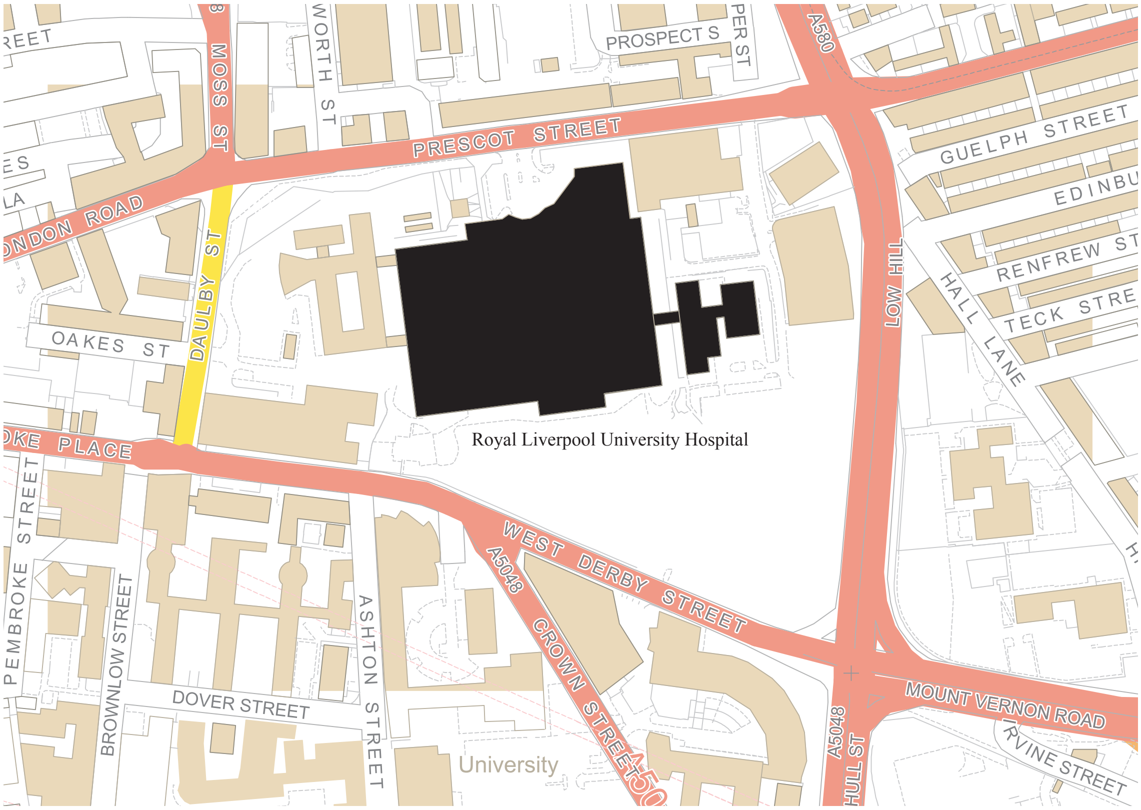

Fig. 1. Site plan of the Royal Liverpool University Hospitals.

contribution of patients' behaviour to this remain unknown.

The aim of this study, therefore, was to investigate noise levels and sources of noise in a typical geriatric ward using measurements collected over a period of 24 hours and to then examine changes in acoustic environments using an acoustic computer simulation. Sound recordings were undertaken, following which A-weighted equivalent and maximum noise levels (L_{Aeq} and L_{AFmax}) were analysed. Noise sources in the geriatric ward were also determined with regard to maximum noise levels. Furthermore, computer simulations were conducted after validating the model against field measurements.

2. Methods

2.1. Case study site

Designed as a case study, measurements were taken on geriatric ward at the Royal Liverpool University Hospitals in the UK in December 2015. The location of site shown in Fig. 1 and it is located along the minor roads (e.g., B5340). As shown in Fig. 2, one ward was included in the study including: two single-bedded rooms, two four-bedded rooms, and one six-bedded room. Single-bedded rooms were facing the North, whilst other rooms were facing the South. All room dimensions are listed in Table 1 in the form 'width × length × height' in metres. All the rooms had an identical height of 2.8 m with larger rooms having greater width and length. The patients on the ward were aged between 66 and 98; 66% were male and 33% were female. Among the patients, 33% were known to have dementia, 33% were admitted with delirium and 13% developed a new delirium during their admission.

Temperature and relative humidity were measured three times a day (11 am, 1 pm and 3 pm) at the centre position of each room using a Maplin 4-in-1 Multi-Function Environment Meter. Room temperatures ranged between 23.0 °C and 24.6 °C with very small variation across the rooms. This result is extremely close to the winter optimal temperature range, 22–24 °C, recommended by the CIBSE Guide A [12]. Relative humidity in the rooms was also acceptable [13], ranging from 43.1% to 51.6%.

2.2. Measurement procedure

Noise measurements were undertaken over three days during typical UK wintertime weather. Noise levels in the patients rooms were measured from one morning through to the next, a total period of 24 hours. Noise was recorded using a half-inch free field microphone (Behringer ECM8000) attached to a portable sound recorder (Zoom H4n) connected to a power supply. The microphone was mounted on a tripod and positioned 0.5 m above the patient's head, and approximately 1.0 m above floor level. The microphone was placed as far away as possible from sound reflecting surfaces (e.g., walls), medical equipment and general daily activity. The noise levels were monitored continuously and all data were transferred to an external hard drive prior to the next recording period. Before the data collection, the entire measurement system was calibrated using an acoustic calibrator (B&K Type 4280).

2.3. Data analysis

From the sound recordings, the A-weighted equivalent sound pressure level (L_{Aeq}) and A-weighted maximum sound pressure level with Fast time-weighting (L_{AFmax}) were calculated at one minute intervals. The recordings were analysed using dBTrait software from 01dBmetravib. In the present study, 24-hour period is divided into the day (07:00–19:00), evening (19:00–23:00), and night (23:00–07:00); therefore, noise levels were calculated for three different periods as well as for 24 hours. Noise events and sources were identified once the noise levels exceeded WHO guideline values. The noise sources were subjectively identified by listening to small sections of the recordings and analysing time histories and frequency characteristics [14].