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# Sound field of typical single-bed hospital wards

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ABSTRACT

The aim of this paper is to investigate the basic characteristics of sound fields in the increasingly concerned single-bed hospital wards, the effects of commonly used furniture, and the feasibility and strategic use of acoustic simulation techniques for such spaces. Two typical single-bed wards at a Critical Care Unit were selected as the case study site. Eight different room acoustic conditions were created by gradually moving pieces of furniture out of the ward. It has been shown that in the ward without acoustic ceiling, under empty room condition the RT ranged from 0.8 s, typically at low frequency, to 2.3 s at 630 Hz; the variations in both SPL and RT at different receivers were insignificant except at low frequencies, so that in such single-bed wards a diffuse field could be assumed; and longer RT and higher SPL were found when furniture was gradually moved out of the ward. In the ward with acoustic ceiling, the effect of furniture was less. There was a good agreement between measured and simulated RT and SPL, showing the usefulness of computer simulation for this kind of spaces. In the simulation, the effect of surface diffusion coefficient was generally insignificant, whereas the effect of edge diffusion should be taken into account, especially for the RT prediction. The feasibility of geometric simplification was also demonstrated.


## 1. Introduction

Recently there is an increasing tendency that more single-bed wards are encouraged, especially in the UK National Health Service (NHS) hospitals, due to a number of advantages in terms of hospital costs, infection control and therapeutic impacts. The Health Building Note 04 recommends that 50% of hospital beds should be single beds rather than the traditional 10% [1].

In terms of creating a better cure environment, hospital units should be designed to reduce noise while retaining efficiency and effectiveness of operation [2]. Although some studies have been carried out concerning hospital noise, most of them concentrated on noise level surveys with limited acoustic indices considered [3]. The effects of reverberation as well as sound reflection patterns have been largely ignored. In particular, the sound field of typical single-bed hospital wards has not been systematically examined. The latest Health Technical Memorandum 08-01 [4], which sets out acoustic criteria for the design and management of new healthcare facilities, does not have specified or detailed acoustic design targets, partly due to insufficient acoustic field measurements. Moreover, limited solutions are given to meet the acoustic criteria in this document. Furthermore, while in hospital wards it is commonly accepted that furniture affects the sound fields, there is little information on their absorption and diffusion coefficients, which are very useful at the design stage, especially for room acoustic simulation.

The main aim of this research is therefore to study the basic characteristics of sound fields in typical single-bed hospital wards, and the influence of commonly used hospital furniture on the acoustic environment. This research also aims to investigate the feasibility and strategic use of acoustic simulation techniques for such spaces, especially concerning the appropriate absorption and diffusion coefficients.

## 2. Methods

### 2.1. Case study site

Noise in Intensive Care Units (ICUs) is always above the internationally recommended levels [5], and ICU patients are more likely to suffer from excessive noise exposure. Therefore a typical ICU at the Critical Care Department of the Northern General Hospital in Sheffield was selected as the case study site. The dimensions of its single-bed wards were approximately 5.5 m × 4.8 m × 3 m, as shown in Fig. 1. Due to different levels of infection control, there were two types of ceiling, which were acoustically absorptive and reflective, referred below in this paper as Ward A and Ward B, respectively. The suspended acoustic ceiling in Ward A consisted of mineral fibre tiles with an air space of 665 mm, whereas the ceiling in Ward B was 12.5 mm plaster board. The floor and wall finishes were the same for Ward A and Ward B. The floor was polyflor classic

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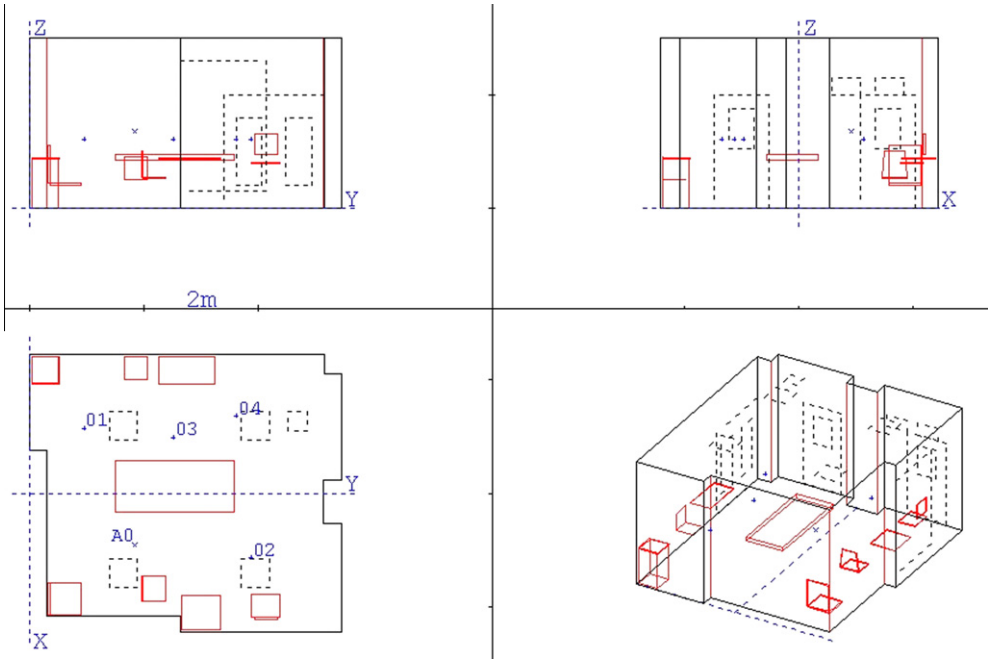


**Fig. 1.** Ward B, where A0 indicates the Omni-directional source, and O1–O4 refer to the four receivers.

mystique stuck to concrete, with coved vinyl skirting. The walls were painted by clinical oil based eggshell, and were filled by 70 mm metal studs at 600 mm centres lined both sides with wallboard with skim coat plaster finish on 12 mm plywood on.

In Ward B eight different room acoustic conditions were considered by gradually moving out from the ward pieces of furniture including chairs, tables, computer, patient bed as well as medical equipment, as illustrated in Fig. 2; whereas in Ward A only two extreme conditions were taken into account, namely empty and fully-furnished, given that the acoustic conditions in Ward A were better due to the absorbent ceiling. With regard to the condition of bed, the foam mattress and bed sheet were present, without pillow and blanket.

### 2.2. Measurement procedure

The measurements were taken when the wards were vacant, and during the measurement all the doors and windows in the

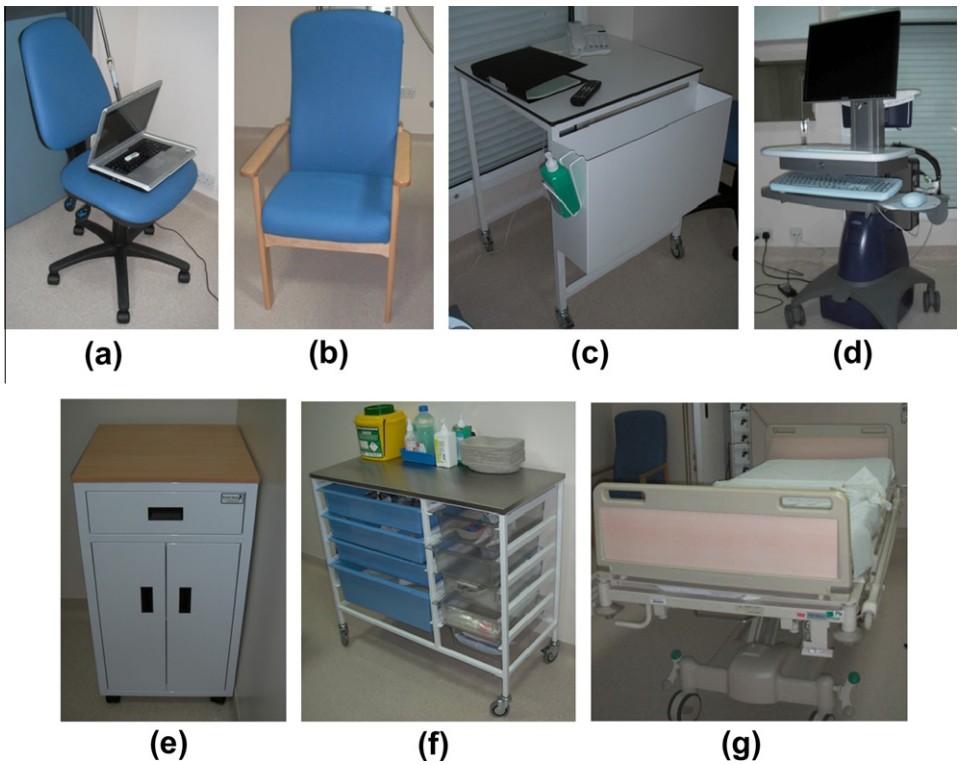


**Fig. 2.** Seven types of furniture in Ward B: (a) small chair, (b) big chair, (c) office table, (d) computer table, (e) cabinet, (f) drawer table, and (g) bed.