Introduction
Noise pollution, an excessive or annoying degree of noise, is an increasingly important public health issue in industrialised countries. Noise pollution can have a number of detrimental effects including autonomic stimulation, auditory fatigue, psychosocial effects and noise-induced hearing loss. Statutory regulations in Ireland limit workplace noise exposure to an average of 87 A-weighted decibels [dB(A)] over eight hours, mandating employer action to reduce risk once exposure exceeds 85 dB(A). The World Health Organisation recommends that noise levels should not exceed 35 dB(A) in patient treatment areas. This guideline was developed in 1965 to protect the health and performance of staff. Noise may also have adverse influences on the comfort and safety of patients. Previous studies have demonstrated that personnel working in orthopaedic operating theatres are exposed to significant levels of noise. Anaesthetists noise exposure in the Irish orthopaedic operating theatre is currently unknown. The aim of this study was to measure the exposure of anaesthetists to noise in the setting of an elective orthopaedic operating theatre catering for patients undergoing major joint arthroplasty.

Methods
Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals. The study was conducted at St. Mary's Orthopaedic Hospital, Cork. No changes were made to the normal anaesthetic or surgical care of each patient. Routine patient care was unaffected by this prospective observational study. Patient information was not collected, therefore individual consent was not obtained. No attempt to control noise was made before commencing the study. A new sound level meter (ISO-TECH SLM-1352N, Range 30-130dB, RS Components Ltd., Northamptonshire, England) was calibrated to industry standards. Based on preliminary recording of operating sound levels prior to the study period, 40 – 100 dB was the range chosen for this study. The A-weighted decibel scale [dB(A)] was used to record sound levels in this study. This is the most commonly used in clinical practice, as it filters out inaudible frequencies to which the cochlea is insensitive. Thus, the A-weighted decibel scale correlates closely with the human response to noise. The primary outcome measure for this study was mean daily noise exposure in the enivrons of the anaesthesia machine. Secondary outcome measures in the study included sources of sound and peak sound levels in the operating theatre. Baseline sound level readings were taken in an inactive operating theatre prior to commencing the formal study. Sound level readings commenced at the start of the operating list and continued throughout the day until the operating list finished. The sound level meter was mounted on a tripod, connected to a laptop computer and placed within two meters of the anaesthesia machine. This recorded noise exposure in the immediate environs of the anaesthetist. The meter recorded sound levels every second over the course of the standard working day. The data was downloaded onto a Microsoft Excel database. Subsequent analysis utilised a time-weighted average over a three-second cycle. This permitted detection of sudden explosive noise, while limiting the number of data points in each data series. A sound level recording was also taken every five seconds. A paper record was used to document the date, time and source of any sound louder than 65 dB(A) as previously described. This qualitative record was transferred onto a Microsoft Excel database. Microsoft Excel was used to calculate mean daily sound levels and peak daily sound levels. The qualitative paper record was analysed to identify the most common sources of sound louder than 65 dB(A).

Results
The study was conducted over nine days in July and August 2008. During this period, 43 operative procedures were performed on 34 patients (12 total hip replacements; 9 total knee replacements; 8 knee arthroscopies; 9 distal lower limb surgeries; 3 upper limb surgeries). The mean (SD) noise level in an empty operating theatre was 56.8 (0.38) dB(A). The maximum sound level was 92.8 dB(A). The average and maximum sound levels were 63.0 (SD 4.26) and 92.8 dB(A) respectively. Noise was louder than 65 dB(A) 22.2% of the time and louder than 80 dB(A) less than 1% of the time. Staff conversation and metal instruments were responsible for 29.5% and 19.9% of peaks louder than 65 dB(A) respectively. Sound levels recorded were lower than recognised levels associated with hearing loss. Sound regularly exceeded World Health Organisation (WHO) recommended levels for patient comfort and safety. Anaesthetists need to be aware of the influence of environmental noise on clinical practice.

Abstract:
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Abstract
Excessive noise exposure can have adverse effects on the health and performance of healthcare providers. Irish statutory regulations limit daily workplace noise exposure to 87 A-weighted decibels [dB(A)]. The World Health Organisation recommends noise levels remain under 35 dB(A) in patient treatment rooms. We measured anaesthetists noise exposure during elective orthopaedic surgery. The mean and maximum sound levels were 63.0 (SD 4.26) and 92.8 dB(A) respectively. Noise was louder than 65 dB(A) 22.2% of the time and louder than 80 dB(A) less than 1% of the time. Staff conversation and metal instruments were responsible for 29.5% and 19.9% of peaks louder than 65 dB(A) respectively. Sound levels recorded were lower than recognised levels associated with hearing loss. Sound regularly exceeded World Health Organisation (WHO) recommended levels for patient comfort and safety. Anaesthetists need to be aware of the influence of environmental noise on clinical practice.

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Anaesthetists' Noise Exposure in Orthopaedic Operating Theatres

Discussion

Several studies have shown that hospitals are noisy places. The average sound level recorded in this operating theatre was 63 dB(A), correlating well with the range most frequently reported in other studies of operating theatre noise [60-75 dB(A)]. The level of sound recorded in this study was lower than that required by Irish statutory regulations. These regulations are designed to protect employees from potential occupational hearing loss which is known to occur at 85 dB(A). At noise exposure above this level it is recommended that employers take appropriate action to reduce adverse health risk to employees. Thus, the sound level recorded in this study is unlikely to lead to noise-induced hearing loss in the anaesthetist. However, there is still cause for concern as the noise level recorded is substantially louder than the 35 dB(A) recommended by the World Health Organisation (WHO); keeping noise levels as low as possible in areas in which patients are treated, as this is most conducive to a relaxing and safer environment. Excessive noise can be a source of severe distress to some patients, thus compromising their comfort and safety in the operating theatre.

Exposure to excessive noise levels can have detrimental effects on the anaesthetist's health. Elevated sound levels can elicit changes in the autonomic nervous system, causing catecholamine and corticosteroid release. Occupational exposure to levels of noise as low as 55 dB(A) have been reported to be associated with adverse physiological events such as hypertension, fatigue and headaches. Constant exposure to noise can lead to a near constant state of agitation, potentially leading to higher incidences of peptic ulcer disease, asthma, and colitis.

Noise in operating theatres can also have adverse effects on anaesthetists performance. The effect of noise on performance depends on a number of factors, including the stress tolerance of the individual, as well as the complexity of the task and the type of noise. Noises which are unpredictable, uncontrollable, or both, have a greater adverse effect on performance than predictable noises. Noise also impairs performance for a long time after the noise has stopped. Sound, when perceived as noise, causes annoyance and can affect one's ability to perform intricate task. If the noise is intense, irregular or uncontrollable, the extent of these reactions is increased. When exposed to pre-recorded operating room noise, anaesthetists show deterioration in the tests for mental efficiency and short-term memory, evidence that the sound levels anaesthetists work in are too high. Administration of anaesthesia is a task where even momentary inefficiency can have detrimental effects on the patient. If the average rate of work is of concern, then noise is relatively unimportant. If, as in anaesthesia, a momentary lapse of concentration could have serious consequences, then high and unpredictable sound levels are a definite risk.

Noisy situations can impair, and even prevent, communication within the operating room. If procedures in theatre are to be carried out efficiently and safely, clear communication is essential. The human ear can find it difficult to distinguish between a number of distinct auditory signals presenting simultaneously, a phenomenon known as masking. In the operating theatre, background noise can mask important clinical auditory clinical signs. It can also cause the Lombard effect, where speech is raised to counteract noise, noise creates more noise. Simple strategies to control noise in the theatre environment might include keeping staff conversation to a minimum, in particular reducing unnecessary conversation; turning off the music or radio; keeping the operating theatre door closed; allowing staff outside the operating theatre to handle telephone calls; putting up signs inviting staff to lower their voices; care when handling metal instruments to reduce sudden explosive sounds; putting monitors on standby when not in use.

In conclusion, the noise levels recorded in this study were not sufficient to precipitate hearing loss in the anaesthetist and are acceptable under Irish Health and Safety legislation. However, levels were louder than that recommended by the World Health Organisation and were of sufficient magnitude to potentially increase the risk of clinical mishap and interfere with anaesthetist performance. Modern operating theatre governance might include a strategy to control noise pollution in the theatre environment.

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References