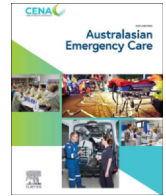




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## As loud as a construction site: Noise levels in the emergency department

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## ABSTRACT

**Background:** The Emergency Department (ED), while being an integral part of healthcare systems, frequently experiences noise levels surpassing the World Health Organization's recommended thresholds. These excessive noise levels could considerably compromise the safety and wellbeing of both patients and staff.

**Methods:** To evaluate noise levels throughout the ED environment, this study utilized dosimeters to measure noise levels over a 24-hour period in six distinct locations, including the ED Waiting Room and Treatment areas.

**Results:** The study found that noise exceeded the WHO recommendations in all six areas of the ED for the entire 24-hour period. Peak noise levels were recorded up to 102.8 dB, which is as loud as noise levels at a construction site. The ED Waiting Room exhibited high peak and average noise levels, indicating the urgent need for quality improvement efforts. These findings align with the results of previous research, thereby suggesting that noise levels in the ED have remained problematic for more than a decade.

**Conclusion:** The findings of this study underscore the importance of addressing excessive noise levels in the ED to create a safe and therapeutic hospital environment for both patients and staff. Healthcare organizations must implement proactive measures to address excessive noise levels in the ED.

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## Introduction

The Emergency Department (ED) may have a strong influence on the patient experience, which frequently serves as the initial touchpoint for those seeking medical care [1]. However, inherent challenges within the ED environment may adversely impact the patient experience. For instance, patients often present to the ED with distress and pain, whilst the physical environment of the ED may be overcrowded, uncomfortable, unfamiliar, lack privacy, and have excessive noise [1,2]. Noise measurement indicates that the ED is one of the noisiest places in the hospital setting [3]. Whilst the World Health Organization (WHO) recommends that noise levels in hospitals should not exceed 35dBA during the day [4,5], studies have identified average noise levels in ED exceeding 55 dB [6,7], with peak noise levels up to 117 dB [8]. Notably, noise levels increase exponentially, whereby for every 10-decibel increase, the sound is perceived to be twice as loud [6].

The pervasiveness of excessive noise levels in the ED can have negative consequences for both patients and staff, including increased stress levels, decreased patient satisfaction, impaired communication, and diminished staff performance and well-being [3,8,9]. Moreover, high noise levels have been linked to a range of adverse physiological effects, such as elevated heart rate and stress levels in patients [10]. The World Health Organization has highlighted that excessive noise may have important safety implications in hospitals, including impaired communication, with communication errors identified as the leading cause of sentinel events in hospitals [11,12].

In a previous study that investigated noise levels across multiple clinical areas of the ED, the highest noise levels were identified in the acute and resuscitation areas, with mean noise levels across all clinical areas exceeding 55 dB [6]. However, the study was conducted more than a decade ago, hence contemporary findings about ED noise levels are needed. This study aims to investigate whether noise still constitutes a significant issue within the ED environment. Our study will also monitor noise levels across six distinct sections within the ED, measured over a continuous 24-hour cycle, thereby facilitating targeted interventions to mitigate the impact of noise levels for patients and staff.

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## Method

### Site

The research was undertaken in the Emergency Department of a prominent public healthcare facility situated in the central business district of Sydney, Australia. This hospital serves as a key referral institution and is a principal provider of trauma services. On average, the hospital has 145 presentations to the ED per day, with 34% of patients arriving by ambulance [13].

### Materials

Noise levels in the ED were measured using Casella DBadge2 Noise Badge Dosimeters over a 24-hour period. A-weighted decibels were used to measure the loudness of the noise as this measurement simulates how the human ear perceives noise [14]. The study utilized two types of noise measures, LAEQ (the average sound level) and LAFmax (the maximum sound level), with measurement occurring in minutely intervals for 24 h.

### Procedure

Six locations were selected for the placement of dosimeters, which represents the patient journey through ED. Patients gain access to the Emergency Department (ED) by either presenting themselves directly in the Waiting Room or being transported to the hospital by ambulance through the Ambulance Bay. After arriving in ED, patients typically undergo evaluations and receive care from medical and nursing personnel in the ED Treatment Areas. Following their initial treatment, patients might either be sent home, moved to a hospital ward, or kept for further monitoring overnight in the "Emergency Medical Unit" (EMU). The chosen measurement period of 24 h enabled evaluation of both daytime and night-time noise levels, which was also the maximum recording capacity of the dosimeters, with measurement commencing at midday. Data was collected during a typical weekday period in June 2022. To estimate the level of noise patients might encounter, dosimeters were strategically positioned near the head of patient beds, including those within the ambulance bay cubicles. In the waiting area, a dosimeter was installed on the wall at a height approximating a seated patient's head level. To maximise the accuracy of measurements, the dosimeters underwent calibration immediately prior to the evaluation.

**Table 1**  
Descriptive summary of average noise levels in the ED (LAEQ).

	Mean	Std. Deviation	Minimum	Maximum	F (p value)
ED Wait Room	59.96	4.60	45.18	81.81	1456 (< 0.05)
Ambulance Bay	56.86	5.00	44.05	78.59	
ED Treatment 1	59.40	3.77	49.73	74.33	
ED Treatment 2	60.01	3.66	51.53	72.18	
EMU 1	51.92	3.59	46.92	65.25	
EMU 2	51.04	3.55	47.34	69.45	

**Table 2**  
Descriptive summary of peak noise levels in the ED (LAFmax).

	Mean	Std. Deviation	Minimum	Maximum	F (p value)
ED Wait Room	73.45	5.27	56.17	99.68	886.4 (< 0.05)
Ambulance Bay	70.92	5.29	55.78	102.81	
ED Treatment 1	72.21	5.19	56.90	97.81	
ED Treatment 2	71.64	5.51	57.11	91.99	
EMU 1	65.27	5.78	56.50	87.20	
EMU 2	62.72	5.92	56.78	94.81	

### Analysis

The noise measurement data was then collected from the dosimeters in decibels (dB) and converted into Excel format for analysis using R statistical software (version 4.3, R foundation for statistical computing, Vienna, Austria). Descriptive summary of average and peak noise levels at standard one-minute intervals were calculated. Statistical differences were tested using one-way ANOVA with  $p < 0.05$  being considered significant. LAEQs were further summarised into hourly averages and graphed to illustrate the variations in noise levels over 24 hrs in the study locations. The proportion of the time average noise levels exceeded specific dB levels were also computed.

### Results

The average noise levels in the ED during the 24-hour period was 56.53 dB. As shown in Table 1, average noise levels (LAEQ) were highest in the ED Treatment areas, with a mean of 59.40 dB and 60.01 dB respectively. The ED Waiting Room also had a relatively high average noise level with a mean of 59.96dBs. In contrast, the overnight stay areas (EMU) had the lowest average noise levels with means of 51.04 dB and 51.92 dB respectively.

As shown in Table 2, the highest peak noise levels were identified in the Ambulance Bay (102.81 dB) and ED Wait Room (99.68 dB). However, despite having the highest peak levels, the mean peak levels recorded in the Ambulance Bay (70.92 dB) were lower than those in both ED Treatment areas (72.21, 71.64). Specifically, the ED Wait Room had the highest mean peak noise levels at 73.45 dB. One-way ANOVA results revealed  $p$  values  $< 0.05$ , indicating significant variations in average noise levels and peak noise levels between ED locations (Tables 1 and 2).

### Variation of ED noise levels over 24 hours

Overall, the results showed that the average noise levels were relatively lower between 12 am and 6 am followed by an increase thereafter in all six ED locations. Compared to overnight stay areas, noise levels were higher in the ED Wait Room, Treatment areas and Ambulance Bay. Average noise levels were observed to be highest in the afternoon and early evening (between 2 pm and 7 pm) at most locations. In the ED Waiting room, noise levels experienced a peak between 7 and 9 pm followed by subsequent decline (Fig. 1). Statistically significant differences in hourly average noise levels over time was also observed (Supplementary Table 1).

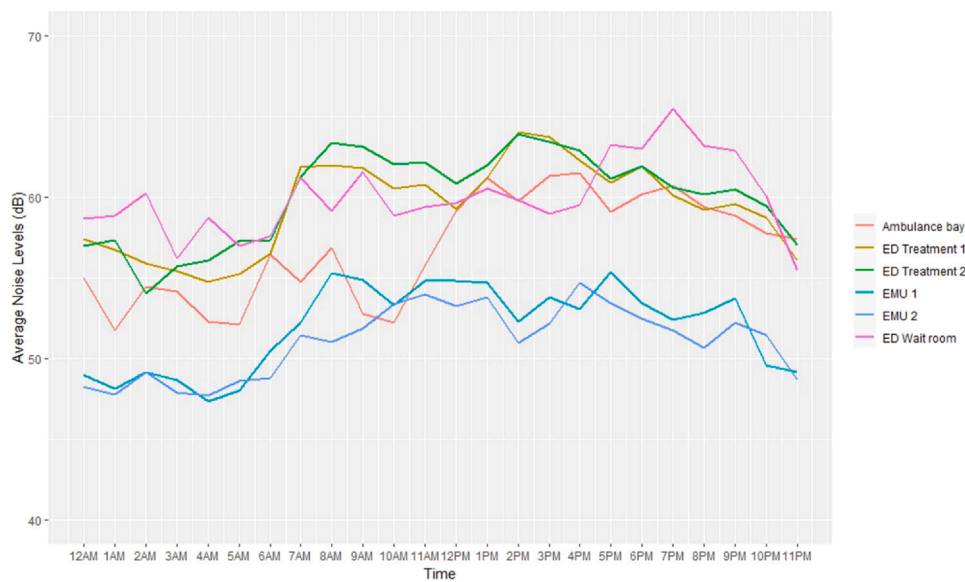


Fig. 1. Average hourly noise levels in ED over 24 hrs.

Table 3  
Proportion of time sound levels exceeded specific dB levels.

Sound levels (dB)	ED Wait Room	Ambulance Bay	ED Treatment 1	ED Treatment 2	EMU 1	EMU 2
40	100.0	100.0	100.0	100.0	100.0	100.0
45	100	99.3	100.0	100.0	100.0	100.0
50	98.7	91.0	99.8	100.0	65.0	48.5
55	86.6	64.3	86.5	88.8	20.6	14.3
60	48.3	26.0	45.9	52.3	1.7	2.2
65	13.5	4.0	6.3	7.8	0.1	0.2
70	1.47	1.4	0.3	0.1	0.0	0.0
75	0.21	0.2	0.0	0.0	0.0	0.0

The proportion of time average noise levels in the ED locations exceeded specific dB levels is detailed in Table 3. As shown, the average noise levels exceeded 40 dB at all locations at all times. Noise levels exceeded 60 dB in ED Wait Room (48.3% of the time) and ED Treatment rooms (45.9% and 52.3% of the time), which was significantly higher than EMU (1.7% and 2.2% of the time). Noise levels above 65 dB was observed in ED wait room for 13.5% of the time.

Discussion

The findings of this study demonstrate that the noise levels in the Emergency Department (ED) have remained relatively consistent for more than a decade, with our results aligning with average and peak noise measurements reported by Short et al. (2011) and Tijnelis et al. (2005). Our research identified average noise levels in the ED over a 24-hour period at 56.5 dB, a value which is 21.5 dB beyond the recommended guidelines set by the WHO. Given that a rise of 10 dB is often perceived as a doubling in the volume of sound, the detected noise levels within the ED surpass the recommended thresholds with a perceived loudness factor of more than four times. Comparing our results with the findings of Short et al. (2010), we identified a similar trend concerning the average noise levels throughout multiple acute areas of the Emergency Department. Both studies identified noise levels in the acute ED areas exceeding 55 dBs, with quieter periods noted from 10 pm to 6 am.

Our research highlighted the problematic nature of noise in the admission points of the ED, with peak noise levels comparable to those encountered at a construction site [15]. Although the Ambulance Bay registered the highest peak noise levels, both the ED

Waiting Room and Treatment areas exhibited higher average noise levels. This suggests that, despite the sporadic instances of high noise levels in the ambulance bay (possibly caused by ambulance sirens), the sustained high average noise levels in the ED Waiting Room and Treatment Rooms may exert a more significant and enduring impact on both patients and staff. Although this study did not identify the causes of noise, previous research suggests that primary causes of noise in ED’s are people-related (45%), such as conversations, followed by administration noise (25%), such as phones and intercoms [16].

The implications of these findings underscore the need to manage noise levels in the ED as they can adversely affect both patients and staff. In order to counteract the detrimental effects of high noise levels in the ED, it is vital for healthcare organizations to make concerted efforts to cultivate a therapeutic hospital setting. This could be achieved by lowering noise levels via environmental enhancements, such as sound-absorbing walls and ceilings [17]. After conducting this research, a range of improvement strategies were implemented in the hospital ED, including staff training about the impact of noise, providing patients with resources to minimise noise disturbances (such as earplugs), and implementation of visual noise alerts in the ED (e.g. “Sound Ear” devices). Further research is required to assess the effectiveness of these interventions and investigate other strategies to reduce noise levels in the ED.

Limitations

The research was conducted in a single public hospital, which may limit the generalizability of the findings to other Emergency

Departments. Additionally, the study did not account for potential confounding factors, such as patient volume or acuity, which may influence noise levels in the ED. The measurement of noise levels was also restricted to a single overnight period, which precluded the examination of longer-term trends. Furthermore, external factors such as seasonal variations or day of the week were not controlled for and could have influenced noise levels in the ED. These limitations should be considered when interpreting the results of the study, and future research should aim to address these limitations to gain a more comprehensive understanding of noise levels in the ED.

### Future research

Future studies should aim to identify the primary sources of noise within the ED, with a particular emphasis on the Waiting Area, which may also investigate potential correlations between noise levels and influencing factors, such as patient volume in the ED. In addition, to fully understand the subjective impact of noise, patient-reported measures may be employed to gain insights about the effects of noise on patient experience. Furthermore, a range of interventions could be implemented to reduce noise in the ED, with further research conducted to evaluate the efficacy of these different initiatives.

### Conclusion

The issue of excessive noise in the ED remains problematic, with current noise levels mirroring those documented in studies over a decade ago. Noise measurement indicates the highest levels of noise at hospital admission points, possibly related to ambulance sirens and patient distress. The ED Waiting Room was identified as a primary area of concern due to sustained high noise levels, thereby suggesting the need for targeted improvement activities. It is recommended that future research should investigate the sources of noise in the ED and assess the efficacy of noise-reducing interventions. In summary, the persistent issue of excessive noise in the Emergency Department is not only a longstanding concern, but also a point of urgency, which may significantly impact upon the well-being and safety of both patients and staff in the hospital setting.

### Ethics approval statement

This study was approved by the hospital Human Research Ethics Committee (HREC) in Sydney, Australia (2021/ETH11585).

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### Data Availability

The data that support the findings of this study are available from the corresponding author, CA, upon reasonable request.

### Declaration of Competing Interest

The authors declare that there is no conflict of interest.

### Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.auec.2023.07.004](https://doi.org/10.1016/j.auec.2023.07.004).

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