# An investigation of sound levels on intensive care units with reference to the WHO guidelines

# 一项基于WHO指南的调查重症监护室声音强度的研究

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# 摘要

Introduction： Patients in intensive care units (ICUs) suffer from sleep deprivation arising from nursing interventions and ambient noise. This may exacerbate confusion and ICU-related delirium. The World Health Organization (WHO) suggests that average hospital sound levels should not exceed 35 dB with a maximum of 40 dB overnight. We monitored five ICUs to check compliance with these guidelines.

背景：ICU病人遭受由护理干预和环境噪音所致的睡眠剥夺。这可能会加重ICU病人的意识障碍和ICU相关谵妄。WHO建议医院夜晚的平均声音强度不应超过35dB且最大限度不超过40dB。我们监测了5个ICU来评价这些指南的遵从情况。

# 摘要

Methods： Sound levels were recorded in five adult ICUs in the UK. Two sound level monitors recorded concurrently for 24 hours at the ICU central stations and adjacent to patients. Sample values to determine levels generated by equipment and external noise were also recorded in an empty ICU side room.

方法：我们在英国五个成人ICU里记录声音强度。两个声音强度检测仪分别在ICU的中心位置和病人旁边同时记录24小时。我们在ICU一侧的病房里记录了由机器设备产生的和外部杂音产生的声音水平的样本值。

# 摘要

- Results： Average sound levels always exceeded 45 dBA and for 50% of the time exceeded between 52 and 59 dBA in individual ICUs. There was diurnal variation with values decreasing after evening handovers to an overnight average minimum of 51 dBA at 4 AM. Peaks above 85 dBA occurred at all sites, up to 16 times per hour overnight and more frequently during the day. WHO guidelines on sound levels could be only achieved in a side room by switching all equipment off .

- 结果：各个ICU平均声音强度总是超过45 dBA，50%的时间声音在52到59 dBA之间。声音强度存在昼夜变化，随着夜班交班之后声音强度减小，在凌晨4点达到一夜之间平均最低值51 dBA。每个记录点都会发生超过85 dBA的峰值，夜间每小时高达16次，白天比夜间更频繁。WHO指南推荐的声音强度可能只能在ICU一侧的病房里关掉所有设备后才能达到。

# 摘要

Conclusion： All ICUs had sound levels greater than WHO recommendations, but the WHO recommended levels are so low they are not achievable in an ICU. Levels adjacent to patients are higher than those recorded at central stations. Unit-wide noise reduction programmes or mechanical means of isolating patients from ambient noise, such as earplugs, should be considered.

结论：所有ICU的声音强度都大于WHO推荐范围，WHO推荐的声音强度太低，以至于没有一个ICU达到。病人旁边记录的声音水平高于ICU中心位置。应考虑减少整个ICU的噪音水平或通过一些设备将病人从周围环境噪音中隔离开来，比如耳塞。

# Introduction

Over 30% of patients treated in ICUs become confused or develop delirium. These patients have longer hospital stays and higher mortality and morbidity. Risk factors for the development of ICU-related delirium are sedation use  and invasive procedures, but there also is a link with environmental factors, including noise-induced sleep disturbance.

在ICU治疗的病人超过30%会出现意识障碍或谵妄。这些病人拥有更长的住院天数以及更高的发病率和死亡率。发生ICU相关谵妄的危险因素有镇静剂的使用和侵入性操作，但是也与环境因素有关，包括噪音诱发的睡眠障碍。

# Introduction

Although there is wide variation due to individual sensitivity to noise and tendency to aggravation, the normal healthy adult can tolerate an A-weighted sound level in decibels (dBA) of about 50 to 55 dBA relatively well during the day and 40 to 45 dBA overnight.

尽管由于对噪音和噪音加重趋向的敏感性不同而个体差异很大，普通健康成人能耐受的A-加权声音强度，白天大约在50到55 dBA之间相对较好，夜晚40到45 dBA。

# Introduction

At these levels, most individuals would not experience annoyance, sleep disturbance or any detrimental health effects. However, quantifiable effects from sleep disturbance can be seen at time-averaged sound levels (LAeq) as low as 30 dBA and corresponding peak noise levels (LAmax) of 45 dBA or less.

在这些声音强度下，大多数人不会感到烦恼、影响睡眠或承受任何对健康有害的影响。然而，在时间平均声音强度低至30 dBA和相应的噪音强度峰值小于等于45 dBA时，睡眠障碍的影响便可察觉。

# Introduction

The World Health Organisation (WHO) Guidelines for Community Noise includes advice on noise levels in hospitals and suggests that, because patients are less able to cope with the increased stress levels generated by excess environmental noise, the sound level in hospitals should not exceed 35 dBA LAeq for areas where patients are treated or observed, with a corresponding LAmax of 40 dBA [4].

因为病人对环境噪音产生的额外增加的应激水平的应对能力更差，WHO指南对社区噪音包括对医院噪音强度的建议是，在医院病人接受治疗和观察的区域的时间平均声音强度不应该超过35 dBA，相应的噪音强度峰值不超过40 dBA。

# Introduction

We decided to assess the sound levels in the ICUs in our hospital group and adjacent hospitals to see how they compared with these standards.

因此，我们决定评估我们医院和几家相邻医院的ICU的声音强度，比较它们与WHO标准的差别。

# Methods

This study was undertaken over two weeks in June 2012. Daytime and night-time sound levels were monitored during the week and at the weekend in five ICUs in the Thames Valley region of England (John Radcliffe Hospital, Oxford, Adult ICU and Neurosciences ICU; Churchill Hospital, Oxford, Adult ICU; Royal Berkshire Hospital, Reading, Adult ICU; and Wycombe General Hospital, High Wycombe, Adult ICU).

这项研究在2012年6月进行了两周。在英国泰晤士山谷地区的五个ICU里，监测一个工作日和一个周末的白天和夜间的声音强度。（牛津，约翰拉德克利夫医院成人ICU和神经ICU；牛津，丘吉尔医院成人ICU；雷丁，皇家巴克西尔医院成人ICU；海威科姆，韦康比综合医院成人ICU）

# Methods

These units were chosen for both their proximity and their heterogeneity because they are examples of different physical ward layouts, patient populations and building designs. This exercise did not involve patient recruitment or the use of any identifiable information.

选择这些单元是因为他们既邻近又存在异质性，因为他们代表不同的病房物理布局、患者群体、建筑设计。这项研究不包括病人纳入标准或者也使用任何患者的人口统计学和临床信息。

# Methods

Our local ethics policy states that studies based on fully anonymised data which the study team cannot trace back to individuals does not constitute ‘research involving human participants’, and therefore this study was not subject to ethical review. The lead physician at each unit gave written permission for the sound levels to be measured, and staff members working on the units were aware of the monitoring.

研究所在地的伦理规范声明，那些基于完全匿名的研究，如果研究团队不追踪具体个人数据时，不构成“涉及人体实验”。因此这项研究不受理论审查的管制。但每个ICU的科室领导都签署了一个关于声音强度测量的同意书，同时让在单元工作的职工知道这项监测。

# Methods

In each ICU, the two monitors ran concurrently for 24 hours for each period of recording, one placed centrally in the unit on or adjacent to the central station and one placed adjacent to a patient's head.

在每一个ICU，同时使用两个监测仪持续24小时记录声音强度，一个放在单元的中央或邻近中心站，另一个放在邻近病人头部的地方。

# Methods

Short-duration sample recordings were also taken in an unoccupied ICU side room in the John Radcliffe Hospital Adult Intensive Care Unit with the monitors and other device alarms sequentially activated. These included examples of the most common alarm signals as well as ambient noise only with all equipment in the room powered down.

在监护仪和其他设备报警声音持续开着的情况下，我们还在约翰瑞德克里夫医院成人ICU一侧闲置的病房里收集了简短的录音样本。这些样本例子不仅包含了最常见的报警信号，还包含了关掉病房里所有设备后的环境噪音。

**Table 1 ICU details**

| Details | John Radcliffe Hospital Adult ICU | Churchill Hospital Adult ICU | John Radcliffe Hospital Neurosciences ICU | Royal Berkshire Hospital ICU | Wycombe General Hospital ICU |
|---|---|---|---|---|---|
| Number of beds | 12 in 3 bays plus 4 side rooms | 6 plus 2 side rooms | 12 | 9 plus 2 side rooms | 7 plus 2 side rooms |
| Nursing handovers | 7:30 AM and 7:30 PM | 7:30 AM and 7:30 PM | 7:30 AM and 7:30 PM | 7:30 AM and 7:30 PM | 7:30 AM, 1:00 PM and 8:00 PM |
| Medical handovers | 8:30 AM and 8:30 PM | 8:30 AM and 8:30 PM | 8:30 AM and 8:30 PM | 8:00 AM and 8:00 PM | 8:00 AM and 8:00 PM |
| Visiting times | No restrictions | No restrictions | No restrictions | No restrictions (with a quiet period from 3:00 PM to 4:30 PM) | Open visiting except from 1:00 PM to 3:00 PM |

Table 1 gives details of the results from the ICUs in the study.

表1列举了各个ICU的基本特征。

**Table 2 Sound levels averaged over 24 hours[a]**

| Location and day | Central station | Adjacent to patient |
|---|---|---|
| John Radcliffe Hospital Adult ICU weekday | 58.4 dB | 59.7 dB |
| John Radcliffe Hospital Adult ICU weekend | 59.1 dB | 59.5 dB |
| Royal Berkshire Hospital ICU weekday | 58.7 dB | 59.9 dB |
| Royal Berkshire Hospital ICU weekend | 57.7 dB | 58.5 dB |
| Wycombe General Hospital ICU weekday | 52.4 dB | 55.4 dB |
| Wycombe General Hospital ICU weekend | 51.3 dB | 54.1 dB |
| John Radcliffe Neurosciences ICU weekday | 58.0 dB | 58.8 dB |
| Churchill Hospital Adult ICU weekend | 55.7 dB | 55.4 dB |

[a]dB, decibel. Sound levels averaged over 24 hours for each site. At the John Radcliffe Hospital, the Royal Berkshire Hospital and Wycombe General Hospital, two recordings were measured: on a weekday day and night and on a weekend day and night. Only one recording was taken at the Neurosciences ICU and the Churchill Hospital ICU in Oxford.

表2给出了放在中心位置和放在病人旁边两组录音，每个以24小时为一个周期的录音的声音强度的平均值。

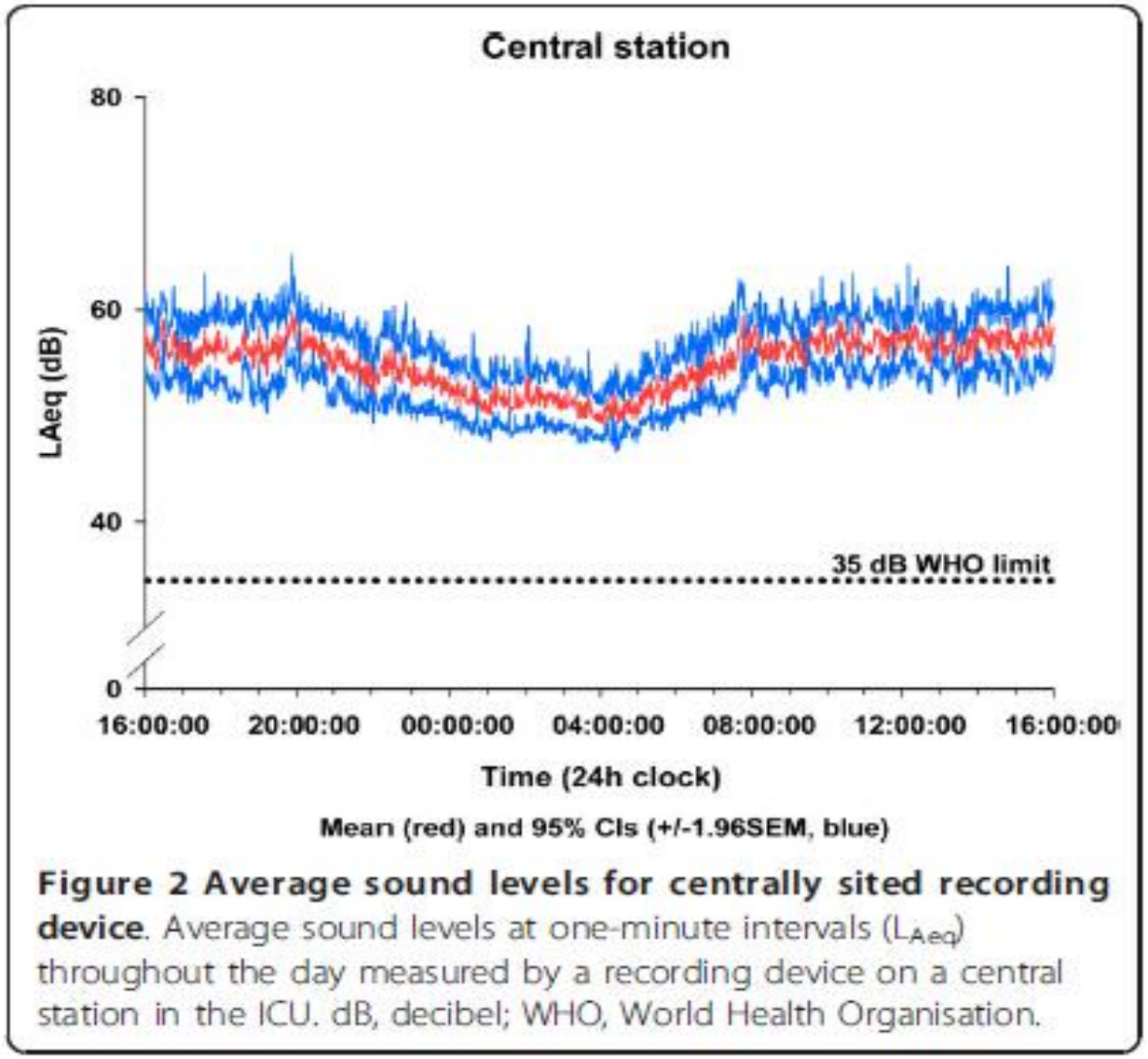


**Figure 2 Average sound levels for centrally sited recording device**. Average sound levels at one-minute intervals ($L_{Aeq}$) throughout the day measured by a recording device on a central station in the ICU. dB, decibel; WHO, World Health Organisation.

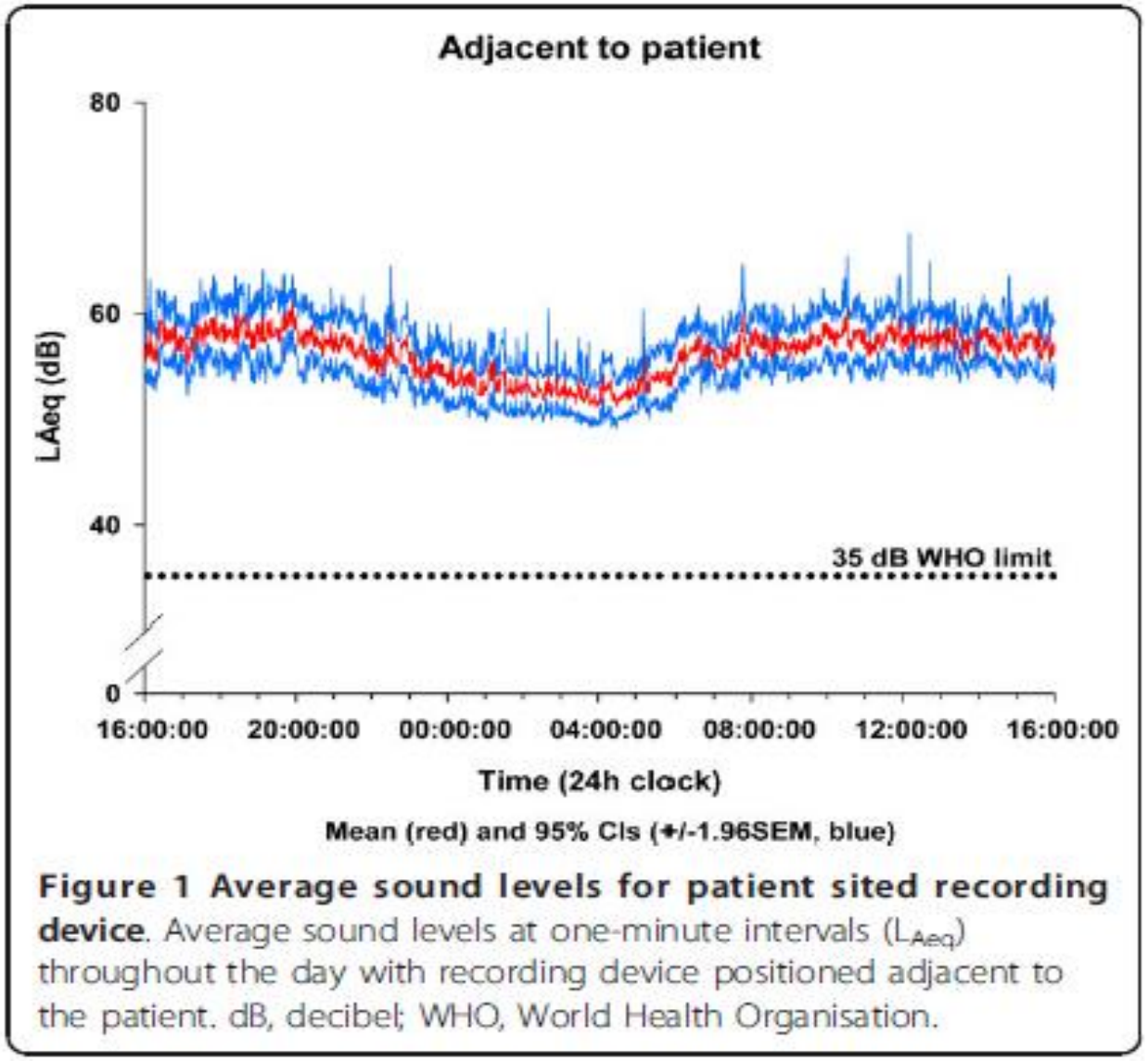


**Figure 1 Average sound levels for patient sited recording device**. Average sound levels at one-minute intervals ($L_{Aeq}$) throughout the day with recording device positioned adjacent to the patient. dB, decibel; WHO, World Health Organisation.

所有ICU录音的时间平均声音水平始终高于45 dBA，大于50%的时间声音水平在52-59 dBA之间。

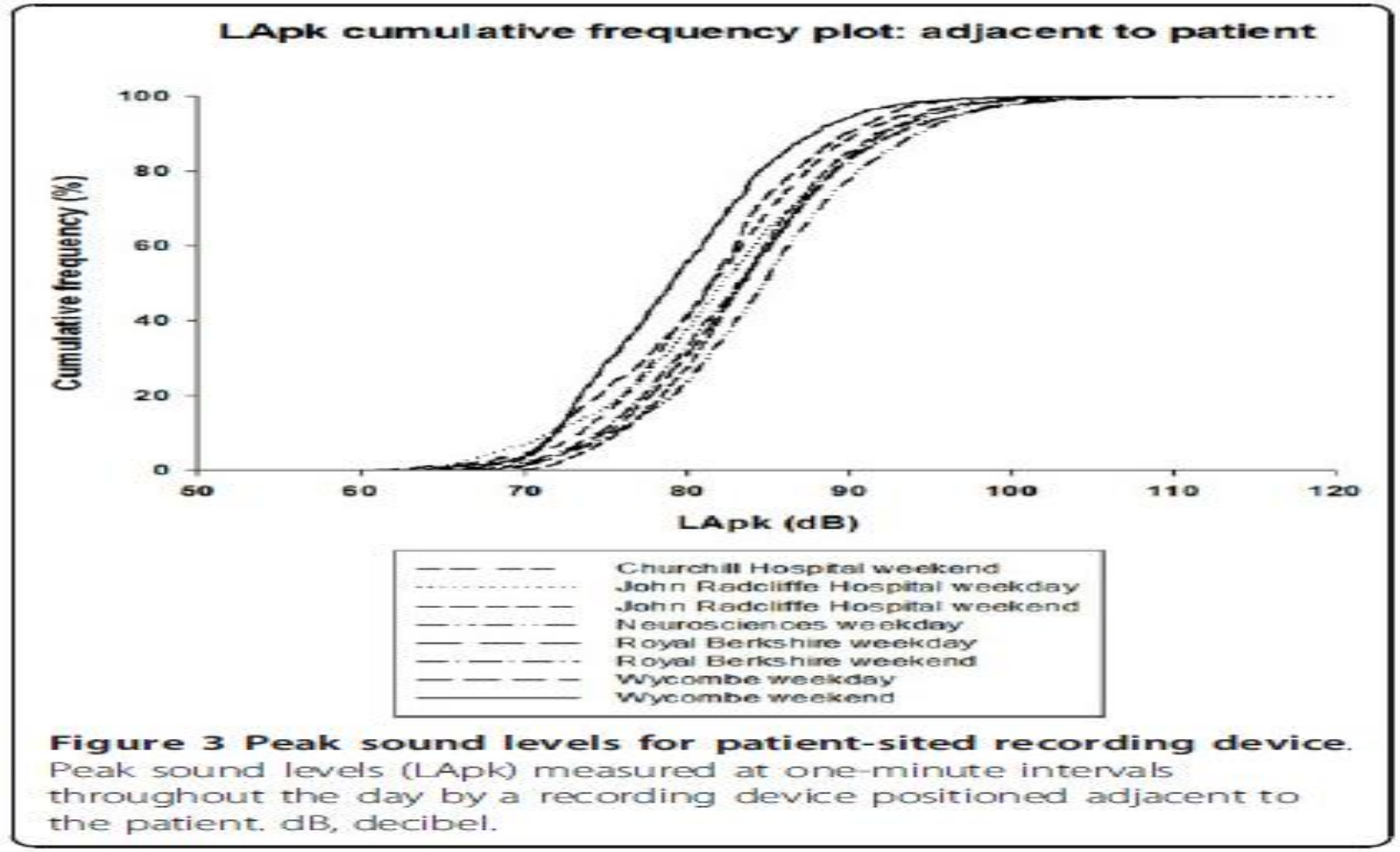


**Figure 3 Peak sound levels for patient-sited recording device.** Peak sound levels (LApk) measured at one-minute intervals throughout the day by a recording device positioned adjacent to the patient. dB, decibel.

图3给出了在每个ICU里病人旁记录的每分钟录音的峰值的累积频率图。样本中超过50%的时间峰值在79-84.6 dBA之间。每分钟峰值均超过60 dBA。录音中最高的峰值是127.9dBA。

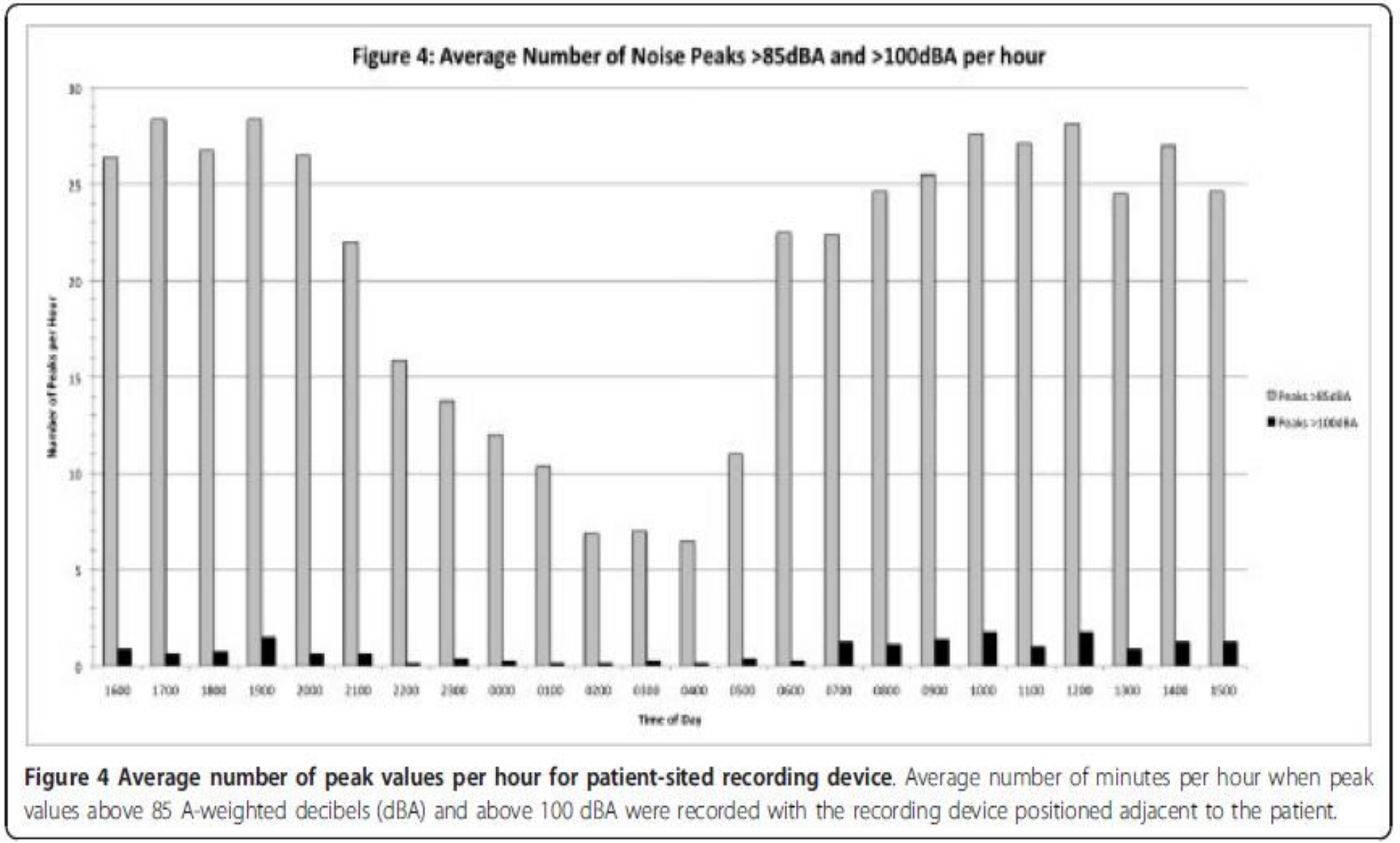


**Figure 4 Average number of peak values per hour for patient-sited recording device**. Average number of minutes per hour when peak values above 85 A-weighted decibels (dBA) and above 100 dBA were recorded with the recording device positioned adjacent to the patient.

图4显示了所有病人旁录音点峰值超过85 dBA和超过100 dBA的每小时的平均分钟数。与图1和图2中时间平均声音强度一样，这也存在明显的昼夜变化。

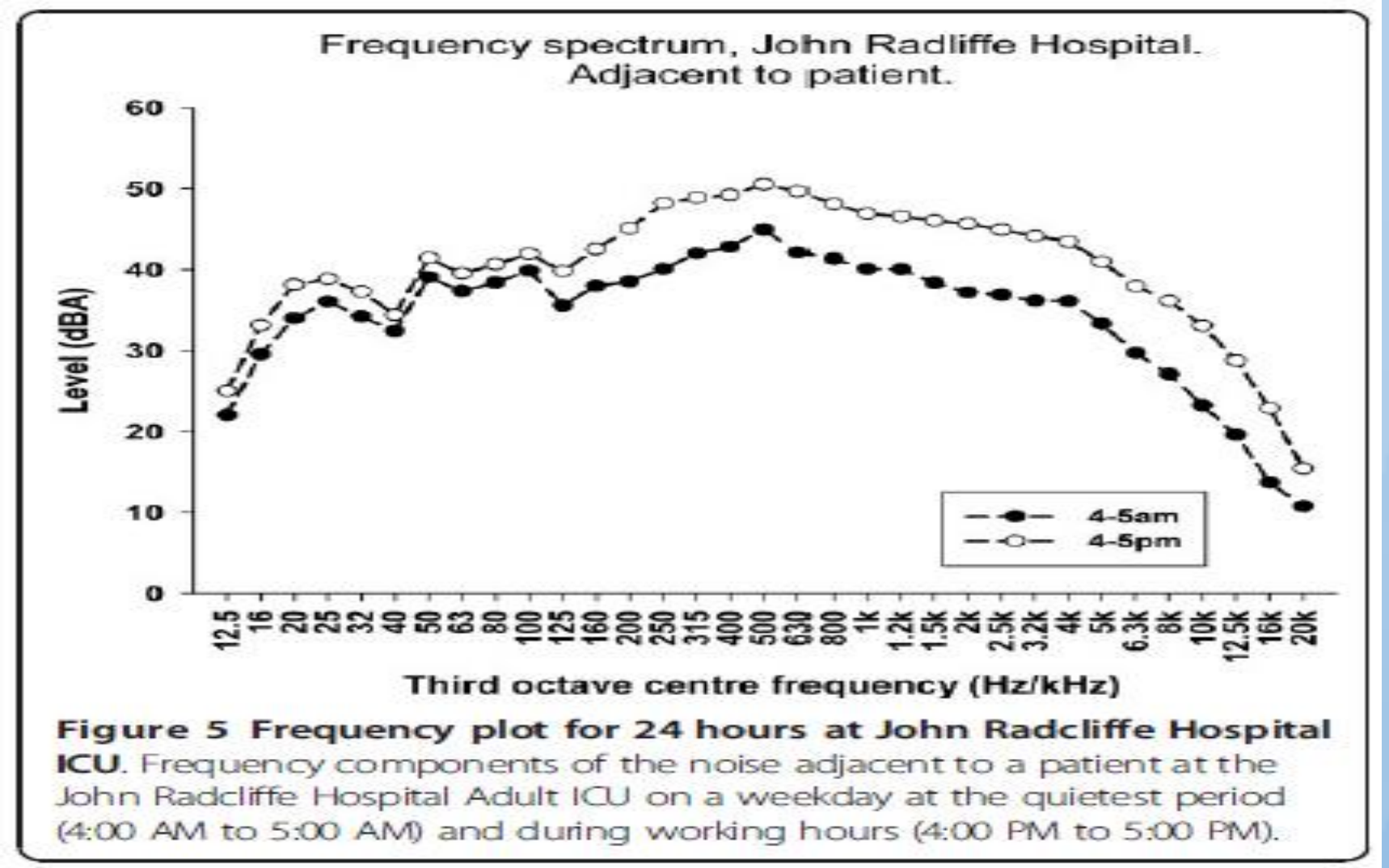


**Figure 5 Frequency plot for 24 hours at John Radcliffe Hospital ICU.** Frequency components of the noise adjacent to a patient at the John Radcliffe Hospital Adult ICU on a weekday at the quietest period (4:00 AM to 5:00 AM) and during working hours (4:00 PM to 5:00 PM).

图5显示了在John Radcliffe Hospital成人ICU里病人旁记录的最安静一小时(4:00 AM to 5:00 AM)和最繁忙的一小时(4:00 PM to 5:00 PM)中各声音频率的平均声音强度。

# Results

Recordings were also taken at midmorning in an empty side room at the John Radcliffe Hospital Adult ICU with the door closed and the recording equipment placed where the patient's head would normally be situated.

上午十点左右，在约翰瑞德克里夫医院成人ICU一侧的闲置病房，关上门后，我们将录音设备放在病人头部一般放置的位置进行录音。

# Results

With all equipment in the room switched off, the LAeq was 34.1 dBA, with increases (1) to 43.5 dBA when the ventilator was running with a test lung; (2) to 47.2 or 51.2 dBA when the ventilator sounded a low- or high-level alert, respectively; (3) to 53.0 dBA with the suction unit turned on; (4) to 59.2 dBA when the monitor sounded a high-level alert; and (5) to 63.3 dBA when the syringe pumps were alerted.

关掉屋里所有的设备，时间平均声音强度为34.1 dBA；当呼吸机吹着膜肺时增加到43.5 dBA ；当呼吸机低音报警和高音报警时分别增加到47.2 和 51.2 dBA；当吸引器开着时增加至53.0 dBA ；当监护仪发出高音报警时到59.2 dBA ，当注射泵报警时增加至63.3 dBA 。

# Discussion

Noise is measured using a logarithmic scale of dB. The threshold for normal human hearing is 0 dBA, a quiet room or a whisper is about 30 dBA, normal conversation is about 55 dBA, a television generates about 60 dBA, heavy traffic at 10-m distance is about 80 dBA and a pneumatic drill is about 100 dBA.

声音dB是用对数尺度来测量的。人类听力的阈值是0 dB，一个安静的房间或耳语时约为30 dB，普通对话大约55 dB，电视的声音大约60 dB，在距离交通拥挤的地方10米的位置是大约80 dB，一个气钻大约100 dB。

# Discussion

A 3-dB change in noise level is considered just discernible; a 5-dB change is clearly discernible; and a 10-dB change louder or softer is perceived as a doubling or halving of volume, respectively. For speech to be easily intelligible, it needs to be 15 dB above background noise levels.

3 dB的声音强度变化被认为是可辨别的；5 dB的变化是可以清晰辨别的；声音强度增强10 dB或减弱10 dB就能被认为声音增强了一倍或减弱了一半。要使演讲声音容易听清楚，需要比环境声音高15 dB。

# Discussion

Thus the recommended WHO average levels for hospital wards are the equivalent of a very quiet room with transient peaks at night well below conversation level.

因此，WHO建议的医院病房的平均声音水平相当于一个非常安静的房间的声音水平，这个房间只能在晚上短暂地出现峰值低于普通对话的声音。

# Discussion

Although it has been reported that there is no significant reduction in overnight activity in the ICU [5], the link between sleep deprivation and poor outcome has been well-reported in recent years [6-8], and all five units in our present study routinely decrease overnight activity and lower the unit lighting to encourage natural sleeping patterns.

尽管有文献报道ICU的夜间活动没有明显减少，但是由于研究表明睡眠剥夺与ICU患者预后不良存在着相关性，在我们研究的五个ICU常规减少夜间活动，并调低灯光以促进自然的睡眠模式。

# Discussion

The noise levels certainly drop by about 5 dB in the early hours of the morning, but only to the level of continuous conversation. The beginning and end of the night are characterised by obvious increases in noise levels at handover time (see Figures 1 and 2).

我们发现，声音强度在凌晨有一定的降低（大约5 dB），但只是降到持续交谈的声音水平。夜晚的开始和结束的标志是交班时间声音水平明显升高。（Figures 1 and 2）。

# Discussion

On average, there were approximately 25 minutes of every hour during the day when peak levels above 85 dBA occurred. Peak levels above 85 dBA occurred less frequently overnight, but a patient can still expect to be disturbed at least once every 7 to 16 minutes of every hour between 10:00 PM and 7:00 AM (Figure 4).

我们发现，在白天平均每小时大约有25分钟声音峰值高于85 dBA。夜晚峰值高于85 dBA的频率少些，但是，在晚上10点到早晨7点(Figure 4)病人仍然可能每7-16分钟至少被打扰一次。

# Discussion

At these dB levels, it is highly likely that this is alarm activity, and, as has been reported elsewhere [9], electronic sounds are more arousing than human voices, so they are very likely to continually disturb patients' sleep. Frequent and persistent arousal has been shown to have negative effects for both healthy volunteers and patients [10,11].

这些声音水平很可能是有报警发生所致，而且正如在别处报道过的一样，电子声音比人类的声音更能唤起听力，所以它们很可能持续打扰病人的睡眠。频繁和持久的唤醒已表明对健康的志愿者和病人都有负面影响。

# Discussion

Hospitals generally appear to be getting noisier over time. A review of published data over the past 50 years [12] suggests an average increase of 15 dB since the 1960s, more than a doubling of the perceived noise. The same study looked at noise in multiple hospital locations in an American teaching hospital and demonstrated the highest levels in the paediatric ICU, although there were no recordings from the adult ICUs.

随着时间的推移，医院似乎变得更加吵闹。一篇回顾过去50年数据的综述显示从1960年以来声音强度平均升高了15 dB ，大于可感知到的声音的两倍。另一项同样着眼于医院噪音的研究，通过对美国一家教学医院的多个医院场所进行监测，发现在PICU的噪音水平最高，尽管没有成人ICU的录音。

# Discussion

In previous studies conducted in specialist ICUs, average levels were about 10 dB higher in a Turkish cardiac surgical ICU with a similar time profile [13], similar to our results in a two-bed Swedish neurosurgical ICU with a comparable frequency distribution of peaks [14], and 5 to 10 dB higher in an American paediatric ICU with no diurnal variation [12].

与以前在专科ICU进行的研究比较发现，一个土耳其心脏外科ICU开展了一项相似的横断面研究，其结果要比我们的平均声音水平高差不多10 dB。我们的结果与瑞典的一个仅有两张床的具有相似峰值频率分布的神经ICU的结果相似。而美国一个PICU的声音强度要比我们的结果高5-10 dB，在这个ICU声音强度没有昼夜变化的。

# Discussion

- A comparable study recorded sound levels in an outpatient chemotherapy clinic [15] and found similar, constant, average (55 to 60 dB) and peak (>90 dB every minute) sound pressure levels during the day. Concurrent questionnaires completed by patients, visitors and staff revealed that, whilst staff felt that the noise was disruptive, in particular causing difficulties with communication, neither patients nor visitors were concerned.

一项类似的研究发现，化疗门诊整个白天的平均（55–60 dB ）和每分钟峰值（>90 dB ）声音强度是几乎不变的。同时由病人、家属以及工作人员完成的问卷调查显示，工作人员感觉到噪音是破坏性的，尤其是感到沟通困难是由噪音导致的，而不是由病人或访视者所致。

# Discussion

Although this suggests that levels seen in the ICU may be acceptable, the authors of that study found a correlation between the time an individual spent at the clinic and the level of irritation expressed. Thus the levels measured in our investigation are likely to affect both staff and patients in the ICU, and attempts should be made to lower noise levels.

尽管我们ICU的声音强度可能是可接受的，但之前研究的作者发现个人在门诊待的时间与其感到被噪音所干扰的水平具有相关性。因此，我们监测到的这一声音强度可能同时影响ICU里的工作人员和病人，应该努力去降低噪音水平。

# Discussion

The frequency spectra of the alarm sounds were recorded in an attempt to distinguish alarm sounds from background noise, but the acoustic ‘signature’ of the alarms was difficult to distinguish from the broadband background noise. As a result, we could not consistently measure alarm and non-alarm sounds separately.

我们记录了报警声音的频率范围，试图将报警声音从背景噪音里区分开来，但是报警的声学信号很难从宽频带的背景噪音中区分开来。因此，我们不能分别对报警声音和非报警声音进行持续测量。

# Discussion

However, these sounds have been reported elsewhere [5], and it is clear that a significant proportion of the background noise is probably generated from modifiable behaviour such as conversation, operating and moving equipment, telephone use and allowing doors and container lids to close freely.

但是在别的研究中报道了这些非报警声音，并且清楚的是，背景噪音中有相当大的一部分很可能是由可改变的行为产生的，如对话、操作、设备的移动、使用电话和让门或容器的盖子自由的关闭。

# Discussion

A number of studies have reduced LAeq levels in the adult ICU, at least for a limited period of time, by introducing noise awareness initiatives and unit-level behavioural changes [16-18]. Introducing ‘quiet times’ has also been shown to improve general well-being [19] and sleep patterns when synchronised with natural circadian rhythms [18].

很多研究至少在一个有限的时间段里减小了成人ICU里的平均声音水平，通过引起对噪音意识的积极性和整个ICU的行为改变。介绍“安静时刻”也显示改善整体状态和与自然生理节律同步的睡眠模式。

# Discussion

Three previously reported studies [20-22] used continuous polysomnography alongside environmental noise measurements to determine whether noise could be the reason for irregular sleep patterns in ICU patients and reported that environmental noise caused between 11% and 17% of arousals and awakenings.

三篇以前的研究报道，通过使用连续的多导睡眠监测与环境噪音测量值来确定噪音是否导致ICU病人不规律睡眠模式，发现环境噪音导致了11%到17%的唤醒和觉醒。

# Discussion

In interviews after ICU discharge, patients regularly reported disturbed sleep, attributing this to noise, light and frequent nursing interventions [23-28]. Sleep disruption in the ICU is also associated with increased requirements for anxiety and depression treatments [28]. Mechanical measures to reduce perceived sound levels, such as earplugs or ear defenders, which each reduce perceived noise by 15 to 30 dB, have also been shown to be effective.

在采访转出ICU的患者中，患者经常提出睡眠干扰，这归因于噪音、光线和频繁的护理干预。在ICU里的睡眠剥夺也与焦虑和抑郁的治疗需求增加有关。机械措施降低感知到的声音水平被证明是有效的，比如耳塞或护耳器，它们降低感知到的噪音的水平为15到30 dB。

# Discussion

A recent 136 patient, randomized controlled study in a large Dutch mixed-use ICU showed a dramatic reduction in delirium and an improvement in sleep with this simple intervention [36]. An earlier, smaller US study in a general ICU and a cardiac ICU showed subjectively reported sleep quality was improved with the use of earplugs [37].

近期在荷兰一个大型混合型的ICU里一项136位病人的随机对照研究发现，这一简单的干预显著减少谵妄并改善睡眠。在美国一个综合ICU和心脏ICU进行的一项更早但规模较小的研究表明，使用耳塞可以改善患者自主评价的睡眠质量。

# Discussion

Discussions with ICU staff during our data collection period revealed that many we spoke to considered some patient to be disproportionate to their urgency, which led to louder sounds being prolonged while more immediate needs were treated. This inappropriateness in the alarm 'urgency mapping' [38] may quickly lead to desensitisation [39] and a corresponding reduction in alarm response.

在收集数据期间，我们与ICU工作人员的讨论时发现，与我们交谈的很多人认为一些患者的仪器报警与他们的紧急情况不成比例，当有其它更紧急的事需要处理的时候，就导致了这些报警声音被延长。这种报警“紧迫性映射”不相称可能会很快导致脱敏作用和相应的报警处理减少。

# Discussion

Alarm fatigue has been cited in a recent report as the leading hazard faced by hospitals in the United States [40]. Visual correlation of the data recorder real-time screens with alarm sounds confirmed that equipment alarms were the likely source of at least some of the peak values.

最近美国一篇报道已把警报疲乏当成医院面临的首要危险。实时数据记录器的结果与报警声音的相关性证实了报警很可能至少是一些峰值的来源。

# Discussion

It has been shown that active alarm management can reduce the total number of alarms. A study in the United States [41] introduced a programme by which staff were encouraged to modify machine default limits in line with their patients' individual physiology, thus reducing the opportunity for alarm fatigue to become established.

已经证明积极的报警管理可以减小报警的总数。美国的一项研究介绍了一种方案，通过鼓励工作人员根据病人的个体生理情况来调节机器的默认值，从而减少报警疲乏的建立机会。

# Discussion

Additionally, the development of smart alarms has been advocated [42-44]. In 2009, Gorges et al. [45] reported that only 23% of the alarms in the ICU were ‘effective’, specifically suggesting that introducing a 19-second delay would eliminate 67% of the ignored and ineffective alarms.

另外，发展智能报警也被提倡。2009年Gorges 等人报道了ICU里只有23%的报警是有效的，特别建议了引入一个19秒的延迟将消除67%的报警忽视和无效报警。

# Discussion

Research is ongoing to improve the system by which patients whose condition is deteriorating are identified [44,46-48], and, although not in widespread use in the United Kingdom, there are alarm management systems which can transfer the audible alert from the patient bedside to a centralised control room or to the care provider.

系统升级的研究正在进行，以便对那些病情恶化的病人加以标识，并开发一个报警管理系统，尽管在英国不是广泛使用，但它可以将病人床旁的声音报警传递到一个集中的控制室或者传递给监护者。

# Discussion

There may therefore be technological solutions that could be used alongside awareness programmes to lower sound levels by more than that which can be achieved by behavioural interventions alone.

因此，可利用技术措施和警报意识计划一起来降低声音强度，而不仅仅是通过单独的行为干预来实现。

# Discussion

We could achieve sound levels within the WHO guidelines only in a closed side room with all patient monitoring equipment switched off. Although some studies have found that it is possible to lower noise levels, at least temporarily, none achieved levels below the WHO guideline limit. Our findings suggest that, with the current equipment required for patient care, the WHO guidelines are not achievable in ICUs in the United Kingdom.

我们只有在ICU旁关上门并关掉所有监护设备的空闲病房里才能达到WHO指南推荐的声音强度。尽管一些研究发现降低噪音水平是可行的，至少临时可行，但没有一个能低于WHO指南的界限水平。我们的调查结果表明，根据当前监护病人的设备要求，WHO指南推荐的水平在英国的ICU里是达不到的。

# Limitations

Our study was limited to one day of recording at each site. One full week at each site would have provided more robust data less susceptible to short-term events, which might have affected the sound levels recorded on any given day.

我们研究的不足在于，每个记录点只记录了一天的时间。记录一整周的时间应该会提供更加完整的数据，可减少短期事件的影响，这些短期事件可能会影响既定某一天记录的声音强度。

# Limitations

We did not collect information on patient sleep assessment or document activity around the patient bed space (for example, treatment and interventions or visitor and/or patient use of television and/or radio), which may have contributed to the noise levels in the patient's vicinity.

同时，我们没有收集评估病人睡眠的信息或者病人床旁空间中的活动的文档记录（比如治疗和干预或探视和/或病人使用电视机和/或收音机），这些可能会增加病人周围的噪音水平。

# Limitations

A more accurate description of the sources of the noise may have been possible with more frequently sampled data, combined with greater frequency discrimination. This would have enabled us to run more detailed analysis of noise levels, particularly with regard to the number of peak levels and their duration.

一个更加准确的对噪音来源的分析可能需要更多的频率样本数据和频率辨别能力更强的设备。这会使我们对噪音的强度做到更详细的分析，尤其是关于峰值的数量和持续时间。

# 谢谢