

Patterns and predictors of sound levels in hospital rooms

Dear Editor,

Excessive sound levels in the hospital can impair the work performance of healthcare professionals and affect patient well-being.¹ Previous studies have also linked excessive sound levels with sleep disturbances and cardiovascular morbidity.² While there have been data published regarding noise levels in the intensive care unit (ICU),³ it is unclear whether there are differences in sound levels between ICUs and general wards (GWs). We sought to compare the patterns and predictors of sound levels in ICUs and GWs. We hypothesised that sound levels would be higher in ICUs than in GWs, and that sound levels in ICUs and GWs would be associated with patient-related equipment sources and non-equipment sources, respectively.⁴

We measured sound levels in 4 wards in 4 GWs and 3 ICUs, all with single bedrooms, at the National University Hospital, Singapore. The investigator was tasked to stand in the room for 1 minute every hour, and performed measurements sequentially from room to room without delay. Six days (3 weekdays and 3 weekends) of 24 hours each in June 2018 were evaluated. Paired average and peak sound levels inside each room were measured 1m away from the head of bed and for over 1 min hourly, via mobile phone apps (Decibel Ultra [Patrick Schaefer] for iOS [Cisco Systems Inc, San Jose, US] and Sound Meter [Abc Apps] for Android [Google LLC, Mountain View, US]).⁵ Sound levels were measured with fast, A-weighting. Usual timings of doctor's ward rounds were from 1800h to 1000h, while nursing shift changes occurred at 0730h, 1600h and 2100h. As no patient data were collected, the need for ethics review was waived (approval number DSRB/2018/00460).

Multilevel mixed-effects linear regression, with sound level measurements nested within rooms nested within wards, fit by maximum likelihood, was used. In-room variables were analysed as time-varying covariates, and included presence of mechanical ventilation, non-invasive mechanical ventilation, supplemental oxygen devices, suction devices, nebulisers, medication pumps, feeding pumps, radio, television, vital signs monitor, active alarms, staff and family members.

We studied 10,894 pairs of average and peak sound readings (4,724 pairs in ICUs, 6,170 pairs in GWs). Between GWs and ICUs, no significant differences were found for average sound level (mean 48.5dB±standard deviation 10.8dB versus 51.6±6.0dB, $P=0.224$) and

peak sound level (62.3±11.9dB vs 62.3±7.6dB, $P=0.978$). Peak sounds of >80dB were recorded every hour of the day, with proportion of peak sounds >90dB of 0.53% and proportion of peak sounds >100dB of 0.06%. Average sound level did not differ significantly between day (0700h–1859h) and night (1900h–0659h) (49.66±9.38dB vs 49.70±9.37dB, $P=0.212$), though peak sound level was higher during the day than at night (62.9±10.5dB vs 61.5±10.3dB, $P<0.001$). Both average sound level (50.2±8.9dB vs 49.2±9.9dB, $P<0.001$) and peak sound level (62.4±9.8 vs 62.2±11.1dB, $P=0.014$) were higher during weekdays (Monday–Friday, 0800h–0800h the next day) than weekends (Saturday 0800h–Sunday 0800h).

In the ICU, mechanical ventilation and presence of family members were associated with increased sound levels, while supplemental oxygen and medication pump use were associated with decreased sound levels (Table 1). In the GWs, presence of staff members and family members were associated with increased sound levels, while vital signs monitor use was associated with decreased sound levels. In both GWs and ICUs, nebuliser use, alarms and radio/television were associated with increased sound levels.

Contrary to our hypotheses, we found that peak and average sound levels did not differ between GWs and ICUs, while sound levels in both GWs and ICUs were affected by equipment-related and non-equipment-related sources. Average and peak sound levels in both GWs and ICUs exceeded the World Health Organization's recommended night noise level (40dB).⁶ These are comparable to previously published data from other units.⁷ Although significant, there was only a marginal drop of peak sound level (~1dB) from day to night, and marginal drops of average (~1dB) and peak (~0.5dB) sound levels from weekdays to weekends.

Strengths of our study include the detailed 24-hour data for weekdays and weekends. However, only 1 hospital was studied, which limits generalisability. Sound levels measured using mobile phones are also not as accurate as environmental monitoring equipment. A bias in measurement remains when a human is visibly recording sounds, as it is very likely that people within the area would modify their behaviour following awareness of being observed. Thus, it is likely that sound levels are higher than reported, which highlights the need for average and peak sound levels in both GWs and ICUs to be managed at all times, especially using

Table 1. Association of environmental factors on sound levels in hospital rooms

Environmental factors	Change of average sound level (dB) (95% CI)		Change of peak sound level (dB) (95% CI)	
	GW	ICU	GW	ICU
Mechanical ventilation	NA	-0.13 (-0.98–0.73)	NA	1.81* (0.58–3.03)
Non-invasive ventilation	NA	1.35 (-1.40–4.10)	NA	1.37 (-2.56–5.30)
Supplemental oxygen use	0.67 (-0.44–1.78)	-4.83* (-5.82–3.85)	0.31 (-0.86–1.48)	1.14 (-0.26–2.54)
Suction device use	-6.29 (-19.84–7.25)	-0.93 (-2.03–0.19)	-10.98 (-25.40–3.45)	-0.27 (-1.84–1.30)
Nebuliser use	9.01* (1.15–16.88)	2.42* (0.35–4.48)	6.86 (-1.51–15.23)	-0.19 (-3.15–2.76)
Medication pump	-0.18 (-0.96–0.60)	-2.50* (-3.37–1.63)	-0.28 (-1.11–0.55)	-3.79* (-5.03–2.55)
Feeding pump	4.03 (-3.22–11.26)	0.41 (-0.49–1.31)	5.24 (-2.47–12.94)	-0.41 (-1.68–0.87)
Radio/television	0.65* (0.04–1.27)	2.13* (1.31–2.96)	1.60* (0.13–3.10)	2.04* (0.87–3.22)
Vital signs monitor	-1.98* (-3.25–0.70)	0.79 (-0.28–1.86)	-1.93* (-3.27–0.58)	-0.33 (-1.84–1.19)
Alarms	1.78* (0.37–3.18)	0.87* (0.09–1.66)	1.61* (0.12–3.10)	0.54 (-0.59–1.66)
Presence of family	-0.80 (-1.73–0.12)	1.87* (1.08–2.65)	1.33* (0.35–2.31)	1.86* (0.74–2.98)
Presence of staff	2.12* (1.31–2.94)	0.57 (-0.27–1.40)	5.23* (4.36–6.09)	-0.17 (-1.35–1.01)

CI: confidence interval; dB: decibel; GW: general ward; ICU: intensive care unit; NA: not applicable

* $P < 0.05$: using multilevel mixed-effects linear regression, with sound level measurements nested within rooms nested within wards, fit by maximum likelihood

policies that simultaneously target multiple modifiable environmental factors to lower sound levels.⁸ Our results also support guideline-recommended protocols that reduce noise exposure and promote sleep for critically ill patients.⁹

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