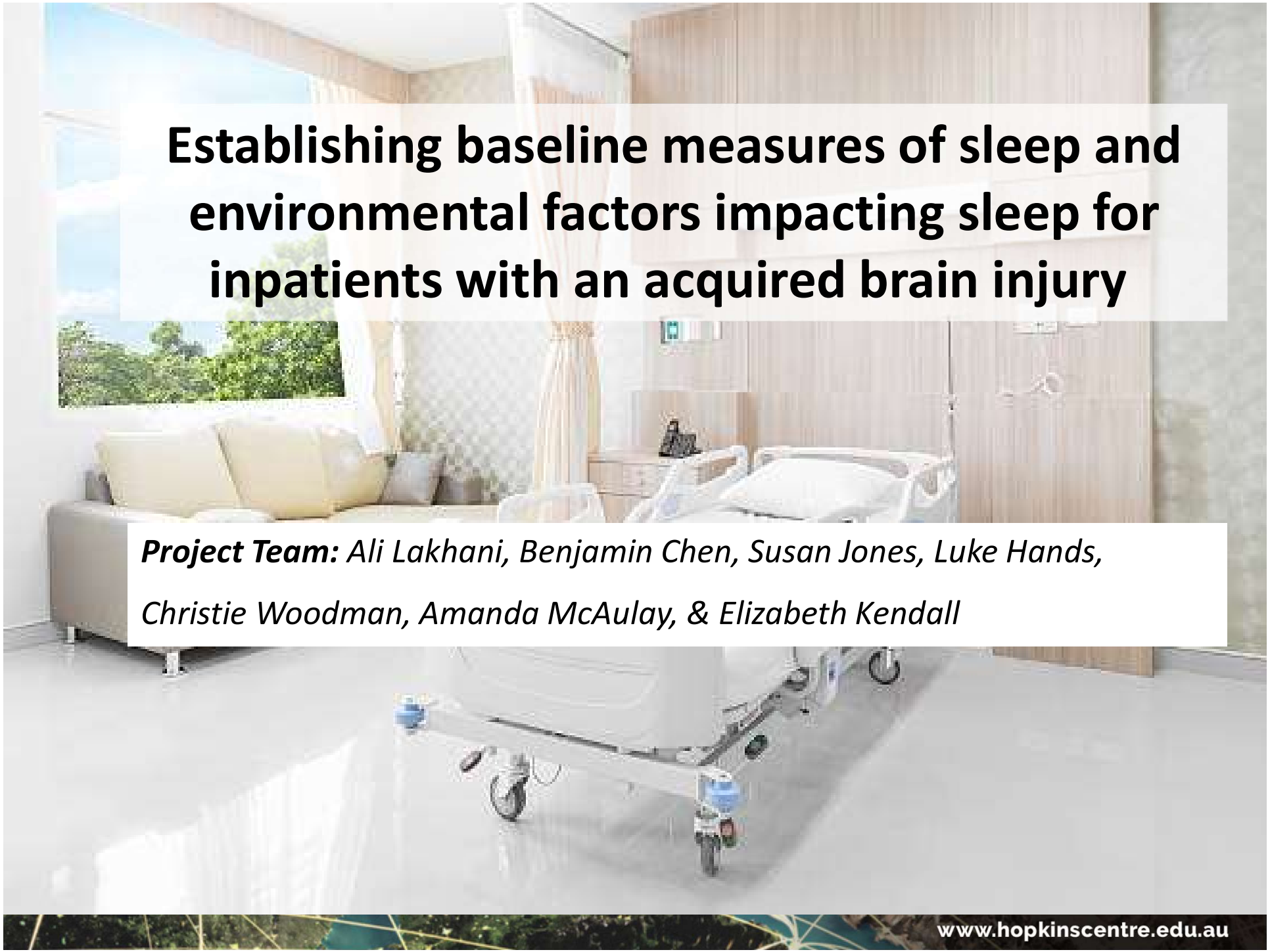


Establishing baseline measures of sleep and environmental factors impacting sleep for inpatients with an acquired brain injury

Project Team: *Ali Lakhani, Benjamin Chen, Susan Jones, Luke Hands, Christie Woodman, Amanda McAulay, & Elizabeth Kendall*

Main Points

- Limited research has investigated the impact of environmental factors overnight on the sleep of rehabilitation unit inpatients.
- A study investigating the impact of environmental factors overnight on the sleep of inpatients with an ABI at the Gold Coast University Hospital Neurorehabilitation Unit is in progress.
- Preliminary findings suggest that noise levels may be higher than World Health Organization guidelines.

The Importance of Sleep

As is the case with many injuries and illnesses, increased sleep over and above that typically required by people without injury is necessary to promote recovery [1, 2].

For people with ABI sleep has been identified as a predictor of: attention [3, 4], physical activity and recovery [5-9], participation in rehabilitation programs [10], social health [11], psycho-emotional health [12-14], quality of life [6], cognition [8, 15-20], activities of daily living [21], and communication [16].

The Effect of Sleep Disturbances on the Functional Recovery of Rehabilitation Inpatients Following Mild and Moderate Stroke

Kyung-Lim Joa, MD, Won-Hyoung Kim, MD, Ha-Yoon Choi, MD, Chan-Hyuk Park, MD, Eun-Suk Kim, MD, Sook-Joung Lee, MD, Soo-Yeon Kim, MD, Sung-Hwa Ko, MD, and Han-Young Jung, MD

Objective: The aim of the study was to explore the impact of insomnia and sleep disturbance on the functional outcomes of mild and moderated stroke.

Design: A multicenter-observational and correlation study was performed. Two hundred eighty patients with mild-moderate severity stroke admitted to three acute hospitals rehabilitation departments. *Diagnostic Statistical Manual of Mental Disorders*, *Fourth Edition*, criteria were used to define patients with insomnia and any sleep disturbance. Patient's initial and final functions were evaluated using the Korean version of the Berg Balance Scale, the Korean version of Modified Barthel Index, the Korean version of Mini–Mental State Examination, the Korean version of the Frontal Assessment Battery, and the Korean version of National Institute of Health Stroke Scale. Sleep disturbance and function were assessed with respect to stroke severity as defined by the Korean version of National Institute of Health Stroke Scale.

Results: The prevalence of *Diagnostic Statistical Manual of Mental Disorders*, *Fourth Edition* insomnia and any sleep disturbance were 26.9% and 56.7%, respectively. After adjusting for age, sex, depression, anxiety, length of stay, and hypnotic usage, the improvement of Korean version of the Berg Balance Scale was significantly lower in the any sleep disturbance group. In the moderate stroke group, the Korean version of the Berg Balance Scale improvement was significantly lower in the any sleep disturbance group, whereas in the mild stroke group, the Korean version of the Berg Balance Scale improvement was not significant.

Conclusions: Sleep disturbance after stroke was found to have negative effects on functional recovery, especially balance improvement in moderate stroke group.

Key Words: Stroke, Sleep, Disturbance, Insomnia, Function, Recovery

(*Am J Phys Med Rehabil* 2017;96:734–740)

Persistent Sleep Disturbances Independently Predict Poorer Functional and Social Outcomes 1 Year After Mild Traumatic Brain Injury

Lai Gwen Chan, MRCP, MRCPsych; Anthony Feinstein, MPhil, PhD, FRCP

Objective: To investigate the effect of sleep disturbances on functional and social outcomes after mild traumatic brain injury. **Setting:** Outpatient traumatic brain injury clinic in a tertiary trauma center. **Participants:** A total of 374 mild traumatic brain injury patients were assessed within 3 months of injury and followed up every 3 months for 1 year. **Design:** Analysis of a historical cohort in a naturalistic clinical setting. **Main measures:** At each visit, symptoms of concussion and psychological distress and indices of functional and social outcomes were measured with the Rivermead Postconcussion Questionnaire, 28-item General Health Questionnaire, and Rivermead Head Injury Follow-up Questionnaire, respectively. Changes in outcome scores over time were explored using repeated measures analysis of variance and compared between subjects with persistent (SD) and recovered (SR) sleep disturbances. Predictors of functional/social outcome were determined using linear regression. **Results:** The percentages of subjects reporting sleep disturbances at each time point were 71.9%, 57.2%, 55.1%, and 53.7%, respectively. For functional and social outcomes, significant effects of time ($F_{3,315} = 9.54$; $P < .001$), group (SD vs SR) $F_{1,317} = 5.32$; $P = .022$, and time X group interaction $F_{3,315} = 4.14$; $P = .007$ were found. Persistent sleep disturbance ($P = 0.011$) and higher symptom burden at 6 months postinjury ($P < .0001$) were independent predictors of poorer outcome. **Conclusion:** Sleep disturbance, independent of psychological distress, is an important prognostic factor of functional and social outcomes after mild traumatic brain injury. **Key words:** *brain injury*, *concussion*, *mild traumatic brain injury*, *sleep disorders*, *traumatic brain injury*, *treatment outcome*

The Relationship Between Sleep-Wake Cycle Disturbance and Trajectory of Cognitive Recovery During Acute Traumatic Brain Injury

Erin M. Holcomb, PhD; Stephanie Towns, PhD; Joel E. Kamper, PhD; Scott D. Barnett, PhD; Mark Sherer, PhD; Clea Evans, PhD; Risa Nakase-Richardson, PhD

Objective: Following traumatic brain injury, both sleep dysfunction and cognitive impairment are common. Unfortunately, little is known regarding the potential associations between these 2 symptoms during acute recovery. This study sought to prospectively examine the relationship between ratings of sleep dysfunction and serial cognitive assessments among traumatic brain injury acute neurorehabilitation admissions. **Methods:** Participants were consecutive admissions to a free-standing rehabilitation hospital following moderate to severe traumatic brain injury (Median Emergency Department Glasgow Coma Scale = 7). Participants were assessed for sleep-wake cycle disturbance (SWCD) and cognitive functioning at admission and with subsequent weekly examinations. Participants were grouped on the basis of presence (SWCD+) or absence (SWCD−) of sleep dysfunction for each examination; groups were equivalent on demographic and injury variables. Individual Growth Curve modeling was used to examine course of Cognitive Test for Delirium performance across examinations. **Results:** Individual Growth Curve modeling revealed a significant interaction between examination number (ie, time) and SWCD group ($\beta = -4.03$, $P < .001$) on total Cognitive Test for Delirium score. The SWCD+ ratings on later examinations were predicted to result in lower Cognitive Test for Delirium scores and greater cognitive impairment over time. **Conclusions:** This study has implications for improving neurorehabilitation treatment, as targeting sleep dysfunction for early intervention may facilitate cognitive recovery. **Key words:** *cognition*, *brain injury*, *rehabilitation*, *sleep*

The Importance of Sleep

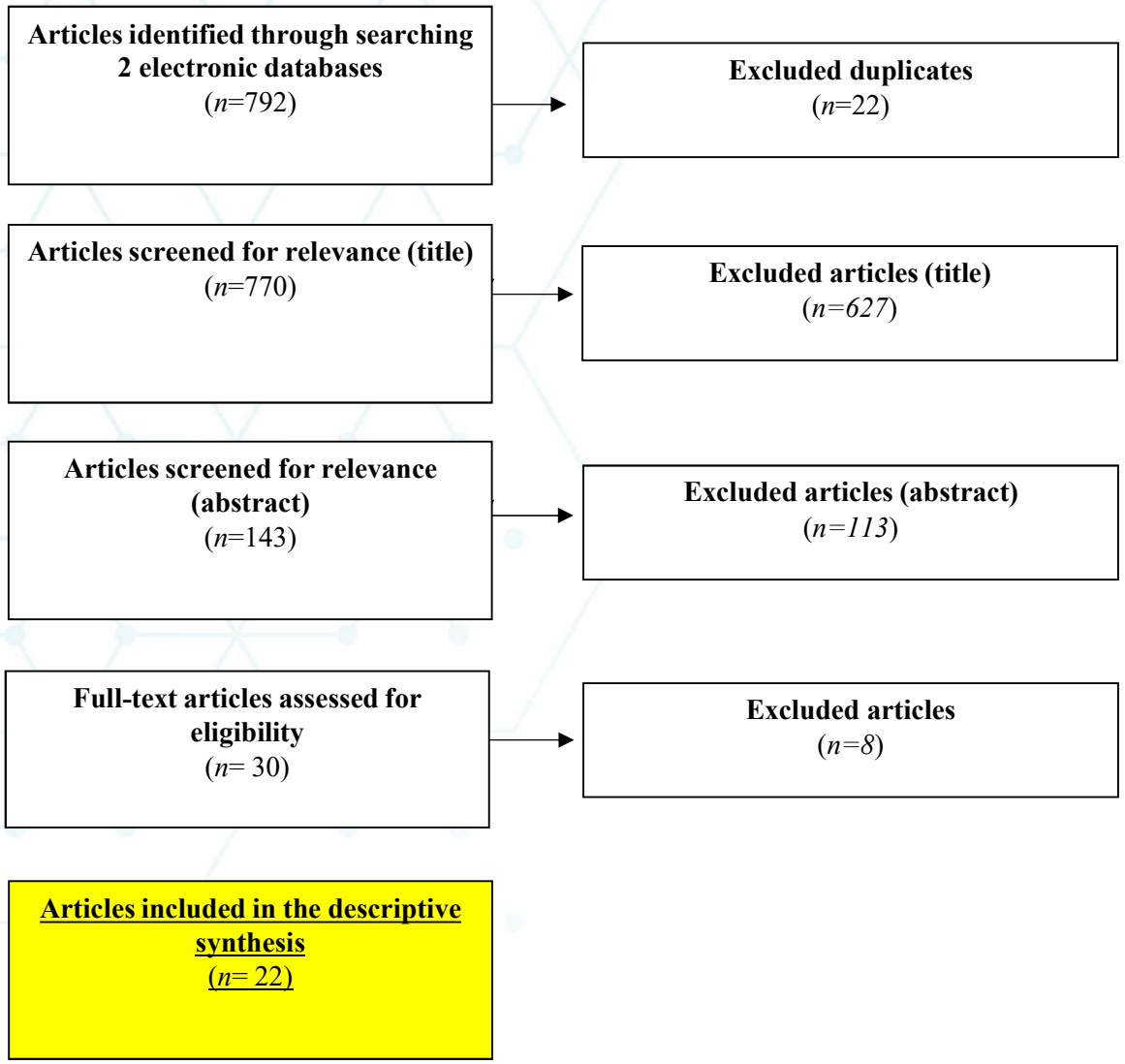
For people with an ABI, increased sleep is especially important during the acute stage of injury [2].

The need for increased sleep during the acute stage of ABI is difficult to address when (i) sleep disorders are a common consequence of injury [16] that often go undiagnosed and treated [22, 23], and (ii) hospital environmental factors can promote sleep disruption and establish unhealthy sleep patterns [24, 25].

Hospital Environmental Factors and Sleep

Searches of CINAHL and MEDLINE were conducted in May 2018 to identify research investigating the impact between environmental factors overnight in hospital and inpatient sleep.

Flowchart


Articles identified through searching 2 electronic databases (n=792)
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Articles screened for relevance (abstract) (n=143)
Excluded articles (abstract) (n=113)
Full-text articles assessed for eligibility (n= 30)
Excluded articles (n=8)
Articles included in the descriptive synthesis (n= 22)

Citation	Population			Variables			
	ICU	Various	Healthy	Light	Noise	Temp.	Humidity
(Bernhofer, Higgins, Daly, Burant, & Hornick, 2014)		x		x			
Boyko et al., 2017)	x				x		
(Buxton et al., 2012)			x		x		
(Dennis, Lee, Woodard, Szalaj, & Walker, 2010)	x			x	x		
(Elbaz et al., 2017)	x				x		
(Engwall, Fridh, Johansson, Bergbom, & Lindahl, 2015)	x			x			
(Engwall et al., 2017)	x			x			
(Fanfulla et al., 2011)		x		x	x		
(Fukuda et al., 2001)		x		x			
(Gabor et al., 2003)	x				x		
(Hinds et al., 2007)		x			x		
(Li, Wang, Vivienne Wu, Liang, & Tung, 2011)	x				x		
(Linder & Christian, 2012)		x		x	x	x	
Litton et al., 2017)	x				x		
(Meehan, O'Brien, Marine, & Curley, 2018)	x				x		
(Monsén & Edéll-Gustafsson, 2005)	x				x		
(Oliveira, Gomes, Bacelar Nicolau, Ferreira, & Ferreira, 2015)		x		x	x	x	
(Park et al., 2014)		x			x		
(Persson Waye, Elmenhorst, Croy, & Pedersen, 2013)			x		x		
(Samsam & Cullen, 2005)	x				x		
(Snyder-Halpern, 1985)			x		x		
(Stanchina, Abu-Hijleh, Chaudhry, Carlisle, & Millman, 2005)			x		x		

Hospital Environmental Factors and Sleep

Studies overwhelmingly investigated the impact of noise [27-30, 33, 35-47]; increased sound throughout the evening adversely impacted sleep outcomes [35-38, 40-44, 46].

Of the studies investigating the impact of light [27, 29, 31-34, 37, 41] on inpatient sleep quality, only two focused on lighting overnight, and not surprisingly, increased light exposure overnight adversely impacted sleep outcomes [37, 41].

Two studies investigated the impact of temperature on inpatient sleep quality [37, 41] with inconclusive findings.

The Current Study

Researchers from The Hopkins Centre, and the Gold Coast University Hospital Neurorehabilitation Unit have collaborated on a study to determine the way in which hospital environmental determinants (noise, light, temperature, and nursing routines) impact inpatient sleep quality and quantity.

Data collection is currently underway and environmental nodes are collecting light, noise, temperature and humidity data.

Noise data over a 7 day period has been aggregated for presentation.

GUIDELINES FOR COMMUNITY NOISE

Edited by

Birgitta Berglund
Thomas Lindvall
Dietrich H Schwela

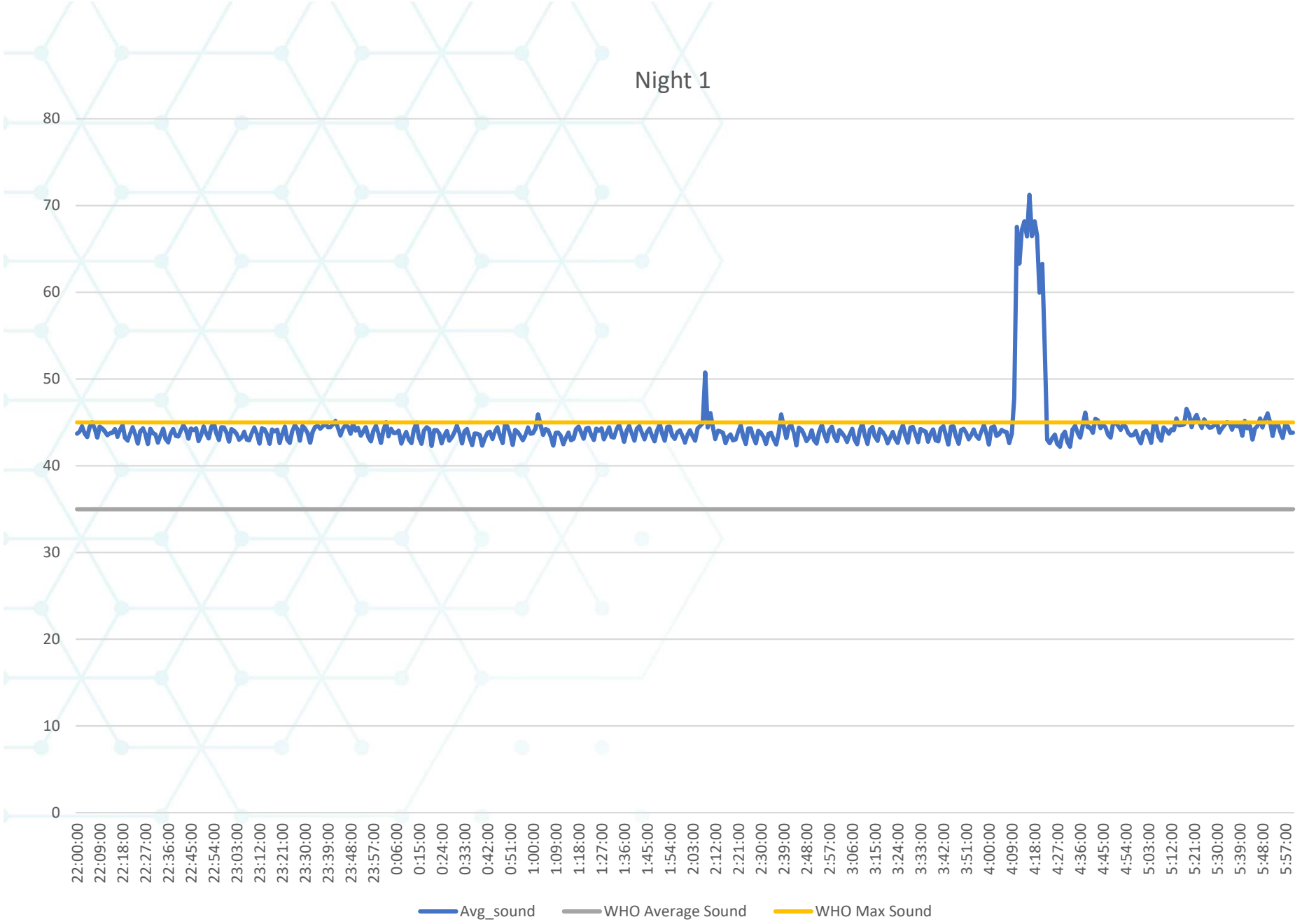
This WHO document on the *Guidelines for Community Noise* is the outcome of the WHO-expert task force meeting held in London, United Kingdom, in April 1999. It bases on the document entitled "Community Noise" that was prepared for the World Health Organization and published in 1995 by the Stockholm University and Karolinska Institute.

World Health Organization, Geneva
Cluster of Sustainable Development and Healthy Environment (SDE)
Department for Protection of the Human Environment (PHE)
Occupational and Environmental Health (OEH)

4.3.3. Hospitals

For most spaces in hospitals, the critical effects of noise are on sleep disturbance, annoyance and communication interference, including interference with warning signals. The LAmax of sound events during the night should not exceed 40 dB indoors. For wardrooms in hospitals, the guideline values indoors are 30 dB LAeq, together with 40 dB LAmax during the night. During the day and evening the guideline value indoors is 30 dB LAeq. The maximum level should be measured with the instrument set at "*Fast*".

Since patients have less ability to cope with stress, the equivalent sound pressure level should not exceed 35 dB LAeq in most rooms in which patients are being treated or observed. Particular attention should be given to the sound pressure levels in intensive care units and operating theatres. Sound inside incubators may result in health problems, including sleep disturbance, and may lead to hearing impairment in neonates. Guideline values for sound pressure levels in incubators must await future research.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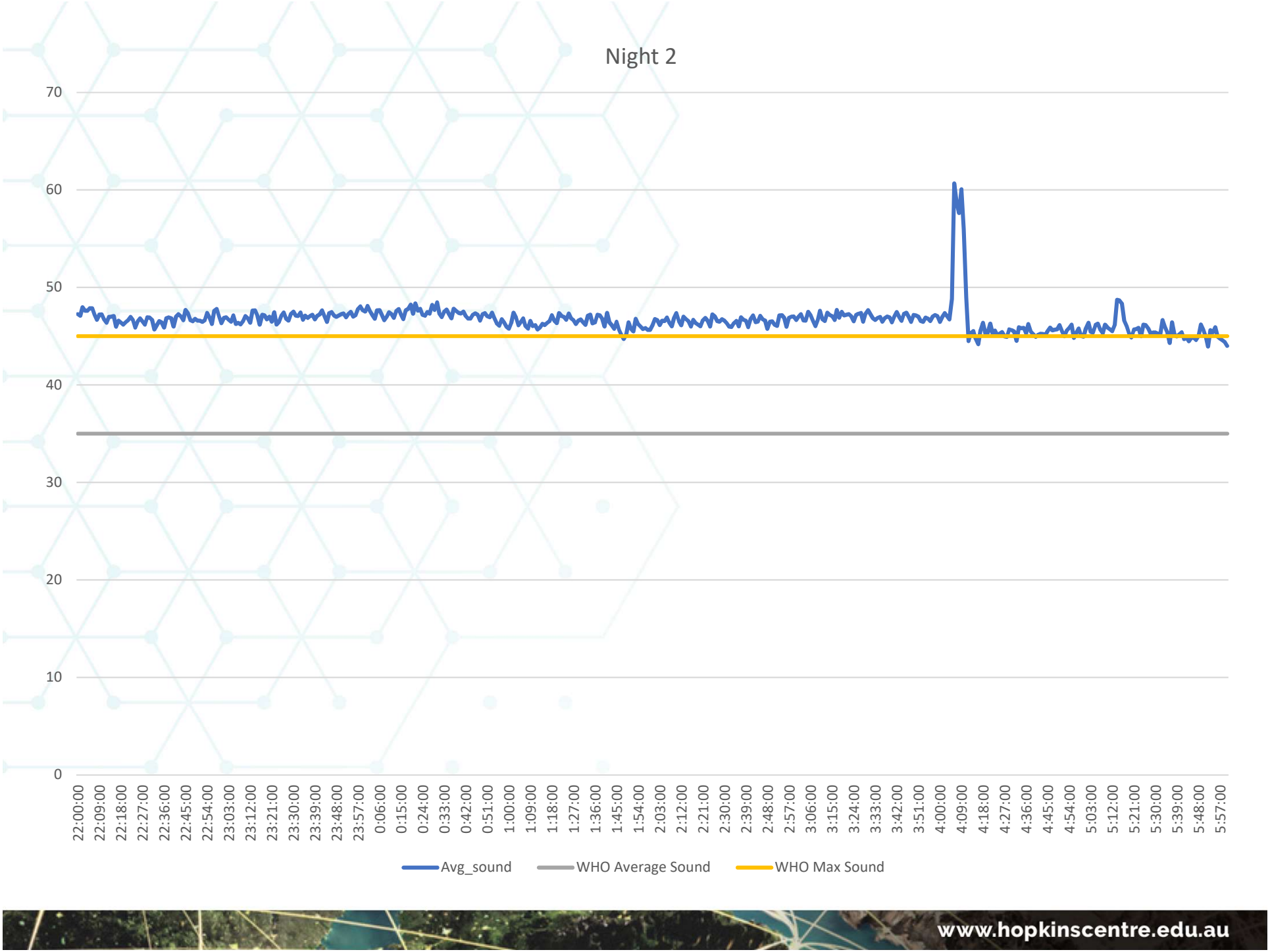
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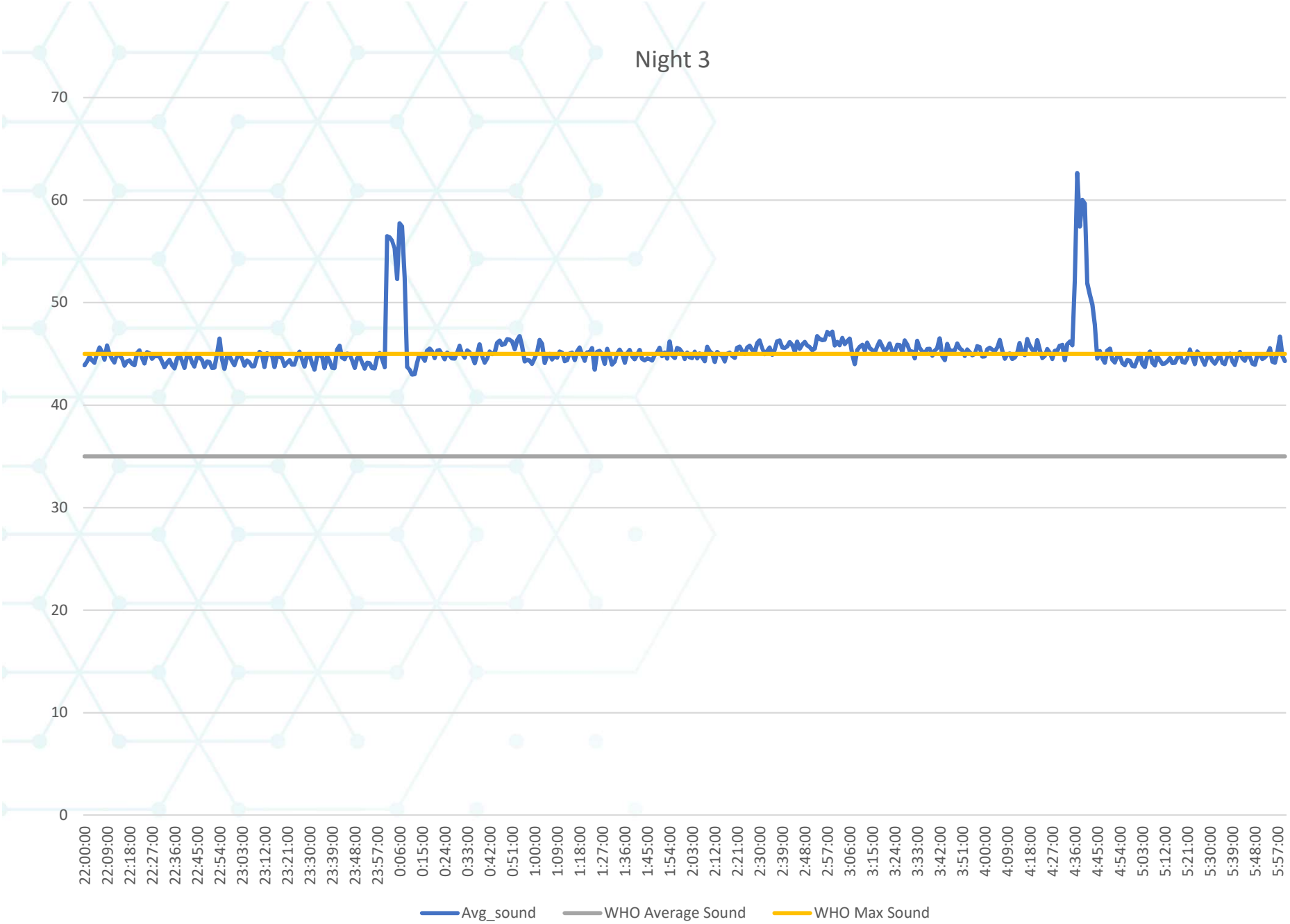
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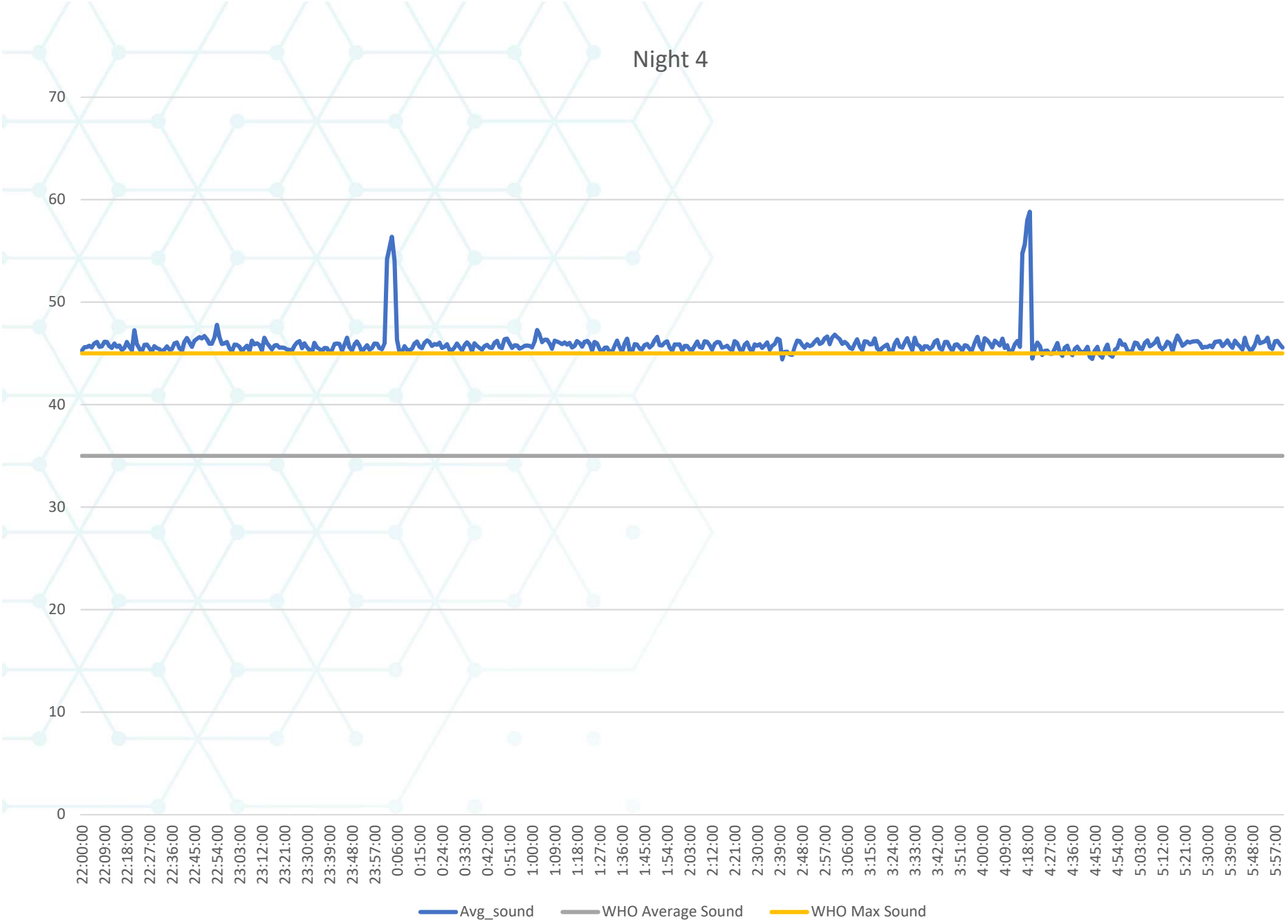
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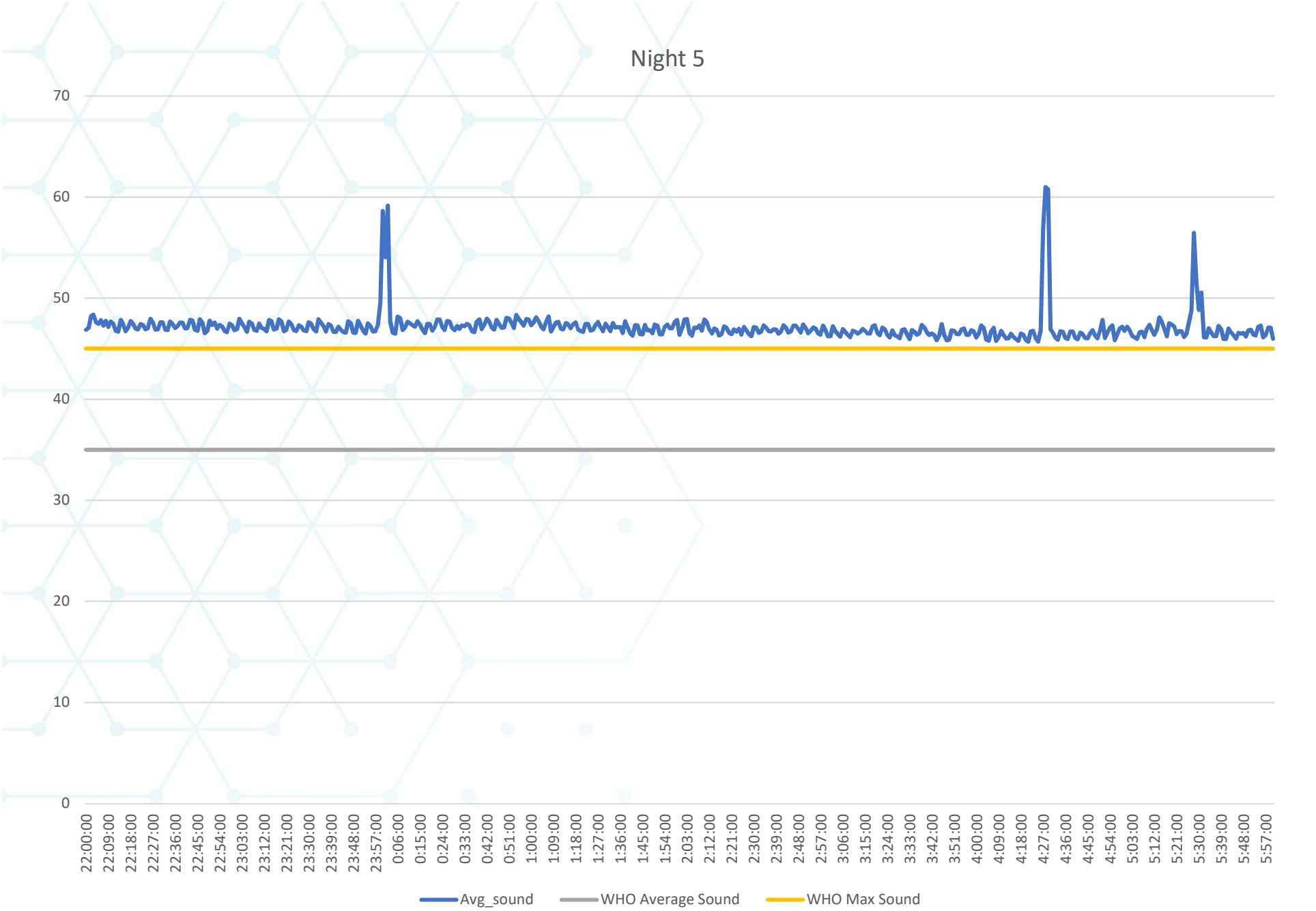
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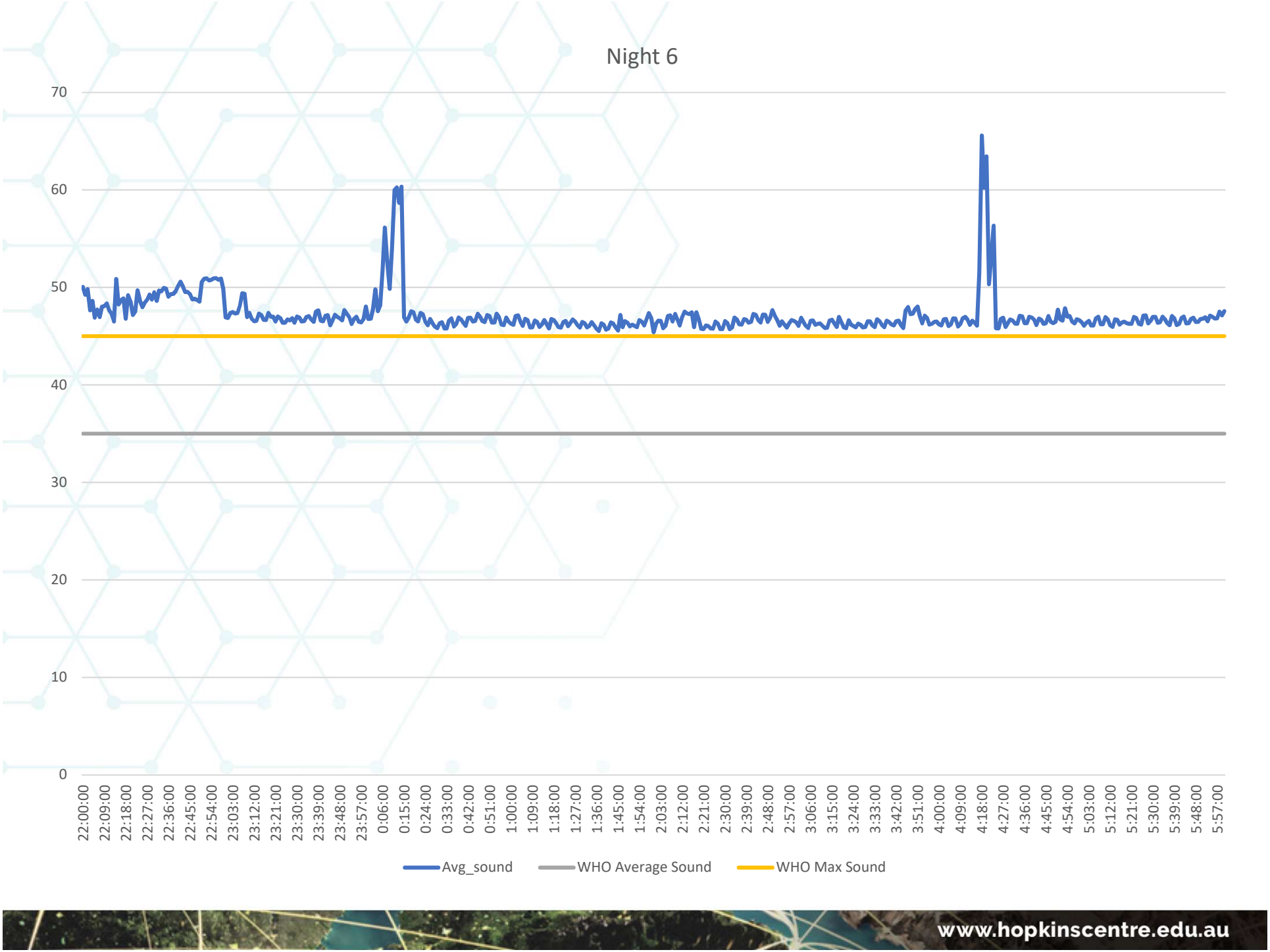
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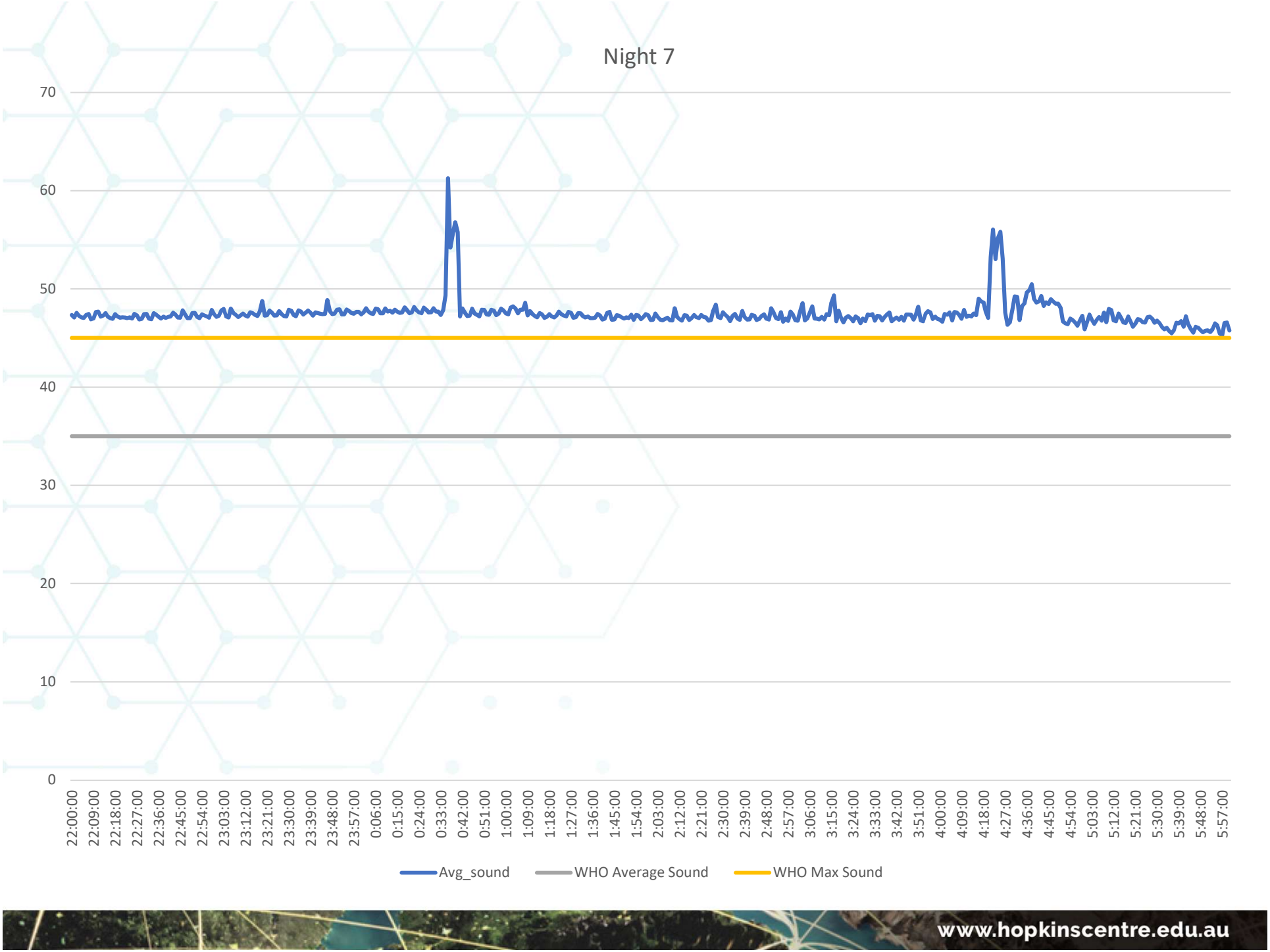
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Original Article

Environment in pediatric wards: light, sound, and temperature

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ABSTRACT

The mutual relationship between sleep and disease is well known, becoming more relevant whenever the disease leads to hospitalization. We intend to describe patterns of environmental factors of some pediatric wards, and to verify if these are in line with those recommended. As a secondary aim, we characterize sleep quality during hospitalization.

Methods: Five pediatric wards of a tertiary-level hospital were included. Light, sound, and temperature were measured and assessed through descriptive statistics. The following recommended values were considered: maximum light 100 Lux, maximum sound 45 dB, and optimal temperature 20–24 °C. A questionnaire was prepared to assess children's sleep, and it was completed by a caregiver.

Results: Light values were within the desirable limits for 86% of evaluated time. In all wards, the intensity of sound was much higher than desirable, being above 45 dB during 85% of evaluated time. The temperature was above 24 °C during 78% of total time.

Based on 34 answered questionnaires (out of 50 distributed), almost half of the respondents believe that sleep quality and restlessness are worse at the hospital. Most children slept for a longer time at home. Eighteen children awoke more times at the hospital, and those awakenings were mostly attributed to noise.

Conclusions: The sound and temperature were higher than recommended. The different values between these wards may be due to different levels of care, but this shows that there are no standard rules on this matter. A worse quality and shorter duration of sleep at hospital were reported. Comprehensive studies are necessary to evaluate the impact of environmental factors on disease recovery.

Table 3
Global sound values on room and hallway, distributed by ward and by day period.

		dB - Mean (±SD; range)		
		(7 am to 8 pm)	(8 pm to 11 pm)	(11 pm to 7 am)
Ward A	Room	62.3 (±8.5; 36.9–84.1)	63.0 (±6.8; 45.5–78.2)	44.7 (±7.5; 32.3–74.8)
	Hallway	59.6 (±5.9; 37.6–79.9)	57.9 (±5.7; 43.0–77.5)	44.1 (±5.6; 34.2–69.9)
Ward B	Room	59.2 (±7.4; 37.5–77.5)	58.1 (±8.2; 38.2–75.7)	43.4 (±5.3; 35.0–69.5)
	Hallway	61.2 (±4.2; 44.6–76.8)	59.2 (±6.0; 43.3–76.8)	48.2 (±4.8; 38.5–63.4)
Ward C	Room	54.8 (±6.6; 42.8–67.9)	57.9 (±5.3; 46.9–66.7)	45.2 (±3.9; 42.4–61.8)
	Hallway	65.2 (±4.0; 53.6–74.8)	62.0 (±5.2; 52.7–76.8)	53.5 (±2.5; 49.9–65.4)
Ward D	Room	*ERROR*	*ERROR*	*ERROR*
	Hallway	61.7 (±3.4; 46.8–75.6)	58.3 (±2.5; 52.9–65.6)	47.6 (±4.7; 38.2–66.0)
Ward E	Room	60.6 (±5.9; 48.7–82.0)	59.7 (±4.6; 52.9–75.5)	54.9 (±5.1; 42.7–63.0)
	Hallway	62.4 (±3.4; 47.4–69.1)	59.8 (±2.9; 51.3–66.1)	50.7 (±4.0; 42.7–63.0)

Characteristics of the Nighttime Hospital Bedside Care Environment (Sound, Light, and Temperature) for Children With Cancer

Background: Children with cancer must cope not only with their disease and its treatment but also with the environment in which treatment is given. The intensities of sound and light levels required to perform necessary patient care may result in a disruptive nighttime care environment. **Objective:** The purpose of this study was to describe nighttime patterns of environmental factors, sound, light, and temperature levels, at the bedside of children with cancer receiving inpatient chemotherapy. **Methods:** Participants were 15 school-aged children receiving chemotherapy on an inpatient pediatric oncology unit. Sound, light, and temperature in the child's room were measured continuously using a digital-sound pressure-level meter and an external channel data logger. **Results:** Mean nighttime sound levels were 49.5 (SD, 3.1) dB (range, 34.6–84.8 dB). Sound and light intensities were greatest early in the shift and decreased through the night. A basic mixed linear model identified significant main effects of time of night for both sound ($F = 50.42$, $P < .01$) and light ($F = 12.43$, $P < .01$). **Conclusions:** Study findings identified a bedside care environment with persistently elevated sound levels and abrupt increases in sound intensity throughout the night. Such a disruptive

Main Points

- Preliminary findings suggest that noise levels overnight are above WHO guidelines.
- These noise levels are comparable to noise levels in ICU settings.
- The study will establish the impact of noise and additional environmental factors on the sleep of rehabilitation unit inpatients.

Thank you

Kindly contact me with any questions that you may have:

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