Preventing sleep disturbance using a qualitative approach

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Abstract - Noise is a significant cause of sleep disturbance, and affects the overall sleep quality, which can result in physiological effects including cardiometabolic, endocrine, cognitive, and psychiatric impacts. While environmental noise, particularly from road traffic is a common cause of sleep disturbance, other sources of noise such as nearby industries or neighbouring leisure activities can also have similar effects. Recommendations in health guidelines are typically expressed using metrics such as L_{night}, $L_{Aeq,T}$ and L_{den}, including when sleep is the considered health outcome. However, these metrics represent an average noise exposure over the measurement period and are limited in representing the risk of sleep disturbance associated with transient noise or sporadic loud events. In this context, it is relevant to qualitatively consider the risks to the environmental value of sleep, as opposed to solely relying on criteria and metrics. This paper discusses how a person/facility (duty holders) responsible for noise emissions or anyone generating noise could consider qualitatively, the value of sleep and implement preventative measures that are not necessarily reliant on quantitative metrics.

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2 INTRODUCTION

There have been several studies aimed at understanding the impacts of noise on overall sleep quality, which have then informed the development of criteria for assessing sleep disturbance. This includes the systematic reviews of scientific evidence that supported the development of the World Health Organization (WHO) guidelines, such as *WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep* (Basner & McGuire, 2018), and the updates to these reviews which include (Smith, Cordoza, & Basner, 2022). There is no doubt that these review papers have their merits and are necessary to gain an understanding and appreciation of the effects of noise on sleep.

However, when it comes to assessing sleep disturbance, it is difficult to have one or two numerical descriptors, that can cover the broad spectrum of responses and reactions to noise during the night. Recommendations in health guidelines are typically expressed using single-number metrics such as L_{night}, $L_{Aeq,T}$ and L_{den}, including when sleep is the considered health outcome. However, these may not be appropriate methods to assess the impacts associated with transient and sporadic events. This is the case for example when the noise source is construction noise or road traffic noise with heavy vehicles (Buret, Just, & Mosley, 2024) (Brown A. L., 2014) (Brown A. L., 2013). Conversely there have been studies aimed at considering the number of events per night, at a particular noise level (Öhrström, Martin, & Rylander, 1990). However, this study by Öhrström, et al. showed that

at various noise levels, depending on the individual's sensitivity to noise, there may be a different number of events that negatively influence sleep quality, and cause sleep disturbance. It is not uncommon for regulators to consider a guideline or criterion that considers, the emergence of noise events compared to the prevailing background noise. However, these guidelines may tend to not consider, or limit, the number of such events which can all present a risk of to sleep disturbance.

This paper does not aim to provide a review of criteria for sleep disturbance or discuss the guidelines adopted by regulators across various jurisdictions in Australia (and worldwide). Instead, it aims to emphasise the importance and need of a qualitative approach for sleep disturbance focussed on prevention. Using a risk-based approach, sometimes clinically referred to as the risk matrix approach (Lemmens, Lopes van Balen, Roselaers, Scheepers, & Spaanderman, 2022) requires consideration of both the likelihood or probability of the event happening as well as the consequence or impact. In this case, assuming the consequence is sleep disturbance, the risk is minimised by reducing the likelihood. This is where a preventative approach is primordial to reduce the likelihood of sleep disturbance, which then enables the duty holder (or noise generator) to eliminate, or minimise the risk, so far as reasonably practicable. For this reason, the paper will outline a possible framework for preventing sleep disturbance focused on the risk to environmental values.

3 EPA VICTORIA POLLUTION REPORTS

In order to develop a preventative and qualitative framework, it is relevant to gain an understanding of the type of noise sources that operate during the nighttime, particularly those that have resulted in sleep disturbance (as reflected in pollution reports received by or referred to EPA Victoria).

The types of noise sources commonly mentioned in these pollution reports include:

- air conditioning units (residential and commercial)
- outdoor Music/entertainment venues
- restaurants
- freight terminals
- waste management and recycling facilities
- landfills
- bus depots
- road traffic noise
- heavy vehicles - truck noise (braking, idling and pass-bys)
- construction noise.

To understand how prevalent sleep disturbance complaints are, EPA Victoria's Data Analysis (DA) team reviewed and analysed noise pollution reports and associated impacts on people as reported to EPA between May 2021 and September 2024. A list of keywords related to sleep disturbance were used by DA to extract information from the pollution reports. Keywords included: "sleep", "insomnia", "awake", "woken", "wake", "woke", "restless", "rest", "deprivation", and "nightmare".

There was a total of 23,382 noise pollution reports received by EPA Victoria (from May 2021 to September 2024). However, some of these were dealt with by other authorities such as councils or the police and were hence omitted from the analysis. The remaining 18,119 EPA related noise pollution reports were analysed and among these, 7,129 reports matched at least one of the search keywords, representing approximately 40% of the total. It should also be noted that 2,263 of the non-EPA related reports also contained keywords associated with 'sleep'.

Figure 1 below shows the above-stated statistics graphically, categorising the pollution reports into various categories, such as “commercial” or “industrial” premises, etc.

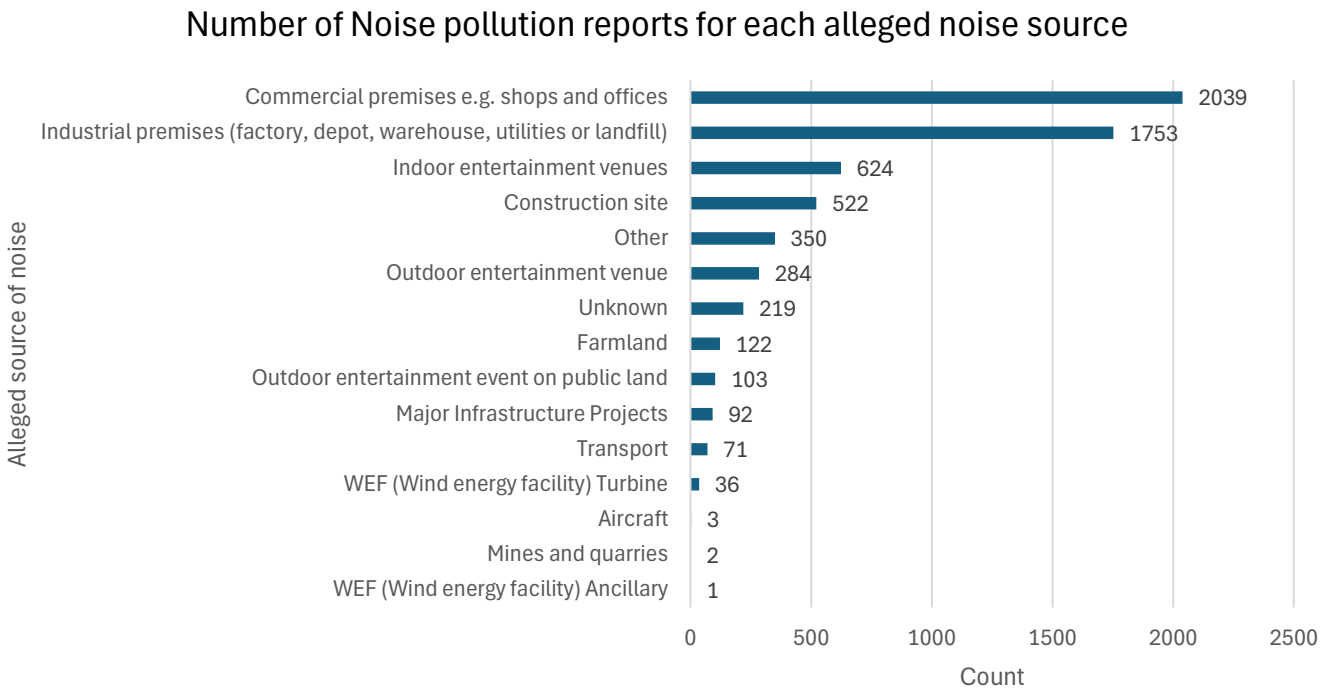

Figure 1 Bar plot illustrating the number of counts for each alleged noise source containing the keywords related to sleep disturbance

It is evident that sleep disturbance, and other night time impacts (as per the keywords found in the pollution reports) of noise are prevalent, representing almost 40% of pollution reports received by EPA. Of the 18,119 reports, over 3,500 were from commercial, industrial and trade premises. This highlights a need for consideration of noise mitigation measures, to reduce the impacts of noise on sleep, particularly sleep disturbance. As discussed above, while developing criteria may provide context to an assessment of noise during the nighttime, it is of greater value to consider a risk-based approach, focusing on eliminating, or minimising the risk to the environmental value of sleep at night. This is also consistent with the intent of the Victorian environment protection framework, discussed in more detail in the following section.

4 QUALITATIVE APPROACH TO SLEEP DISTURBANCE

A qualitative approach to preventing sleep disturbance can be enable considering the obligations and instruments under the *Environment Protection Act 2017* (Vic) (the Act), and in particular the general environmental duty (GED) and Environment Reference Standard (ERS).

It should be noted that the framework for environmental noise is not limited to GED and the ERS, but also includes an obligation to not emit, or permit to emit, unreasonable noise. While this will not be discussed here for brevity, specific guidance on unreasonable noise can be found in the *Unreasonable noise guidelines*. (EPA Victoria, 2023)

4.1 Environment Reference Standard

The Environment Reference Standard (Victoria State Government, 2021) is a legislative instrument made under the Environment Protection Act 2017 (Victoria State Government, 2021). It defines and identifies the environmental benchmark to be achieved and maintained in Victoria and defines environmental values that describe environmental and human health outcomes.

The ERS covers four aspects of Victoria's environment: ambient air, ambient sound, land, and water (surface water and groundwater). Table 1 below reproduces the environmental values of the ambient sound environment as set out in Part 3 of the ERS.

Table 1 ERS Environmental values for ambient sound

Environmental value	Description
Sleep during the night	An ambient sound environment that supports sleep at night
Domestic and recreational activities	An ambient sound environment that supports recreational and domestic activities in a residential setting
Normal conversation	An ambient sound environment that allows for a normal conversation indoors without the need to raise voices
Child learning and development	An ambient sound environment that supports cognitive development and learning in children
Human tranquillity and enjoyment outdoors in natural areas	An ambient sound environment that allows for the appreciation and enjoyment of the environment for its natural condition and the restorative benefits of tranquil soundscapes in natural areas
Musical entertainment	An ambient sound environment that recognises the community's demand for a wide range of musical entertainment

4.2 The General environmental duty

The ERS is supported by the obligations under the general environmental duty by assessing the risk to the environmental value of sleep at night. The GED requires any person engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste to minimise those risks so far as reasonably practicable. The interaction of the ERS with the GED is outlined in Section 2.3.3 of EPA Publication 1992 *Guide to the Environment Reference Standard* (EPA Victoria, 2021). With the ERS framework and GED, duty holders need not rely on a criterion to determine the impact of their noise source/facility on the nearby community. Instead, proactive measures should be taken to ensure the risk is minimised so far as reasonably practicable.

In order to do this, it is paramount to review the design and operation of the facility and understand the risk factors. Certain risk factors of the facility may increase or decrease the likelihood of the noise source causing harm (sleep disturbance) and therefore play a vital role in understanding the level of risk a facility might pose to the environmental value of sleep during the night. Examples of these risk factors include (this is not an exhaustive list):

- location of the facility/noise source (Urban or rural area)
- proximity to sensitive areas

- proximity to other noise sources
- time of day
- type of activity
- type and number of noise sources
- presence of low frequency noise or noise character (tonal, intermittent or impulsive)
- noise emitted and variability of the noise – vehicle movements, bangs and crashes (compared to continuous machinery noise).

Once the risk factors such as those presented above have been identified and considered, the likelihood of sleep disturbance occurring due to the noise source/facility, and therefore the risk, can be minimised by implementing mitigation measure, in line with the GED and ERS framework. Some examples of these measures include (this is not an exhaustive list):

- reducing the operating hours of the business to avoid night time works/operation.
- reducing capacity/ operational load during the night time to reduce noise impacts
- designing facilities to site noise sources away from residential receivers
- designing and proactively implementing noise control regardless of the noise limit, or criteria
- considering alternative haulage routes, particularly during the night time to avoid passing through residential areas
- maximising distances from the noise source to receiver
- managing and implementing good driver/operator behaviour, particularly for trucks or heavy machinery operating during the night time.
- ensuring plant items and vehicles are well maintained, with functioning mufflers, to avoid noisy accelerations/ decelerations and tailgate rattling
- ensuring effective communication with the community so that they are aware of any noisy works (unavoidable or managed impact construction works) and are provided options to make alternative arrangements such as respite breaks or offers of alternative accommodation.

Implementing measures such as the above regardless of a criterion and ensuring the obligations under the GED are satisfied, is an example of how a risk-based preventative and qualitative approach can be used to minimise the risk to the environmental value of sleep during the night, so far as reasonably practicable.

5 CONCLUSIONS

This paper highlighted a qualitative approach to preventing sleep disturbance by using tools available within the Victorian EPA framework. This includes consideration of the environmental value of sleep at night, as defined in the ERS, to perform a risk assessment and implement measures so far as reasonably practicable, consistent with the obligations under the GED. This ensures that a criterion to quantify the level at which sleep disturbance occurs is not necessary to be developed or implemented. Instead, the onus is on the duty holder/noise generator to consider qualitatively, the environmental value of sleep during the night, and implement measures proactively to minimise the likelihood of sleep disturbance occurring, thereby minimising the risk so far as reasonably practicable.

6 ACKNOWLEDGEMENTS

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7 REFERENCES

Environment Protection Act 2017 (Vic). https://www.legislation.vic.gov.au/in-force/acts/environment-protection-act-2017

Basner, M., & McGuire, S. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. *Int J Environ Res Public Health*, 14;15(3):519.

Brown, A. L. (2013). Issues in the measurement of sleep-related noise. *Proceedings of Acoustics 2013 – Victor Harbor.* Victor Harbour, South Australia, Australia: Australian Acoustical Society.

Brown, A. L. (2014). An overview of concepts and past findings on noise events and human response to surface transport noise. *INTERNOISE 2014 - 43rd International Congress on Noise Control Engineering: Improving the World Through Noise Control.*

Buret, M., Just, E., & Mosley, W. (2024). The Victorian Environment Reference Standard and how it has been considered and applied in noise assessments. *Acoustics 2024 - Acoustics in the sun, 6-8 November 2024.* Gold Coast, Queensland, Australia: Australian Acoustical Society.

EPA Victoria. (2021). Publication 1992. *Guide to the Environment Reference Standard*. Melbourne, Victoria, Australia.

EPA Victoria. (2023, May 1). *Unreasonable noise guidelines*. Retrieved from EPA Victoria: https://www.epa.vic.gov.au/for-business/find-a-topic/noise-guidance-for-businesses/unreasonable-noise-guidelines

Lemmens, S., Lopes van Balen, V., Roselaers, Y., Scheepers, H., & Spaanderman, M. (2022). The risk matrix approach: a helpful tool weighing probability and impact when deciding on preventive and diagnostic interventions. *BMC Health Services Research, 22*, 218.

Öhrström, E., Martin, B., & Rylander, R. (1990). Effects of noise during sleep with reference to noise sensitivity and habituation. *Environment International*, 477-482.

Smith, M. G., Cordoza, M., & Basner, M. (2022). Environmental Noise and Effects on Sleep: An Update to the WHO Systematic Review and Meta-Analysis. *Environ Health Perspect*, 130(7):76001.

State of Victoria. (2021, 05 26). Environment Reference Standard. *Victoria Government Gazette, No. S245 (26 May 2021)(amended by No. S158, Gazette 29 March 2022)*. Melbourme, Victoria, Australia.

Victoria State Government. (2021, 07 1). Environment Protection Act. *No. 51 of 2017*. Melbourne, Victoria, Australia.

Victoria State Government. (2021, 05 26). Environment Reference Standard. *Victoria Government Gazette, No. S245 (26 May 2021)(amended by No. S158, Gazette 29 March 2022)*. Melbourme, Victoria, Australia.