# Comprehensive noise assessments are needed to understand health impacts and inform public policies on noise metrics in the United States and beyond

Jamie Banks

Quiet Communities, Inc., Concord, MA USA

Corresponding author's email address: jamie@quietcommunities.org

## ABSTRACT

Noise, defined as unwanted and/or harmful sound, has many attributes that need to be considered to fully understand its impact on the health and well-being of individuals and communities. In the United States, the A-weighted decibel (dBA) is the most common metric used to characterize environmental noise owing to its simplicity and widespread use in measurements and regulations for occupational noise. But dBA alone does not tell the story of the broader societal impacts of noise on the health and well-being of communities. Supplemental and/or alternative metrics, such as described in the historical work of Fastl and Zwicker, that account for aspects such as frequency band distribution, duration, and pattern are needed to fully assess the auditory and non-auditory impacts of noise from sources including transportation (air, rail, road), construction, and landscape maintenance. For example, a head-to-head study of gas-powered and battery electric-powered leaf blowers showed that, despite having the same ANSI noise rating, a strong low frequency component in the noise from a gas-powered blower enabled harmful noise levels to travel further and more readily penetrate buildings, increasing the breadth of its impact upon community health and well-being compared with the battery-powered blower. This example and another from aviation will be used to discuss the critical role alternative and supplemental metrics must play in understanding health impacts and informing public policy decisions in the US and other countries that have sought to standardize on the dBA approach.

Key Words: Noise, health, metrics, community, aviation, outdoor power equipment

## INTRODUCTION

Noise is unwanted and/or harmful sound (1-2). Protecting the public from the harms of environmental noise requires effective public policy informed by evidence from medical and public health research. In the US, the health of more than 100 million people in the United States is estimated to be at risk from everyday noise in excess of 55 A-weighted decibels (dBA) (3). Sources include but are not limited to air, rail, and road transportation, noisy recreational vehicles such as motorcycles and all-terrain vehicles, industrial machinery, and outdoor power equipment. Abundant research demonstrates that loud noise can damage hearing, diminish learning and productivity and contribute to cardiovascular, cerebrovascular, and metabolic diseases, psychological disorders, and premature mortality through stress-mediated mechanisms (4-5) that have been known for decades.

Effective public policies on noise require an understanding of the problem in terms of the nature of the noise, the impacts, the scope of harm, and the effectiveness of interventions. Appropriate methods and metrics, informed by medical, legal, and policy professionals, are critical to this

effort. Furthermore, these methods and metrics need to be interpreted to convey the impacts on health and well-being and the scope of those impacts to the public, professionals, and policy makers so that informed decisions can be made.

The A-weighted decibel (dBA) is the most common metric used in the United States to characterize environmental noise. The dBA may be a useful metric for assessing the risk of auditory damage, but alone, is often inadequate in communicating the broader impacts of noise on the health and well-being of communities (7-9). Supplemental and/or alternative metrics are needed to fully assess the impacts of noise and understand what needs to be done to protect auditory and non-auditory. Although abundant work has been done on this subject for over 50 years, it is unknown to most federal, state, and local policy makers in the US, in large part due to the defunding of the federal noise control program in 1981. Without the ability to fully comprehend the problem, it may be impossible to develop effective solutions and policies designed to protect people from harm.

## IT'S NOT JUST DECIBELS

When Americans think of noise, they immediately think of loudness, at least in the way that it is used in common parlance and as measured in decibels. But noise is not just about decibels of loudness. Loud noise can be pleasurable or intolerable depending on the source. Think of a violin concerto and a power drill – both at 85 dBA. The dBA metric does not differentiate the human response (10). Other attributes of the noise must be considered that contribute to stress and stress-mediated health problems. These attributes include duration, pattern, sharpness, roughness, repetition, tonality, sound frequency, time of exposure (i.e., day or night), and human response, aspects well-delineated in the historic work of FastI and Zwicker (11). For example, is the noise a high-pitched squeal or a low-pitched vibration? How far does it travel? Does it come through walls and windows? Is it disrupting sleep? Is it possible to get away from it? All these attributes factor into how noise impacts human health and the scope of those impacts, i.e., the number of people affected in a given community and the seriousness of those impacts.

In terms of health, repeated noise exposure is known to prime the vasculature for endothelial harm (12). Nighttime noise has been found to be especially harmful regarding risk of hypertension (13). Loudness thresholds need to be adjusted need to account for low frequency components known to be especially harmful to non-auditory health (8,14).

Assessing those attributes requires other metrics, such as those listed in Table 1 below. Two examples will be discussed in greater detail to illustrate the principles being discussed.

**Table 1.** Metrics of sound measurements

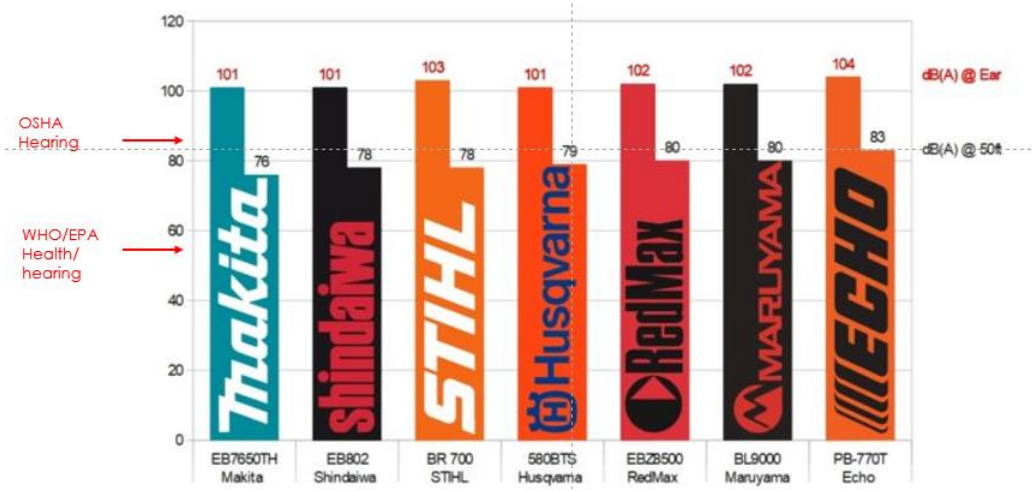
| **Parameter** | **Measure** | **Unit of Measure** |
|---|---|---|
| Loudness | Sound energy | Decibel |
| Frequency | Vibration | Hertz |
| Pattern | Fluctuation | Continuous, repeating, episodic, impulse |
| Duration | Length of time | Hours, minutes, seconds |
| Tonality | Hum, hiss, screech, drone | Octave band analysis |
| Response | Subjective, e.g., pleasure, annoyance | Sone |
| Scope | Number of people affected | Distance traveled |

## EXAMPLE 1. LEAF BLOWERS

The gas/petrol-powered leaf blower (GLB) is the tool of choice for many land care professionals in the United States as well as many American homeowners. The ubiquitous presence of GLB sound, frequency of exposure, loudness and nature of the sound, constant throttling up and down, and simultaneous use of multiple machines are causing distress in communities across the country. Over 200 municipalities in the US have enacted some type of restriction on the use of GLBs and many more are trying (15).

Manufacturers are required to disclose dBA sound pressure measurements at 50 feet from a machine at full throttle according to the standard set by the American National Standards Institute (16). Some manufacturers also disclose dBA at the operator's ear. As shown in Figure 1 below, popular models of commercial GLBs can exceed 100 dB at the operator's ear and up to 83 dB at 50 feet. Run for hours at a time, these levels exceed the average 85 dBA threshold set by the US Occupational Safety and Health Administration (OSHA) to protect hearing health (17) and exceed average community outdoor noise levels of 55 dBA set by the World Health Organization (WHO) and US Environmental Protection Agency (EPA) to protect the auditory and non-auditory health of the public (8, 9, 18).

**Figure 1. Noise levels produced by popular models of commercial gas-powered leaf blowers**




Source: OPE Review, December 2017; OSHA and WHO/EPA levels added by J Banks.

Acoustic studies find that a strong low frequency component in GLB noise allows noise 55 dBA and higher to travel over long distances and readily penetrate through windows, distinguishing it from the noise produced by battery electric blowers (19-21); this strong low frequency component is also characteristic of other internal combustion engines (7, 14). Because low frequency noise is especially hazardous to health (8), it is recommended that dBA thresholds be adjusted downwards or that alternative decibel metrics be used, e.g., C-weighted decibels.

A head-to-head study finds that even when rated at the same dBA level at 50 feet, the sound from a GLB carries further and more readily penetrates inside homes and buildings compared with the sound from the battery electric blower (19). Figure 2 illustrates what that means in terms of scope of impact of > 55 dBA noise in a hypothetical urban community of 91 homes (assuming 1/8-

acre/0.5-hectare zoning [~5,500 square feet/511 square meters] and an 800-foot/244-meter diameter around the point source).

**Figure 2.** Battery electric vs gas-powered leaf blower: Number of homes affected by noise >55 dBA (pink shaded area)

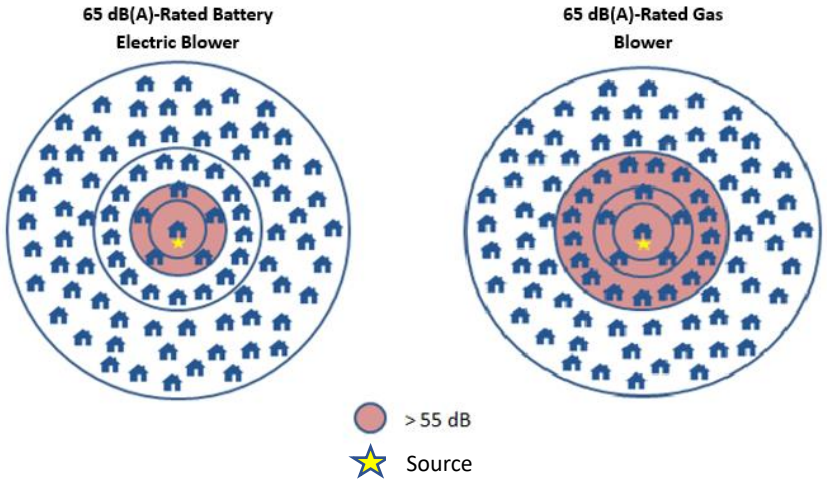



Figure 2 shows that despite the same manufacturer noise rating of 65 dBA, 6 homes are affected by noise >55 dBA when the battery electric blower is operated, while 23 homes are affected with noise >55 dBA when the GLB is operated.

The knowledge gained by understanding the contribution of frequency spectrum to community impact can facilitate decisions to base policy on manufacturers' ratings alone or on understanding the differential impact that the combination of dBA and frequency spectrum have on communities and the related scope of harm.

**EXAMPLE 2. AVIATION METRICS**

The US Federal Aviation Administration (FAA) uses the 65 dBA day-night level (DNL) to define "significant impact" and compatibility with residential land use, which relies on the concept of "annoyance" as the only meaningful impact of noise (22). The 65 DNL metric is based on 12.3% of people being highly annoyed and is not related directly to today's understanding of the health impacts of noise (22-23). The FAA itself is unable to explain how it decided that 65 dBA DNL was compatible with residential land use. The number of Americans estimated to be living within the 65 DNL aviation contours is less than 500,000.

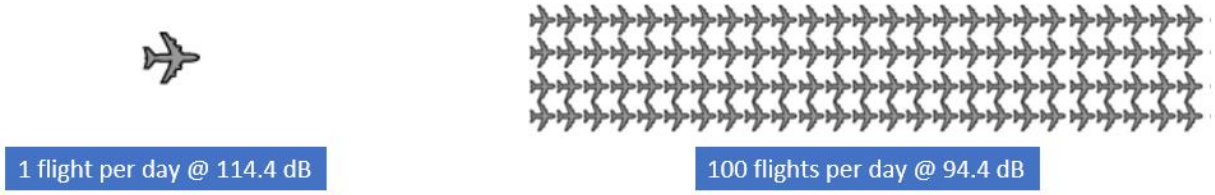
The 65 DNL is at odds with national (US Environmental Protection Agency) and international (World Health Organization) levels that are 2-4 times lower (9, 18) and at odds with the science showing that harm occurs at this level. Lowering the DNL to 55 as has been employed in other countries, would substantially increase the number of Americans living in areas of significant impact and residential incompatibility (24).

Despite the fact that jet engine noise has been reduced, results from the FAA's Neighborhood Environmental Survey, published in February 2021, showed that many more people are highly

annoyed by aircraft noise than was previously thought (25). And as noted, high levels of annoyance are indicative of stress-mediated responses and increased risk of disease. At a minimum, if the same logic were applied to a new average metric, the DNL indicative of "significant impact" and "residential compatibility" would be well below 50 DNL, and more in line with World Health Organization guidelines on environmental noise (9).

However, even a lower DNL would not account for factors known to adversely affect health, like duration, repeat exposure, or low frequency components of aircraft noise. As shown below in Figure 3, an average – in this case, 65 dBA DNL – can mean 1 flight per day at 114 dB or 100 flights per day at 94 dB (26). In other words, an average metric does not adequately convey the impact on health.

**Figure 3.** Example of two situations yielding 65 DNL




Adapted from US General Accounting Office, Aircraft Noise: FAA Could Improve Outreach Through Enhanced Noise Metrics, Communication, and Support to Communities. GAO-21-103933. September 28, 2021 (25).

It is widely agreed in the United States that the 65 dBA DNL metric needs to be replaced, as indicated in this excerpt from a letter sent by members of the US Congress to the previous FAA Administrator saying:

> *Fundamentally, … the method the FAA uses to measure aircraft noise is deeply flawed…If these metrics are not reliable, that calls into question the FAA's entire framework of regulations and programs to reduce aircraft noise.* -- US Congressional Quiet Skies Caucus (25 members) letter to FAA Administrator Steve Dickson, March 10, 2021

New metrics, including "N Above" have been proposed as replacements. N Above measures the number of planes going over a house which are above a given decibel level. So, for example, N65 would show the number of planes over 65 decibels which fly over a home during a given period.

## CONCLUSION

Noise, defined as unwanted and/or harmful sound, has many attributes that need to be considered to fully understand its impact on the health and well-being of individuals and communities and to develop informed policy. The dBA metric may be a useful indicator to assess the risk auditory damage but, by itself, is not appropriate for assessing the myriad effects of noise on auditory and non-auditory health and well-being or the scope of those effects. Reliance in the United States on the dBA is insufficient for developing policy to protect public health either in the United States or anywhere else. The field of noise metrics and assessments needs to be re-cast to account for the various attributes of major environmental noise sources and the translation of those attributes to the nature and scope of impact on health and community well-being. If we choose tools like dBA

that do not accurately characterize impacts, how can government agencies develop effective solutions and policies?

In the two examples provided we note that regulatory authorities, at least in the United States, depend on noise metrics that, on their face, may appear reasonable but which underestimate the adverse health impacts of noise on humans, especially non-auditory health impacts. Reliance on the dBA as a sole metric to reflect impact from noise emitted by internal combustion engines is of special concern.

It is the moral responsibility of those who understand how to measure sound, and the impacts of noise on health, to inform legislators, regulators, news media, and the public about the adverse impacts of noise on health, how to measure sound accurately in all its dimensions, how to represent the scope of impact, and how to reduce noise at its source.

A quieter world will be a safer and better world for all.

**Acknowledgements**

Thanks to Daniel Fink and David Sykes for their helpful edits and suggestions.

## REFERENCES

1. Fink DJ. A new definition of noise: noise is unwanted and/or harmful sound. Noise is the new 'secondhand smoke.' Proc Mtgs Acoust. 2019;39:050002.
2. Noise as a public health hazard. Policy statement 202115. American Public Health Association, October 26, 2021. Available at https://apha.org/Policies-and-Advocacy/Public-Health-Policy-Statements/Policy-Database/2022/01/07/Noise-as-a-Public-Health-Hazard
3. Hammer M, Neitzel R, Swinburn T. Environmental noise pollution in the United States: launching an effective public health response to prevent heart disease, hearing loss, and other health effects. Environ Health Perspect 2014;122:115-9.
4. Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, et al. Auditory and non-auditory effects of noise on health. Lancet. 2014 Apr 12;383(9925):1325-1332.
5. Münzel T, Schmidt FP, Steven S, Herzog J, et al. Environmental noise and the cardiovascular system. J Am Coll Cardiol. 2018 Feb 13;71(6):688-697. doi: 10.1016/j.jacc.2017.12.015. PMID: 29420965.
6. Beutel ME, Jünger C, Klein EM, Wild P, et al. Noise Annoyance Is Associated with Depression and Anxiety in the General Population- The Contribution of Aircraft Noise. PLoS One. 2016 May 19;11(5):e0155357. doi: 10.1371/journal.pone.0155357.
7. National Academy of Engineering. Technology for a Quieter America. Washington, DC: The National Academies Press, 2010. Available at https://nap.nationalacademies.org/catalog/12928/technology-for-a-quieter-america
8. Guidelines for Community Noise (1999) B Berglund, T Lindvall, DH Schwela (eds). Geneva:World Health Organization. Available at https://apps.who.int/iris/handle/10665/66217
9. Environmental Noise Guidelines for the European Region. Copenhagen, Denmark:World Health Organization Regional Office for Europe, 2018. Available at https://www.who.int/europe/publications/i/item/9789289053563
10. Fastl H, Florentine M. Chapter 8. In Florentine M, Popper AN, Fay RR (eds), Loudness. New York:Springer, 2011.

11. Fastl H, Zwicker E. Psychoacoustics: Facts and Models, 3rd Edition. Berlin:Springer-Verlag, 2007.
12. Schmidt FP, Basner M, Kroger G, Weck S, et al. Effect of nighttime aircraft noise exposure on endothelial function and stress hormone release in healthy adults. Eur Heart J. 2013; 34(45):3508–14a.
13. Saucy A, Schäffer B, Tangermann L, Vienneau D, et al. Does night-time aircraft noise trigger mortality? A case-crossover study on 24 886 cardiovascular deaths. Eur Heart J. 2021 Feb 21;42(8):835-843. doi: 10.1093/eurheartj/ehaa957.
14. Supplemental Metrics for Day/Night Average Sound Level and Day/Evening/ Night Average Sound Level, I-INCE Publication Number: 2015-1, Final Report of the I-INCE Technical Study Group on Metrics for Environmental Noise Assessment and Control (TSG 9), April 2015.
15. Mutchler K. Westport RTM again eyeing leaf blower restrictions. CT Insider, Sept 10, 2022.
16. ANSI/OPEI B175.2-2012. Outdoor Power Equipment - Internal Combustion Engine Powered Handheld and Backpack Blowers and Blower Vacuums - Safety Requirements and Performance Testing Procedures. American National Standards Institute.
17. Occupational Safety and Health Administration. Occupational Noise Exposure. Available at https://www.osha.gov/noise#:~:text=Standards,%2Dweighted%20average%20(TWA).
18. US Environmental Protection Agency. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. 550/9-74-004.Washington, DC:US Environmental Protection Agency, March 1974.
19. Pollock C, Sparks G, Banks JL. Lawn and garden equipment sound: A comparison of gas and battery electric equipment. J Environ Toxicol Stud 2018;2(2).
20. Walker E, Banks, JL. Characteristics of lawn and garden equipment sound: A community pilot study. J Environ Toxicol Stu 2017;1(1).
21. Pasanen T, Rytkonen E, Sorainen E. Leaf Blower Noise. Joint Baltic-Nordic Acoustics Meeting 2004, 8-10 June 2004, Mariehamn, Åland BNAM2004-2
22. Fidell S, Mestre V (2020). Chronology of U.S. Aircraft Noise Regulation. In: A Guide to U.S. Aircraft Noise Regulatory Policy. Springer, Cham. https://doi.org/10.1007/978-3-030-39908-5_2ICAO
23. Banatvala J, Peachey M, Münzel T. The harms to health caused by aviation noise require urgent action. BMJ. 2019 Sep 2;366:l5329. doi: 10.1136/bmj.l5329.
24. East Midlands Airport, Noise Action Plan 2019-2023: Supplemental Information. Available at https://live-webadmin-media.s3.amazonaws.com/media/5942/ema-nap-supplementary-information-final-publish.pdf
25. Miller, NP, Czech JJ., Hellauer KM, Nicholas BL, et al. TC-21-4_Analysis of the Neighborhood Environmental Survey. DOT/FAA/TC-21/4, January 11, 2021. Available at https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/ArtMID/3682/ArticleID/2845/Analysis-of-NES
26. FAA Could Improve Outreach through Enhanced Noise Metrics, Communication, and Support to Communities. Washington, DC:US General Accounting Office, September 18, 2021. Available at https://www.gao.gov/products/gao-21-103933#:~:text=Support%20to%20Communities-,Aircraft%20Noise%3A%20FAA%20Could%20Improve%20Outreach%20Through%20Enhanced%20Noise%20Metrics,%2C%20fuel%20use%2C%20and%20emissions.