Beyond Decibels: Redefining Noise Hazards Using Kurtosis

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Abstract

This paper explores the role of kurtosis, a statistical measure of the "peakedness" of noise signals, in redefining noise hazard assessments. Traditional noise metrics, which focus on average sound levels and exposure duration, fail to account for the added risk posed by impulsive, non-Gaussian noise. Research, including controlled animal studies and large-scale human field investigations, demonstrates that noise with high kurtosis, characterized by intermittent, high-intensity bursts, causes significantly greater hearing damage than steady-state continuous Gaussian noise of equal energy. Chinchilla experiments revealed a dose-response relationship between kurtosis and cochlear hair-cell loss, while human studies confirmed that kurtosis-adjusted metrics better predict noise-induced hearing loss (NIHL) in industrial settings. These findings challenge the adequacy of current occupational noise exposure limits, which rely solely on energy-based metrics. Hearing loss prevention programs for complex noise environments can be improved by integrating kurtosis into future damage risk criteria and noise exposure standards. By incorporating kurtosis, policymakers and practitioners can more effectively protect workers from the unique hazards of impulsive noise.

Introduction

In an impressive experiment a decade ago, 225 chinchillas were exposed to different patterns of industrial noise. Each group of animals heard the same total noise energy at the same overall sound level – yet their hearing outcomes diverged dramatically (Qiu et al., 2013). One group was bathed in steady "Gaussian" noise, a constant hum with randomly varying amplitude, at 97 dBA. Others heard "complex" noise with the same average level but laced with intermittent, high-intensity bursts – bangs and clanks more akin to a factory floor or construction site. The results were eye-opening: animals subjected to the non-Gaussian noise suffered far greater permanent hearing loss and destruction of inner-ear hair cells than those hearing the smooth steady soundfile (Qiu et al., 2020). In fact, the damage *increased consistently as the noise's bursts increased*, even though the decibel level and exposure duration stayed the same. This finding struck at the heart of how we assess noise risks in the workplace. It wasn't just *how loud or how long* the noise was – the *pattern* of the noise mattered in a fundamental way.

What explained the extra hazard hidden in those intermittent crashes and bangs? The key turned out to be a statistical metric called *kurtosis*. In simple terms, kurtosis measures the "peakedness" of a noise signal – essentially how often and how extreme the rare *surges* of sound are, compared to a standard steady noise. Steady, Gaussian noise has a kurtosis value of three. The clanky, impact-heavy noises had kurtosis well above 3, reflecting their frequent, outlier peaks. For the same level, the animals exposed to noise with higher kurtosis exhibited the most hearing trauma (Hamernik et al., 2007; Qiu et al., 2013). In the chinchilla experiment, the group exposed to noise with kurtosis 100 (very spiky noise) showed substantially more cochlear hair-cell loss than those exposed to kurtosis 25 noise, which, in turn, fared worse than the kurtosis 3 (Gaussian) group (see Figure 1). This dose-response relationship suggested that kurtosis captures a dimension of noise hazard that decibel level alone misses.

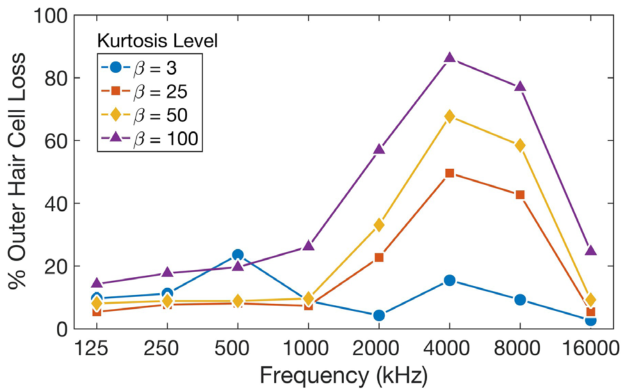

***Figure 1.** The average percent outer hair cell loss of three groups exposed to 97 dB SPL non-Gaussian noise with kurtosis () = 25, 50, or 100. The mean data from the group exposed to the 97 dB SPL Gaussian (= 3) noise is shown for comparison. Adapted from Qiu et al., 2013.*

Perhaps most importantly, the animal tests demonstrated that if you *control for kurtosis*, that is, compare noises with the same kurtosis value, then the finer details of the noise's temporal pattern (exactly how peaks are spaced or how long they last) make little difference in the resulting hearing loss. In other words, kurtosis distilled the complex time-varying character of hazardous noise into a single, meaningful number (see Figure 2). This discovery has paved the way for a new approach to protecting hearing: one that goes *beyond decibels* and incorporates kurtosis into noise exposure metrics. Now, a flurry of recent research from laboratory studies to large-scale field investigations is coalescing around kurtosis as a critical factor in assessing noise-induced hearing loss (NIHL). Here, we'll explore the science behind kurtosis, the latest findings on its practical importance, and how it could revolutionize hearing conservation programs in industries rife with "noisy" noise.

1. What is Kurtosis and Why Peaks Matter

Simply put, kurtosis (β) is a statistical measure of how heavy the tails of a distribution are relative to a normal, or Gaussian, distribution (Qiu et al., 2020). For noise analysis, it effectively gauges the prevalence of extreme amplitude (impulses) in a sound wave. Think of two workplaces: one is a textile mill with a constant mechanical drone around 90 dBA; another is a metal fabrication shop where quiet lulls are punctuated by deafening hammer strikes, also averaging ~90 dBA over a shift. Traditional noise metrics (like the 8-hour equivalent level, $L_{Aeq,8h}$) treat these as roughly equal exposures. After all, both have similar average decibel levels. But intuitively, and as data now confirm, the metal shop is far more damaging to hearing. The difference is kurtosis: the metal shop's noise has frequent, high peaks (high kurtosis), whereas the textile mill's noise fluctuation is narrower (low kurtosis). Kurtosis, in effect, quantifies the hazard of non-Gaussian noise in a way that pure decibel averages cannot.

Why do these spikes matter biologically? Intense impulses can cause *mechanical and metabolic stress* in the ear that steady noise does not. Sudden pressure bursts may produce instantaneous physical damage, especially if extremely high, and also provoke stronger metabolic activity in cochlear cells, which leads to cell death over time. Repeated high peaks thus accelerate the wear-and-tear on the auditory system. For many years, researchers have observed that gunfire, punch presses, or jackhammers seemed worse for hearing than their time-weighted decibels implied (See the review of noise exposure studies in Suter, 2017; Zhang et al., 2022). Kurtosis provides a way to formally capture that extra risk. In 1986, acoustician Erdreich suggested kurtosis could distinguish hazardous impulse-laden noise from benign steady noise (Erdreich, 1986). What's new is the wealth of data and refined methods now proving Erdreich right and turning kurtosis into a practical tool.

2. Lessons From the Lab: Animal Studies Validate Kurtosis

The quest to quantify impulsiveness took off in the 1990s and 2000s with controlled animal experiments. Chinchillas, whose hearing range and damage susceptibility are similar to humans, were frequently used for NIHL studies (Qiu et al., 2020). Roger Hamernik and colleagues (SUNY Plattsburgh) conducted a series of studies exposing chinchillas to complex noise under tightly controlled conditions (Lei et al., 1994; Hamernik et al., 2006, 2007; Qiu et al., 2007, 2013). The strategy was elegant: hold the total energy and spectrum constant but vary the kurtosis and temporal patterns of the noise. From these animal experiments emerged four key findings (Qiu et al., 2020):

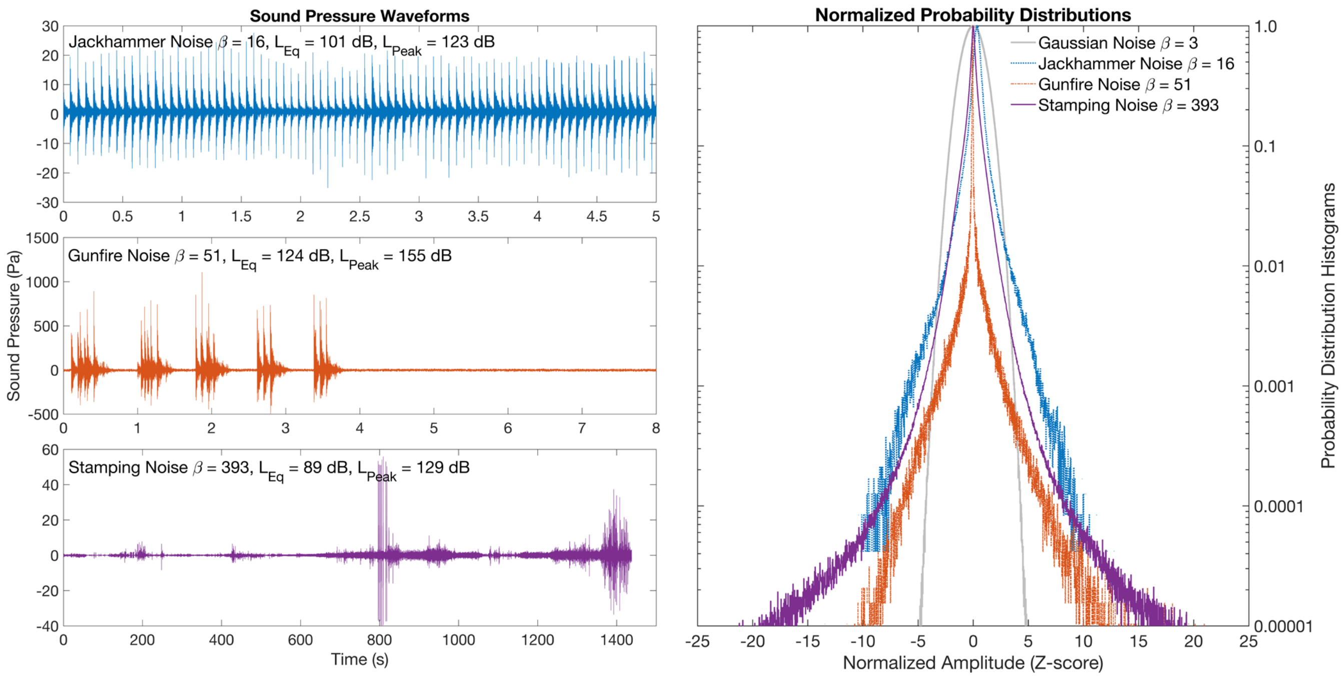

Figure 2. *Panel A: Three examples of signals with high kurtosis. The jackhammer noise was sampled from a microphone near the operator's shoulder. The gunfire noise was sampled at an indoor firing range with multiple shooters firing three round bursts with an M4 rifle. The stamping was collected at a factory in China. Panel B: The probability distributions from the three noise samples. The sound pressure was normalized by dividing the pressure by the standard deviation of the respective samples. The gray trace for the Gaussian noise is largely limited to ±5 standard deviations, whereas the tails for the non-Gaussian noises exhibit normalized amplitudes well outside ±5 standard deviations – indicating a higher probability for extreme amplitudes. Gunfire noise is asymmetrically distributed.*

- Impulsive noise is more hazardous than steady noise of equal energy, and kurtosis explains much of that added hazard.
- Hearing loss increases with kurtosis for a given sound energy.
- Both energy and kurtosis are needed to assess hearing risk from complex noise.
- If energy and kurtosis are fixed, the exact temporal structure has minimal effect on hearing loss. (In practical terms, you don't need to catalog every bang and pop – just measure kurtosis).

These findings gave scientific credence to incorporating kurtosis into noise risk assessments. Still, the question remains: do these principles hold in humans in real workplaces? Human experiments that present greater than minimal risk, several layers of approval, and require careful oversight to prevent injury to participants. However, epidemiological studies and field measurements can bridge the gap. Starting around 2010, researchers collected human data to see if kurtosis-based metrics better predict hearing loss in noise-exposed workers.

3. From Chinchillas to the Factory Floor: Human Evidence

Initial evidence came from a 2010 study by Zhao et al., who examined hearing loss in workers exposed to high-level complex noise versus those with steady noise exposure. They introduced a novel, kurtosis-adjusted noise exposure metric and found it indeed improved the correlation with high-frequency hearing loss (Zhao et al., 2010). By tweaking the traditional cumulative noise exposure (CNE) calculation to include a kurtosis term, Zhao and colleagues could essentially overlay the dose-response curve of impulsive-noise workers onto that of steady-noise workers. In other words, after accounting for kurtosis, the hearing loss patterns between the two groups lined up, implying the metric captured the excess risk from complex noise. This finding was a strong indicator that demonstrated kurtosis adjustment isn't just an academic exercise – it can actually normalize risk estimates across very different noise environments.

Follow-up studies reinforced this. Xie et al. (2016) looked at steel plant workers (complex noise) vs.

textile plant workers (steady noise) and again found that complex noise caused significantly more hearing loss for similar, unadjusted exposure levels. Applying the same kurtosis-adjusted CNE measure caused the disparate hearing loss curves to converge. By 2020, there was broad agreement that standard metrics underestimated NIHL risk in non-Gaussian noise, and that a kurtosis-adjusted metric could correct the bias (Zhang et al., 2022). Some studies concluded that relying solely on the equal-energy rule (the basis of most regulations) likely "does not protect large numbers of workers" in complex noise industries (Zhang et al., 2020; Liu et al., 2025). Real-world data were catching up with the lab science.

So, what does a kurtosis-adjusted metric look like? Two approaches have emerged:

- **Adjust through exposure duration (CNE method):** Zhao et al. (2010) proposed adjusting cumulative noise exposure according to kurtosis, by amplifying the exposure time of high-kurtosis noise by a certain factor so as to reflect the additional damage. It can be simplified as:

$$\text{CNE-K}=L_{Aeq,8h}+10\log_{10}(T\times f(\beta)),$$

where T is the duration of employment in year, and $f(\beta)$ is an "equivalent time factor" that increases with kurtosis. By selecting an appropriate form of $f(\beta)$, the CNE-K of complex noise can be made to reach the same hazard. In practice, without kurtosis adjustment, a worker in impulsive noise has a greater risk of incurring hearing loss than a worker in steady noise when the exposure levels, $L_{Aeq,8h}$, are equal. This method worked well to align curves, but it ties the correction to the assumption of a certain exposure duration (needing >1 year).

- **Adjust through exposure level (L_{Aeq} method):** Goley et al. (2011) proposed a more straightforward correction: add a penalty in decibels to the measured level based on kurtosis. Their suggested formula:

$$L'_{Aeq}=L_{Aeq}+\lambda\log_{10}(\beta/3),$$

where λ is a constant determined from the chinchilla dose-response data and $\beta/3$ represents how many times more "peaked" the noise is than a Gaussian baseline. This is exactly the kind of metric Qiu's animal studies hinted at: a single number incorporating both energy (L_{Aeq}) and temporal structure (via β). Goley's team calibrated λ using the chinchilla data and arrived at λ≈4.02 (Goley et al., 2011). Zhang and his colleagues checked λ using human data and obtained λ=6.5 (Zhang et al., 2022). Essentially, for a given kurtosis, the measured dB is increased by a few decibels to get an "equivalent hazard level."

Both methods, adjusting dose or level, are equivalent ways of incorporating kurtosis. They confirm that *ignoring kurtosis underestimates the risk*, while adjusting for it brings predictions in line with reality. In fact, when Zhang et al. (2022) applied a kurtosis-adjusted $L_{Aeq,8h}$ formula to a large worker dataset, the standard ISO-1999 model's under-prediction of NIHL essentially disappeared. Before adjustment, ISO's purely energy-based model underestimated high-frequency hearing loss by ~10 dB in high-kurtosis (β >50) noise groups. After applying a correction, $6.5\log_{10}(\beta/3)$, the prediction error shrank to within 1 dB! By contrast, using the chinchilla-derived λ = 4.02 left a residual error of 4–5 dB in high-β cases, under-correcting the risk (Zhang et al., 2022). This evidence from human data cemented the case that a slightly bigger kurtosis penalty for humans was needed than initial animal data suggested. Why the difference? This is likely because human studies consider long-term, varied exposures and the threshold of NIHL detection, whereas animal studies often use extreme conditions and look at cellular damage. The human ear's susceptibility, or perhaps the way noise-induced hearing loss is defined, means that moderate, impulsive noise has a larger-than-expected cumulative effect.

4. A Closer Look: Large-Scale Field Studies in China

To truly persuade regulators and industry stakeholders, large epidemiological studies are crucial. Three recent studies from China, where much of this kurtosis research was conducted, provide robust real-world evidence, encompassing thousands of workers:

- Zhang et al., *Ear & Hearing* (2022): This study analyzed 2,601 noise-exposed workers across several industries, with noise recordings and audiometric tests for each. The noise environments ranged from textile factories to metal fabrication, welding, woodworking, naturally spanning a wide range of kurtosis levels. The researchers split the cohort into three groups by kurtosis: *K1 (β between 3 and 10), K2 (β 10 to 50)*, and *K3 (β>50)*. Critically, all groups had similar distributions of $L_{Aeq,8h}$ (~85–90 dBA on average) and similar average exposure durations around 7–10 years. This isolates kurtosis as the key differentiator. The outcome measure was high-frequency noise-induced permanent threshold shift (NIPTS at 3, 4, 6 kHz), which is a sensitive indicator of NIHL.

The findings were striking. In the low-noise range ($L_{Aeq,8h}$<70 dBA), none of the groups had significant NIHL, essentially confirming that, below ~70 dBA, the risk is minimal even if the noise is peaky. But, starting at moderate levels (70–85 dBA), differences emerged. Workers in groups K2 and K3 had significantly more hearing loss than those in K1 for the same exposure level. In other words, even at exposures traditionally considered "safe" (<85 dBA), impulsive noise was causing damage, while steady noise was not. In the 85–95 dBA range common in industry, the hearing loss followed K3 > K2 > K1 in severity. For example, at 90 dBA 8h exposure, a worker in a high-β environment (like a woodworking shop with nail guns, β>50) might have a 10-15 dB NIPTS, whereas a worker in a low-β environment (textile mill, β ~5) might have only ~5 dB NIPTS. At very high exposure levels (>95 dBA), interestingly, the medium-β group's hearing loss tended to catch up to the low-β group, suggesting that at some extreme continuous noise is nearly as bad, but the high-β group still showed much worse loss. This suggests a possible ceiling effect for continuous noise damage and a distinct extra effect for very impulsive noise.

From their worker data, Zhang et al. (2022) derived the kurtosis adjustment coefficient λ=6.5 as discussed and showed that using $L_{Aeq}+6.5\log_{10}(\beta/3)$ dramatically improved hearing loss predictions. They effectively proved that *85 dBA is not equally safe for all noise*, e.g., an impact-rich 85 dB is more dangerous than a smooth 85 dB. Their conclusion was blunt: *"Relying on a single value (i.e., 85 dBA) as a recommended exposure limit does not appear sufficient to protect workers exposed to complex noise."*

The study also gave real-world examples of what kinds of work produce different kurtosis levels. Steady-state (low-β) noise was exemplified by textile spinning, weaving, and paper pulping machines (β roughly 3–10). These are continuous process machines with constant motor noise. Moderately impulsive (mid-β) noise came from metal punching/stamping, assembly lines, drilling, and heat treatment operations (β ~10–50). These jobs have frequent impacts or cyclic bursts. Highly impulsive (high-β) noise included woodworking with nail guns and certain assembly tasks with frequent jolts (β often >50, sometimes into triple digits). Interestingly, the workers in the β > 50 category tended to have shorter job tenures on average (6.5 years vs ~9+ years in lower β groups). This finding presents several avenues for future investigation. Do workers exhibit noticeable hearing shifts earlier in jobs with extremely impulsive noise? Do workers in these same jobs have a shorter tenure and transfer to other less noisy positions? Do employers provide greater compensation to retain workers in these jobs?

- Gong et al., *American Journal of Industrial Medicine* (2025): Building directly on Zhang's multi-industry cohort, Gong and NIOSH colleagues analyzed a large, well-characterized dataset of 2,400 noise-exposed workers (across 13 industries and 64 job titles) with full-shift waveform recordings and matched audiometry. Noise was sampled at high rate (48 kHz) and parsed into non-overlapping 60-s windows to compute kurtosis (β) per minute; shift-level kurtosis was then summarized as either an arithmetic mean (β_{ARI}) or geometric mean (β_{GEO}). Workers were grouped by $L_{Aeq,8h}$ bands (≈76, 85, 90, 97 dBA) to mirror REL/PEL decision thresholds. Using multiple linear regression with $L_{Aeq,8h}$ and log10(β/3) as predictors, the team modeled noise-induced permanent threshold shift (NIPTS) over speech and high-frequency ranges.

First, across most exposure strata, Gong et al. found that the NIPTS rose monotonically with β and the effect was evident from 0.5–8 kHz, with the expected 4 kHz notch prominent in exposed groups. At the very lowest exposure band (70–79 dBA), the kurtosis effect was uncertain, so those data were excluded from coefficient estimation—consistent with the practical view that β becomes decision-relevant above ≈80 dBA.

How big is the kurtosis penalty? When predicting average NIPTS across 1–4 kHz ($NIPTS_{1234}$), Gong estimated λ = 6.1 using β_{ARI} and λ = 6.5 using β_{GEO} in the level-adjusted metric $L'_{Aeq,8h} = L_{Aeq,8h}+\lambda\log_{10}(\beta/3)$. For high-frequency loss ($NIPTS_{346}$, 3–6 kHz) – the range most sensitive to impulsive content – λ increased to 7.2 (β_{ARI}) and 7.9 (β_{GEO}). Model fits were strong (R^2 ≈ 0.78–0.82), reinforcing that kurtosis and energy together explain substantially more of the variance in NIHL than energy alone. Practically, these λ values mean that moderate to high β can add several dB to the effective hazard level– enough to change program enrollment or controls if decisions are based on $L'_{Aeq,8h}$ rather than unadjusted $L_{Aeq,8h}$.

Why does geometric averaging matter? Because the distribution of per-minute β is log-normal, Gong showed that β_{GEO} performs at least as well as β_{ARI} (and sometimes better) for predicting NIPTS – important for instrumentation and standards because β_{GEO} dampens the influence of a few extreme minutes without losing discrimination across the shift. This finding is dovetailed with prior field analyses recommending geometric aggregation for robust kurtosis-aware monitoring.

What does this mean in practice? Combining the earlier of Zhang et al., (2022) and the independent analysis from Gong et al., (2025), evidence is accruing that kurtosis-adjusted $L_{Aeq,8h}$ is a practical, better-calibrated risk metric, especially in the 80-92 dBA range where many workers are exposed at or below traditional action levels. In short: for equal $L_{Aeq,8h}$, higher-β environments carry measurably greater risk, and $L'_{Aeq,8h}$ makes that excess hazard visible for hearing conservation decisions.

- Liu et al., *Ear & Hearing* (2025a): Building on Zhang's data, this study expanded the sample to 4,276 workers and delved into *how best to compute kurtosis over a workday*. One practical challenge is that kurtosis can fluctuate from minute to minute. Should one use a simple average of the kurtosis measured in each minute? A geometric average? Or adjust at the minute level and then combine? Liu et al. compared three schemes:
    a) Scheme 1: Arithmetic averaging – calculate kurtosis in each 60-second window of the shift, then take the simple average to get one β for the day.
    b) Scheme 2: Geometric averaging – calculate β each minute, then use the geometric mean (which is less influenced by extreme outlier values).
    c) Scheme 3: Segmented adjustment – essentially apply the kurtosis correction at a fine scale: for each 60-sec window, convert that minute's $L_{Aeq,8h}$ to an adjusted level (penalize it by kurtosis for that minute), then log-average those 480 one-minute adjusted levels into an 8h level.

They found that Scheme 1 (arithmetic) yielded an adjustment coefficient of $\lambda = 6.5$ (not surprisingly, as it mirrors Zhang's approach). Scheme 2 (geometric) yielded a slightly higher $\lambda \approx 7.6$. Scheme 3 (segmented), where a machine learning model optimized the coefficient, gave $\lambda \approx 5.4$. To evaluate which scheme worked best, they looked at how well each reduced the error between predicted NIHL (using a model like ISO-1999) and the workers' actual measured NIHL across different kurtosis groups. The result: Scheme 2 (geometric mean, λ ~6.5–7.6) and Scheme 3 (segmented, λ ~5.4) performed comparably well, while both outperformed the simple arithmetic approach. In practical terms, using the geometric mean of β for a shift (and an appropriate λ) gave as good an NIHL prediction as the more complex segmented minute-by-minute adjustment. This outcome is encouraging, because geometric averaging is simpler to implement in both dosimeters and standards. The segmented approach is conceptually appealing, accounting for how kurtosis might impact dose accumulation non-linearly, but Liu et al. caution that it is very sensitive to extreme values and one or two freakishly loud bangs in a day could skew the result heavily. Further research is needed to refine this scheme. For now, the *geometric averaging approach with $\lambda \approx 6.5$* looks like a robust and practical choice, aligning well with the earlier Zhang findings.

The takeaway from Liu et al. (2025) is that not only is kurtosis critical, but how you measure it in the field matters. The standard practice in recent studies has been to sample the noise waveform at a high rate (e.g., 48 kHz), break it into 1-minute segments, compute kurtosis for each, and then combine those. Most researchers have used geometric averaging to avoid letting a few minutes of very high kurtosis dominate the day's metric. This makes sense – imagine a machine shop that is mostly steady but has the occasional drop of a heavy object; an arithmetic mean might overemphasize that, whereas a geometric mean will temper it. The latest evidence suggests this is, indeed, the better approach for predicting risk. This insight is useful for standards' bodies when defining how kurtosis should be measured.

5. Toward Safer Standards: Policy Implications

Because of this growing body of evidence, scientists are now calling for updates to occupational noise exposure limits and measurement protocols. Current standards, recommendations, or regulations whether ISO, NIOSH, or OSHA, rely almost entirely on energy-based metrics (L_{Aeq} and exposure duration) and, at best, include separate provisions for extremely high peak noise (e.g., 140 dB peak ceiling) or adjustments for impulsiveness or rates of accrual (e.g. 5 dB exchange rate). They do not yet incorporate kurtosis as a routine factor.

One concrete set of recommendations comes from a 2025 analysis of over 3,400 Chinese workers, which explicitly aimed to evaluate excess risk of NIHL from complex noise and suggest new exposure limits (Liu et al., 2025b). The study confirmed that complex noise (with various β) led to significantly higher rates of hearing loss than predicted by steady-noise models, especially for high-frequency hearing and in earlier years of exposure. Using logistic regression and risk modeling, the authors proposed that, to achieve the same protection for complex-noise workers as we expect for steady-noise workers, the permissible exposure limit would need to be lowered by at least 5 dB. Specifically, they suggested reducing the standard 85 dBA 8-hour limit to 80 dBA when considering an A-weighted pure-tone average (PTA of 1–4 kHz) and down to 77 dBA when focusing on the most noise-sensitive high frequencies (3–6 kHz). In other words, our classic "85 dBA is safe for 8 hours" might actually be 80 dBA for many real-world noises if we want equal safety, and even lower limits for protecting against the high-frequency "noise notch" in hearing thresholds.

Furthermore, for very high-kurtosis noise exposures, an additional safety margin was advised. The study identified a threshold (in their data, $\beta \approx 70$ for 1–4 kHz, and $\beta \approx 25$ for 3–6 kHz) beyond which the risk sharply increased. For those highly impulsive environments, they recommended another 2 dB reduction in the limit. That implies something like 78 dBA or 75 dBA as the effective limit in those cases. These fine-tuned numbers may evolve with further research, but the message is clear: complex noise demands more conservative exposure limits. Governments and standard-setting bodies should revisit the one-size-fits-all 85 dB limit in light of this evidence. A kurtosis-adjusted limit would better protect workers. For instance, regulations might say "If the noise kurtosis exceeds 50, treat the exposure level as 5 dB higher than its A-weighted level when defining exposure limits," or simply have a table of recommended corrections (5 dB penalty for moderately impulsive noise, 10 dB for highly impulsive), which, notably, echoes the older ISO 1999 adjustments, but is now grounded in a quantitative metric.

6. The Bottom Line: Toward A New Era of Noise Control

After years of gradual progress, the concept of kurtosis is reaching a tipping point in the field of occupational health. We now understand that equal-energy metrics alone can leave workers under-protected when noise is intermittent and peaky. The research we've discussed, spanning animal lab studies to large factory studies, provides compelling evidence that *kurtosis is a missing piece* for evaluating complex noise hazards. New research has evaluated construction and military noise exposures (Samardzic et al. 2024; Smalt et al. 2017; and Kulinski et al. 2025). By incorporating this metric, we can distinguish a benign 85 dB drone from a dangerous 85 dB racket and set policies accordingly.

For health professionals and engineers, this means embracing a few statistics in the quest to save hearing. Fortunately, the heavy lifting has been done: the algorithms to compute β are straightforward, and digital sound recording technology is cheaper and more capable than ever. It's entirely feasible that the next generation of noise dosimeters will feature a "kurtosis-corrected dose" readout in real time, alerting a worker not just when their average dose is high, but when an onslaught of impact noise has made it effectively more dangerous than the average suggests.

Policy-wise, integrating kurtosis doesn't necessarily mean scrapping our current exposure limits; it means *adding nuance* to them. Regulators could adopt an approach similar to heat stress indices or chemical exposure adjustments – one number for typical conditions, and correction factors for special cases. Here, kurtosis can serve as that correction factor for noise. Doing so would fulfill a precautionary principle already hinted at in past standards, i.e., the 5 dB/10 dB impulse noise allowances, but with scientific precision.

Ultimately, the goal is to reduce noise-induced hearing loss, still one of the most common occupational injuries worldwide, in an era where impulsive noise is ubiquitous. From manufacturing lines with robotic welders and pneumatic tools, to construction sites with nail guns and explosions, to military weapon fire, modern “noisy” environments are rarely the steady drone of yesteryear’s factories. Our protective strategies must evolve accordingly. Kurtosis gives us a tool to make that leap. By recognizing that not all 90 dB exposures are created equally and adjusting for the impulsiveness of noise, we can better identify high-risk situations and intervene.

Science will continue to refine the details: optimal window lengths, better λ values for various contexts, and interactions with hearing protection, but the consensus is firm that kurtosis belongs in the noise hazard toolbox. For those in charge of safeguarding workers’ hearing, it’s time to start using it. By doing so, we can create more effective hearing conservation programs that keep pace with the realities of industrial noise, ensuring that our standards truly reflect what the ears (and the data) have been telling us all along: *It’s not just the noise you hear, it’s how you hear the noise*. Combining traditional decibel measures with kurtosis will let us hear the full story and act before the damage is done.

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