HearingTracker
For Professionals

Why Extended High-Frequency (EHF) Hearing Assessments Are Necessary

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It's time to stop calling the 8 kHz audiogram the "gold standard" in hearing testing. Modern testing should include EHF thresholds and functional speech-in-noise assessments that align with audiology science and real-world patient complaints.

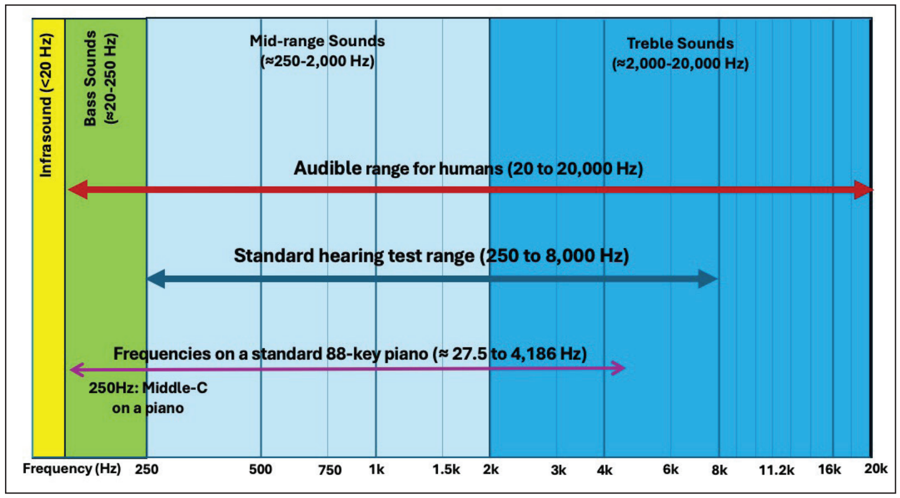

Figure 1. A schematic that shows the audible range for humans (20-20,000 Hz, red line) versus the standard audiometric testing range (250-8,000 Hz, blue line). Frequencies of a piano keyboard are included for reference (thin purple line), demonstrating that music is largely a low-frequency phenomenon. The authors provide support for why important clues about patients' hearing are being missed by not testing beyond 8,000 Hz.

The traditional pure-tone audiogram—typically spanning 250 to 8,000 Hz—remains the so-called "gold standard" for clinical hearing assessment.[1] While reliable for determining threshold sensitivity, it fails to capture key aspects of real-world listening ability. Difficulties understanding speech in noise, tinnitus, and the early stages of auditory nerve and cochlear damage often precede measurable hearing threshold changes through 8,000 Hz.

It is well-known and documented that hearing thresholds through 8,000 Hz may remain "normal" even when there is significant cochlear synaptopathy and auditory neuropathy.

These anomalies may be revealed via extended high-frequency (EHF) assessment. Changes in EHF hearing sensitivity are among the earliest signs of auditory stress and are often linked with reduced speech-in-noise (SIN) performance, localization problems, increased listening effort, and potential changes in cognition.[2] Including EHF audiometry (>8 kHz) with SIN testing, otoacoustic emissions, suprathreshold listening and communication assessments, and cognitive screenings offers a more comprehensive and clinically useful view of auditory health.

This article highlights key epidemiological, physiological, and clinical evidence supporting EHF testing. We address the limitations of the traditional audiogram and provide practical recommendations for audiologists to update comprehensive audiometric assessments in the 21st century.

Why We Should Perform EHF Testing Every Time

Hearing loss is among the most prevalent neurologic conditions worldwide, affecting nearly 1.5 billion people.[3]

Although national associations report that 38-45 million people in the United States have hearing loss, the recent Global Burden of Disease Study[4] reported 73 million people in the U.S. have hearing loss, representing 22% of the population, or 1 in 5 people. Beck & Danhauer[5] estimated 26 million Americans have "sub-clinical" listening problems despite normal thresholds. The Veterans Affairs Portland Health Care System in 2023[6] reported "functional hearing difficulties" in 23 million Americans which were not apparent or explained by conventional audiometric thresholds. Taken together, the above information indicates:

- The chief complaint of most people with hearing and listening problems is often not visible or apparent on traditional audiograms from 250 to 8,000 Hz.
- Approximately 99 million people in the U.S. have hearing and listening problems (nearly 1 in 3 Americans).
- If we do not test beyond traditional audiometric frequencies, we are likely to miss, or perhaps not diagnose, 1 in 4 people with significant auditory complaints.

The US National Health and Nutrition Examination Survey (NHANES) identified early-onset sub-clinical hearing loss (SCHL) in 227 million people—or 80% of U.S. adults—using high-frequency pure-tone averages.[7] Thus, when EHFs are considered, the prevalence of hearing loss is far greater than estimates based on traditional audiograms and is evident decades sooner.

Traditional Audiograms and Speech in Noise (SIN) Testing

Traditional audiometry involves measuring pure-tone hearing thresholds from 250 Hz to 8,000 Hz and has been in use for over 100 years. To date, many hearing care providers refer to conventional audiograms as the "gold standard" of hearing measurement.

Unfortunately, this moniker places too much emphasis and authority on a simple, yet incomplete, measure of a dynamic and complex auditory system; it does not address patient symptoms and functional issues such as speech-in-noise ability, listening and communication ability, and overall audiometric ability and capacity.[8] Traditional pure-tone tests do not explore, explain, or quantify the primary reason most people seek audiologic care, which is the inability to understand speech-in-noise.

Assessing and quantifying SIN has involved the use of the SNR-50—the signal-to-noise ratio (SNR) required by the listener to achieve 50%-word recognition in noise. The SNR-50 can be assessed using many protocols and can be accomplished in less than 5 minutes.[9] Unfortunately, SIN measurement appears to be performed in fewer than one-fifth of all audiometric assessments.

The Problem with Hearing Screening

To be clear, hearing is perceiving or detecting sound, whereas listening is the ability to comprehend sound.[10] The most common complaint hearing care professionals attend to daily is not "hearing loss" specifically, but rather, the inability of adults to understand speech in noise. As such, adult hearing screenings are of questionable value as they do not measure or reflect the ability to understand speech in noise.

Hearing screenings are non-diagnostic, and frankly, they are often not taken seriously by the recipient. Adults who fail hearing screenings often dismiss the results, saying, *"I hear everything that I want to hear"* and *"people mumble these days…"* The person or his/her spouse may half-jokingly refer to it as "selective hearing." These complaints typically indicate that the individual does have undiagnosed and untreated hearing loss, most likely in the extended high-frequency range, but is not interested or convinced that they have a real problem or that they should do something about it.

Most people with significant hearing and listening problems can hear. However, they do not hear enough to listen, understand, or comprehend in challenging situations. Further, many people have undiagnosed auditory processing anomalies.

Unfortunately, those in denial may convince themselves that they can hear by having a familiar voice or a loved one say something clear and loud, which they can easily hear, and then they dismiss their "hearing loss" as hogwash. This situation is unlikely to change with additional hearing screenings but may improve with comprehensive audiometric assessments, including listening and communication evaluations, EHF assessment, otoacoustic emissions (OAE) measurement, and SIN testing, all of which reveal and document auditory deficits that pure-tone audiograms cannot.

Furthermore, hearing screenings risk wasting valuable clinical time, resources, and effort while providing only the most basic level of analysis of a complex and challenging audiometric profile.[8]

Despite 80% cochlear nerve degeneration, pure-tone thresholds can remain deceptively normal.[11-13] While we emphasize that pure-tone hearing threshold testing is an essential part of comprehensive audiometric assessment, especially for determining amplification settings, it is diagnostically incomplete and may even be misleading when used as a stand-alone measure.

Unfortunately, elevated thresholds are not a valid or reliable indicator of cochlear or neural pathology, because individuals with "normal" pure-tone thresholds may harbor substantial and common synaptic and neural deficits. This includes cochlear synaptopathy and auditory neuropathy, which degrade the individual's ability to comprehend speech in challenging acoustic situations. This degradation often occurs years or decades before the damage is evident on traditional audiograms.

The only hearing screenings we endorse are "newborn/infant hearing screenings," which are critically important for early diagnosis and treatment of hearing loss in children.

Hall[14] in 2025 reported that the prevalence of hearing loss in school-aged children is approximately 10 times higher than in infants. That is, acquired hearing loss is more common than congenital hearing loss and may occur during the first few years after birth. Furthermore, undetected and untreated hearing loss is often a significant impediment to language and speech development, education, learning, social interaction, psychological well-being, and other aspects of life.

For adults with suspected hearing loss, it is time for hearing care professionals to simply "just say no" to hearing screenings. A person can lose 75-80% of their auditory neurons but still be able to "press the button when they hear the beep" within clinically normal (or nearly normal) limits. Offering a hearing screening suggests that we can guide or assist patients based on their audiogram results. Yet, when someone passes a hearing screening, we have only tested their ability to hear "beeps" in quiet, and in a limited range of frequencies. Conversely, when someone fails a hearing screening, all we can do is encourage them to undergo a full audiometric evaluation. Yet very few will follow through.

Medwetsky and Scherer[15] reported on 2,049 individuals screened, with 1,337 (65%) failing the screening. A total of 329 scheduled an appointment (16% of 2,049, or 37% who failed the screening). Similarly, Ingo et al.[16] reported that about 2 in 5 (39%) adults who failed an online hearing screening did not follow up with a hearing care professional. Thodi et al.[17] reported that 3,025 adults were screened, with a referral rate for more extensive assessment of 46%, but only 18% eventually underwent amplification.

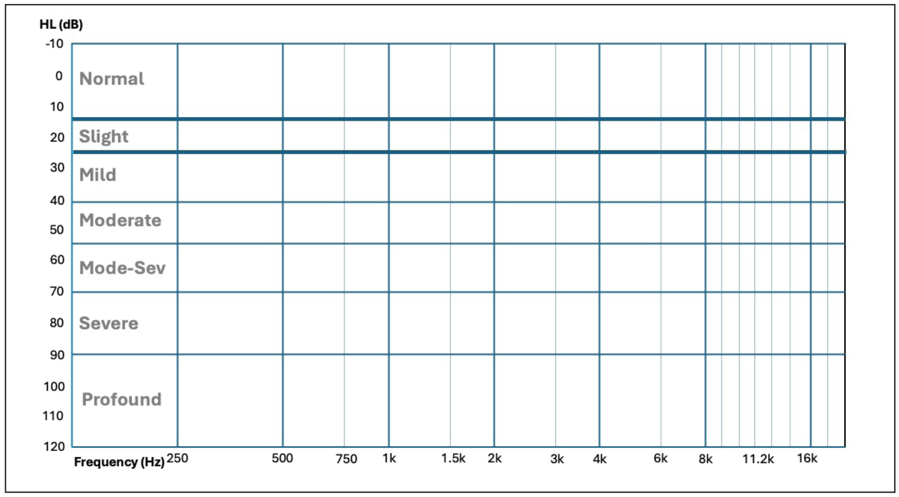

Figure 2. Example of an audiogram with extended high frequencies. The authors and publisher provide this for open access.

Doesn't "Normal Hearing" Mean Normal Audition?

No, "normal hearing" as determined by pure-tone thresholds does not mean normal audition. Most children and adults with auditory processing disorders have normal or near-normal hearing thresholds (for example, we refer readers to a post from a respected pediatric audiologist[18]). Tens of millions of adults and older people complain about the inability to understand speech in noise. They may complain that people "do not speak clearly" or report "hearing difficulty," yet over 26 million of them in the United States have normal pure-tone thresholds.[5] Papesh et al.[19] reported similar findings (23 million veterans) referred to as Functional Hearing Impairment, which was also not explained by their conventional audiometric thresholds.

Adults who present with complaints of hearing difficulty despite normal hearing sensitivity constitute a unique population, many of whom would benefit from extensive audiometric assessment.[20] For some, mild-gain amplification with a focus on ease of listening and an improved SNR would be a reasonable treatment goal.

A Brief History of Audiograms

The first "Auditory Chart" was developed by Hartmann (1885) and included tuning fork results from the left and right ears along the horizontal axis, versus percentage of hearing on the vertical axis.21 This was an early attempt to subjectively characterize hearing ability. In the early 1920s, Fletcher, Fowler, and Wegel were the first to plot octave intervals along the horizontal axis with intensity along the vertical axis.[22] It's likely they were the first to coin the term "audiogram."[23]

As one might expect, the audiogram and the audiometer appeared at about the same time, roughly 100 years ago. The appearance of the audiometer facilitated objective analysis of frequency versus amplitude measures. In the early 1920s, the Western Electric 1A became the first commercially produced electronic audiometer, with a range of 32 Hz to 16,384 Hz. The "1A" was very expensive at that time—apparently equivalent to the cost of an average house. The subsequent "2A" audiometer was more portable and tested 64 Hz through 8192 Hz. This was followed by the Western Electric D5, launched in 1937, which was the first audiometer to feature "0 dB HL" measures. However, it was not until 1951 that the American Standards Association (ASA) introduced audiometric zero based on normative values.

The important "take-away" here is that we have been able to test hearing sensitivity up to 16 kHz for the last 100 years. Yet, today, very few clinicians routinely test beyond 8 kHz. Currently, this is easily accomplished with software upgrades, apps, and headphones designed to assess EHF, available from audiometer manufacturers.

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The Rationale for Including EHF Testing

The limited frequency range (250-8000 Hz) used by hearing care professionals for the last 100 years appears to have been deemed clinically acceptable based on two primary assumptions:

1) Most of the sounds associated with speech occur within the 250 to 4000 Hz range,[24] and
2) Pure-tone patterns presented between 250 and 8000 Hz often correlate with otolaryngologic disease.[25]

For example, the presence of a "Carhart notch" often indicates otosclerosis. A low-frequency fluctuating hearing loss accompanied by dizziness, tinnitus, and other symptoms is frequently linked to Meniere's Disease. Presbycusis usually presents as bilateral high-frequency hearing loss. Acoustic neuroma often appears as unilateral hearing loss or unilateral tinnitus. Clearly, many audiometric patterns have been identified and are easily linked to and support otolaryngologic suspicions and diagnosis.

While these correlations have historical and clinical value, they are also limiting.

By focusing exclusively on traditional audiometric thresholds, auditory anomalies above 8,000 Hz are hidden or invisible and brushed aside as "hidden hearing loss." Audiometric presentations of tinnitus, impaired speech-in-noise understanding,[2,5,26,27] degraded speech clarity, and other auditory processing difficulties associated with asymmetries and interaural differences or head-shadow effects, as well as the inability to estimate distance (based on acoustic cues) are often correlated with auditory neuropathy, cochlear synaptopathy, and other auditory anomalies which are not apparent between 250-8000 Hz.

Although exact numbers are difficult to ascertain, perhaps 5% of hearing problems have medical/surgical etiologies, whereas 95% are audiologic, due to cochlear synaptopathy induced by age-related hearing loss, noise-exposure, ototoxic etiologies, and more.[8]

Hearing and listening challenges are often noticed and reported in mid-life, which may occur decades before traditional audiometry indicates or classifies an individual as hearing impaired. However, once auditory decline begins, the effects may include sensory deprivation, cognitive maladaptation,[28] social isolation,[29] anxiety, depression, reduced quality of life, potential cognitive decline (among those at risk), and more.

Early EHF threshold degradation offers a more sensitive measure of early auditory system involvement and might explain functional hearing difficulties that are otherwise invisible in standard practice (i.e., sub-clinical). At the very least, EHF anomalies alert the patient and the provider to the need for ongoing monitoring of the patient's hearing health.

Wiley et al.[30] report general trends from their large dataset, indicating that EHF thresholds tend to worsen with age. Their results also indicate:

- The highest EHF threshold perceived was most closely correlated with 8000 Hz
- EHFs are generally worse for men than women
- There is no significant difference in men and women's thresholds above 16 KHz.

EHF hearing loss is associated with deficits in localization,[31,32] as well as speech and music perception.[33-37] Langendijk and Bronkhorst[38] concluded that spectral information between 4-16 kHz is used to identify the origin of sound in space: 6-12 kHz contributes to up-down localization, while sound information between 8-16 kHz provides front-back localization cues. Adults with elevated thresholds above 8 kHz consistently perform worse on speech-in-noise tests, require higher SNRs to achieve equivalent understanding, and report greater listening effort and fatigue.[2,27]

As is true in all medical specialties, we believe "diagnosis first, treatment second" is the correct protocol, is in the patient's best interest, and absolutely applies to audiology. Accurately describing and detailing the diagnosis that causes or correlates to the patient's chief complaint should always be the first step. The purpose of a comprehensive audiologic assessment is not to fit hearing aids. Rather, it is to accurately describe and understand the complete audiometric profile for which treatments can be recommended.

In this regard, an EHF assessment may be similar to an imaging study that seeks to detail hidden/invisible anatomic anomalies prior to engaging in treatment. Even in cases where the MRI/CT reveals problems that cannot be directly treated, the imaging study provides a more complete understanding upon which treatment and/or management decisions may be based.

Audiologic treatment should be based on the diagnosis and the patient's specific needs, abilities, situation, desires, and more. For example, each patient with subjective tinnitus may perceive their own unique manifestations of tinnitus, some report sounds that resemble high voltage overhead electric wires, some report ringing, whistling, tones, crickets, and more. Despite significant differences in the manifestation of reported tinnitus sounds, there are some maskers and alternative sounds which successfully help the patient manage their tinnitus: white noise, ocean waves, increased background/environmental noise, narrow bands of noise, etc. Although the tinnitus may be perceived as sounding like X, a masker that sounds like Y may provide benefit. The treatment does not always target the exact/specific diagnosis. The purpose of medical treatment is to cure when possible, and to manage when necessary.

Incorporating EHF testing as a routine part of pure-tone thresholds provides more information at a very low cost and in a relatively short time. An informed diagnosis with EHF often enables early detection of hearing loss and can reveal patterns of hearing loss that might not be visible through traditional pure-tone audiometry. These patterns may be linked to specific causes, leading to more accurate diagnosis, prognosis, intervention, prevention, or treatment. Some examples include:

- Tinnitus. Many tinnitus patients with "normal" audiograms (250-8000 Hz) demonstrate EHF hearing loss—making EHF testing valuable for uncovering hidden deficits.[39]
- Genetic, autoimmune, and Fabry-related hearing loss. EHF thresholds can reveal early cochlear involvement before conventional frequencies show changes.[40]
- Early detection of subclinical hearing loss. Extended high-frequency audiometry and ultra-high-frequency DPOAEs are more sensitive than standard audiometry/DPOAEs for identifying early damage.[41]
- Noise-induced hearing damage (e.g., student rifle teams). Thresholds above 12 kHz are particularly vulnerable to noise damage; importantly, EHF injury may occur without changes below 8 kHz—highlighting the diagnostic value of EHF thresholds.[42,43]
- Spatial hearing deficits in children. EHF hearing loss has been linked to impaired localization and reduced spatial cues.[44]
- Effortful listening. Loss of EHF information contributes to increased listening effort, even when conventional thresholds are normal.[45]
- Speech-in-noise and complex listening difficulties. Reduced ability to manage complex acoustic scenes and identify speech cues may be associated with decreased EHG thresholds.[46]
- Phoneme identification deficits. EHF hearing loss disrupts access to high-frequency speech cues critical for differentiating phonemes during language development.[34]
- Language development delays. EHF deficits in children may impede typical language acquisition, particularly in the early learning years.[47]
- Perceptible loss of speech quality when bandwidth is reduced. Limiting speech bandwidth to 13 kHz causes a noticeable degradation for normal-hearing listeners, indicating that useful speech information exists above this range.[36]
- Early warning signs of age-related hearing loss. Combining OAEs with EHF thresholds may help identify age-related cochlear changes earlier than conventional testing. Biological arguments also suggest humans evolved sensitivity up to 20,000 Hz for detecting prey, predators, and mates.[47]
- EHF thresholds as predictors of speech-in-noise performance. Pure-tone thresholds at 16 kHz reliably predict how well listeners perform in noisy conditions—even when EHF cues are not present in the speech stimulus itself![37]
- High-frequency energy contributes to speech perception in

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noise. Acoustic information above 8 kHz supports listeners' ability to understand speech in challenging environments, which may help explain why people with clinically "normal" hearing often report real-world listening difficulties.[48]

EHF Testing in Comprehensive Hearing Assessment

Across decades of research—and now multiple large epidemiological studies—the evidence is undeniable: conventional pure-tone audiometry captures only a portion of the information needed to diagnose early auditory degradation and decline. Millions of people struggle with speech-in-noise, tinnitus, listening effort, and communication breakdowns despite their hearing being deemed "normal" via pure-tone thresholds from 250 to 8,000 Hz. Extended high-frequency testing, paired with SIN and suprathreshold measures, provides important insights into signs of auditory stress, neural degradation, and functional hearing impairment.

The question is becoming increasingly unavoidable:

Are we sacrificing diagnostic value for the sake of pseudo-clinical expediency? And if so, what responsibilities do we, as clinicians, researchers, and stewards of auditory health, have in updating our test batteries to reflect what science has shown us for decades?

Extended high-frequency thresholds may not answer every question, but they do provide essential information that is valuable to both clinicians and patients. ◆

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