

AUDIOGRAM

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AUDIOGRAM

Primary Disciplinary Field(s): Audiology, Otolaryngology, Speech-Language Pathology

1. Core Definition

The audiogram is the fundamental graphical representation utilized in clinical audiology to map an individual's hearing sensitivity relative to standardized norms. Specifically, it displays the quietest sound levels--known as **pure-tone thresholds**--that an individual can detect across a range of selected acoustic frequencies. This measurement is crucial because it provides objective quantification of hearing ability, allowing audiologists and medical professionals to determine the presence, type, configuration, and degree of any existing hearing impairment. The core utility of the audiogram lies in its comparative nature, contrasting the measured thresholds of the patient, who may be hearing-deficient, against the statistically derived thresholds of young, healthy, normal-hearing individuals.

This clinical measurement serves as the cornerstone for the assessment and ultimate diagnosis of nearly all hearing disorders. Without the standardized data provided by the audiogram, accurate diagnostic differentiation between conductive, sensorineural, and mixed hearing losses would be impossible. The process involves presenting a series of pure tones, one frequency at a time, through an instrument known as an audiometer, determining the minimum intensity at which the patient can reliably perceive the tone approximately 50% of the time. These measured thresholds are then plotted onto the graph, providing a visual profile of auditory function that is essential for both medical intervention planning and rehabilitative strategies.

The reference point for this diagnostic tool is known as **audiometric zero** (0 dB HL), which represents the average hearing threshold of a large group of otologically normal young adults. A key aspect of interpreting the audiogram is understanding that any measurement falling above this 0 dB HL line indicates a deviation from normal hearing. For example, a person whose threshold for a 4000 Hz tone is measured at 30 dB Hearing Level (HL) means that this individual requires the sound to be 30 dB more intense than the average normal listener to just barely perceive that specific frequency. Thus, the higher the plotted point on the graph (the higher the dB HL value), the poorer the individual's hearing sensitivity at that particular frequency.

2. Structure and Standardization

The structure of the audiogram is standardized globally, ensuring consistent interpretation across clinical settings. The graph employs a dual-axis system that precisely relates sound characteristics to hearing sensitivity. The horizontal axis (X-axis) represents the **frequency** of the pure tone, measured in Hertz (Hz). This axis typically covers the critical range for human speech and

environmental sounds, usually from 125 Hz up to 8000 Hz, though ultra-high frequency testing may extend beyond 8000 Hz. The frequencies are plotted logarithmically, meaning the distance between octaves (e.g., 500 Hz to 1000 Hz, or 2000 Hz to 4000 Hz) is visually consistent across the graph, even though the numerical difference increases.

The vertical axis (Y-axis) represents the **Hearing Level (HL)**, measured in decibels (dB). This axis is counter-intuitive in that the intensity of the sound increases as one moves down the graph. The top of the graph typically starts at -10 dB HL (or 0 dB HL), representing exceptional or normal hearing, and progresses downward in increments (e.g., 10 dB steps) often reaching 120 dB HL, which signifies profound hearing loss or the maximum output limit of the audiometer. This inverse plotting convention means that a larger numerical value on the Y-axis (plotted lower on the graph) corresponds to a worse hearing ability, as the patient requires a louder sound stimulus to reach the threshold of detection.

Standardization is strictly governed by international bodies, such as the International Organization for Standardization (ISO) and the American National Standards Institute (ANSI), which dictate the calibration of audiometers and the specific symbols used to represent data points. These symbols differentiate between the ear being tested (right vs. left) and the mode of sound transmission (air conduction vs. bone conduction). For instance, standard notation uses a red circle (O) for air conduction thresholds in the right ear and a blue cross (X) for air conduction thresholds in the left ear. Specific bracket and arrow symbols are reserved for bone conduction thresholds, ensuring that any audiologist can immediately and unambiguously interpret the plotted data.

3. Key Measurement Techniques

Data plotted on the audiogram are derived primarily from two distinct measurement techniques: air conduction and bone conduction. **Air Conduction (AC)** testing assesses the entire auditory pathway, including the outer ear, middle ear, and inner ear (cochlea and auditory nerve). During AC testing, pure tones are delivered via supra-aural headphones or insert earphones. The resulting thresholds determine the patient's overall hearing sensitivity, reflecting how well sound travels naturally through the ear canal, vibrates the eardrum and ossicles, and stimulates the cochlea. These thresholds are the most commonly referenced values when generally describing an individual's hearing level.

In contrast, **Bone Conduction (BC)** testing is designed to bypass the outer and middle ear mechanisms to isolate and assess the function of the inner ear directly. A small vibrator is placed on the mastoid process (the bony prominence behind the ear) or sometimes the forehead. When activated, the vibrator directly stimulates the skull bones, which, in turn, vibrates the fluid within the cochlea, directly exciting the sensory hair cells. The resulting BC thresholds provide a crucial measure of the integrity of the sensorineural system. By comparing the AC thresholds with the BC

thresholds, the audiologist can definitively localize the site of the hearing impairment.

The relationship between Air Conduction and Bone Conduction thresholds is fundamental to audiological diagnosis. When AC thresholds are worse (higher dB HL) than BC thresholds, a phenomenon known as the **air-bone gap** exists, indicating a conductive component to the loss--meaning there is an issue in the outer or middle ear preventing sound from efficiently reaching a normal or near-normal inner ear. If AC and BC thresholds are essentially the same (within 10 dB) and both are below the normal range, the loss is purely sensorineural, indicating damage originating in the cochlea or the auditory nerve. This precise differentiation guides whether the patient requires medical intervention (for conductive issues) or rehabilitative amplification (for sensorineural issues).

4. Interpretation of Hearing Loss Types

The pattern of thresholds plotted on the audiogram allows for the clear categorization of hearing loss into three principal clinical types. **Conductive Hearing Loss (CHL)** is diagnosed when there is a significant air-bone gap (typically greater than 10 dB), but the bone conduction thresholds remain within the normal range. This pattern signifies that the inner ear is functioning adequately, but sound transmission is being blocked or impeded in the mechanical chain of the outer or middle ear--often due to issues like fluid buildup (otitis media), cerumen impaction, eardrum perforation, or disarticulation of the ossicles (e.g., otosclerosis).

Sensorineural Hearing Loss (SNHL) is diagnosed when both the air conduction thresholds and the bone conduction thresholds are depressed (elevated dB HL) to a similar degree across the measured frequencies, meaning there is no clinically significant air-bone gap. In SNHL, the primary damage resides in the sensory organs of the cochlea (cochlear loss, most common) or the neural transmission pathway (retrocochlear loss). This type of loss is often permanent, resulting from aging (presbycusis), noise exposure, ototoxic medications, or congenital abnormalities, and is typically managed through amplification devices like hearing aids.

The third type, **Mixed Hearing Loss (MHL)**, presents a combination of both conductive and sensorineural components. The audiogram for MHL will show elevated air conduction thresholds, reflecting the total hearing loss, but also elevated bone conduction thresholds, indicating existing inner ear damage. Crucially, MHL is characterized by a significant air-bone gap, meaning the air conduction thresholds are still worse than the bone conduction thresholds. This pattern necessitates two separate treatment considerations: addressing the treatable conductive component (often medically) and managing the permanent sensorineural component (often through amplification).

5. Characteristics of Hearing Loss

Beyond simply identifying the type of loss, the audiogram is essential for defining the two critical characteristics of hearing impairment: its **severity** and its **configuration**. Severity refers to the degree of loss, which is typically classified based on the average pure-tone thresholds across the speech frequencies (500 Hz, 1000 Hz, and 2000 Hz), known as the Pure Tone Average (PTA). Standard classifications categorize loss into ranges such as mild (26-40 dB HL), moderate (41-55 dB HL), moderately severe (56-70 dB HL), severe (71-90 dB HL), and profound (91+ dB HL). This classification dictates the expected functional communication difficulties and the urgency and nature of required intervention.

The **configuration** describes the shape or pattern of the threshold line across the frequency range. Various configurations point toward different etiologies. A "flat" configuration suggests thresholds are relatively similar across all frequencies, which is common in some conductive losses or congenital SNHL. A "sloping" configuration, where hearing is better in the low frequencies and rapidly declines in the high frequencies, is the most common pattern, strongly associated with age-related hearing loss (presbycusis) and noise-induced hearing loss. A specific "notch" configuration, often centered around 4000 Hz, is the classic hallmark of occupational or recreational **noise exposure** damage to the cochlea.

Less common but equally significant configurations include the "rising" audiogram (worse low-frequency hearing, better high-frequency hearing), which may be indicative of Meniere's disease or certain conductive pathologies, and the "cookie-bite" or "saucer" shape (mid-frequency loss), often associated with specific inherited forms of hearing loss. Furthermore, the audiogram determines whether the loss is **unilateral** (affecting only one ear) or **bilateral** (affecting both ears), and if bilateral, whether the loss is **symmetrical** (the degree and configuration are essentially the same in both ears) or **asymmetrical** (a significant difference exists between the ears), the latter often requiring immediate medical follow-up to rule out retrocochlear pathologies like acoustic neuromas.

6. Clinical Significance and Applications

The audiogram is indispensable not only for initial diagnostic purposes but also as a foundational tool for planning and monitoring patient management. Clinically, it provides the quantitative evidence required to justify medical referrals, particularly when a conductive component is identified that may require intervention by an otolaryngologist, such as surgery to repair a perforated eardrum or to remove a tumor. It also allows the clinician to counsel the patient accurately regarding their communicative difficulties and to set realistic expectations for the outcome of various treatments.

In the realm of aural rehabilitation, the audiogram is the starting point for effective treatment using amplification. For patients with SNHL, the audiogram dictates the necessary gain and frequency

response characteristics of a **hearing aid**. Modern digital hearing aids are programmed based entirely on the audiometric data, ensuring that the sound frequencies where the patient has the most loss receive the most amplification, while regions of better hearing receive less. In cases of profound hearing loss, the audiogram, along with measures of speech understanding, helps determine candidacy for more advanced interventions, such as a cochlear implant.

Finally, the audiogram is critical for the long-term monitoring of hearing health. Patients receiving ototoxic medications (drugs known to potentially damage the auditory system, such as certain chemotherapies or antibiotics) require routine audiometric monitoring to detect subtle changes in high-frequency thresholds before the damage progresses into the speech range. Similarly, patients with progressive conditions, such as presbycusis or Meniere's disease, undergo serial audiograms to track the rate of deterioration and adjust amplification settings as necessary. The comparison of current and historical audiograms provides an objective measure of the stability or progression of the hearing impairment.

7. Related Terminology

Audiometer: The electronic instrument used to generate the pure tones and measure the hearing thresholds that are plotted on the audiogram.

Audiometric Zero: The reference intensity level (0 dB HL) representing the lowest sound intensity audible to the average normal listener.

Pure-Tone Thresholds: The softest sound level (in dB HL) at a given frequency that an individual can detect 50% of the time.

Audibility Curve: A graph that plots the average minimum audible pressure level (measured in dB SPL) required for normal listeners to detect sound across the frequency range; this is distinct from the clinical audiogram which uses dB HL.

Masking: A technique used during audiometry where noise is introduced to the non-test ear to prevent the sound stimulus delivered to the test ear from being heard by the opposite, better-hearing ear, ensuring accurate threshold measurement.

8. Further Reading

[Wikipedia: Audiogram](#)

[Centers for Disease Control and Prevention \(CDC\): Understanding the Audiogram](#)

[American Speech-Language-Hearing Association \(ASHA\): The Audiogram](#)

[Wikipedia: Hearing Level \(dB HL\)](#)