Add Health
The National Longitudinal Study of Adolescent to Adult Health

Sensory Function User Guide

Add CAPS
Add Health Cognitive Assesment, Physical, and Sensory Function

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1. Introduction

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is a nationally representative sample of U.S. adolescents who were in grades 7-12 during the 1994-1995 school year. Using a complex, school-based cluster-sampling frame, researchers selected high school and feeder school pairs from 80 communities across the United States and drew a sex- and grade-stratified random sample of 20,745 adolescents for inclusion in the study. This sample has been followed from adolescence into early midlife across six waves of data collection to date, with the most recent wave of data collection (Wave VI) taking place between 2022 and 2025 when respondents were ages 39 to 51, with an average age of 44.

Over the years, Add Health has collected a wealth of information from respondents and their parents about demographic characteristics, familial structures, social relationships, health behaviors, cognition, physical and mental health status, medication usage, and health care access. Add Health also has collected anthropometric, cardiovascular, metabolic, renal, hepatic, inflammatory/immune, infectious, neurodegenerative, and multi-omic biomarkers from respondents. In addition, Add Health has merged multilevel contextual data about the economic, school, neighborhood, policy, and environmental contexts in which the respondents are embedded to the core survey and biological data at each wave. The Add Health dataset thereby provides researchers with rich opportunities to explore the causes and consequences of health status across multiple contextual domains as individuals age across the life course.

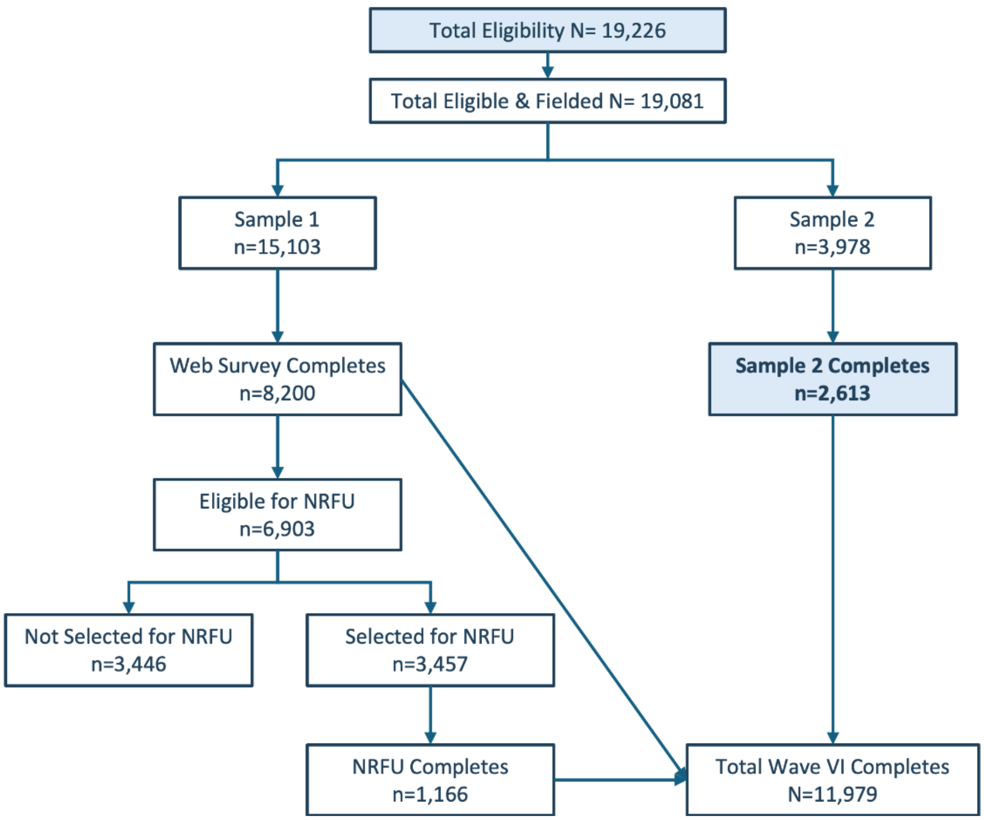
Given its breadth of measures and longitudinal design, Add Health provides a unique opportunity to examine early midlife sensory functioning in a nationally representative cohort that has been followed since adolescence. A central objective of Wave VI was to expand the assessment of cognitive, sensory, and physical functioning. To this end, Wave VI introduced the Add Health Cognitive Assessment, Physical, and Sensory Function (Add CAPS) battery, designed to enable long-term tracking of these domains. These data provide a foundation for identifying early signs of cognitive, physical, and sensory impairment, as well as risk for Alzheimer's disease and related dementias (AD/ADRD) in midlife. The full list of Add CAPS assessments can be found in **Table 1.**

Add CAPS User Guide	Add CAPS Data Set	Add CAPS Assessment	Cognitive Domain Measured
TestMyBrain	accb1_6.sas7bdat	Verbal Paired Associates	Episodic Memory
		Digit Symbol Matching	Processing Speed
		Gradual Onset Continuous Performance Test	Executive Functioning
		Backward Digit Span	Working Memory
NIH Toolbox Cognition	accb3_6.sas7bdat	Dimensional Change Card Sort Test	Executive Functioning
		Pattern Comparison Processing Speed Test	Processing Speed
		Picture Vocabulary Test	Language/Semantic Fluency
Interviewer-Administered Word Recall and Backward Digit Span	accb2_6.sas7bdat	Immediate Word Recall	Episodic Memory
		Delayed Word Recall	Episodic Memory
		Backward Digit Span	Working Memory
Animal Naming Test	acaf_6.sas7bdat	Animal Naming Test	Language/Semantic Fluency
Sensory Function	acsb_6.sas7bdat	hearX hearTest	
Physical Function	acpb_6.sas7bdat	Handgrip Strength	

Table 1. Wave VI Add CAPS assessments and corresponding datasets and User Guides.

Add Health Wave VI was divided into two nationally representative subsamples: Sample 1 and Sample 2 (as detailed in the Sampling and Mixed-Mode Survey Design User Guide; see Hummer et al. 2025). The breakdown of Wave VI sample assignments can be seen in **Figure 1.** Sample 1 members received a primarily web-based, two-phase mixed-mode design, which included web-based cognitive assessments (see the TestMyBrain User Guide (Aiello et al. 2025)). Sample 2 members (N=2,613) received an in-person interview which included the Sample 1 survey content plus in-person cognitive, physical, and sensory functioning assessments (the remaining Add CAPS assessments). At the end of Sample 2 data collection, a small number of Sample 2 members who could not schedule an in-person interview were permitted to complete the web survey and thus did not receive the in-person Add CAPS assessments (N=70).

Figure 1: Overview of Wave VI Sample Design and Completes



Sensory assessments were conducted only among Sample 2 participants (N=2,613). Data included in the Sensory Function dataset can be linked to the full survey data with the Sample 2 Mixed-Mode Survey data file (w6w2.sas7bdat), described in the Wave VI Sampling and Mixed-Mode Survey User Guide (Hummer et al. 2025) and the Wave VI Sample 2: Mixed-Mode Survey Codebook (https://addhealth.cpc.unc.edu/wp-content/uploads/docs/restricted_use/WaveVISample2MixedModeSurveyCodebook.pdf). For cross-sectional estimations of the Add CAPS assessments in Sample 2, optimized Sample 2 weights have been created (variable GSW6_2) and should be used in all corresponding analyses. For further details on the weighting methodology and usage recommendations, please see the Guide to Using Cross-Sectional and Longitudinal Weights in Add Health Wave VI (see Liao et al. 2025).

The inclusion of an interviewer-administered hearX hearTest™ audiology assessment reflects Add Health's commitment to systematically measuring sensory functioning in early midlife within a nationally representative sample.

2. General Overview of the Add CAPS Hearing Assessment

The Add Health Hearing Assessment was conducted in-person among Sample 2 participants. While there are 2,613 total participants in Sample 2 of Wave VI, a total of 2,439 Sample 2 participants participated in the hearing assessment. This Sensory Function data set is best used in conjunction with the Sample 2 Mixed-Mode Survey Data Set (https://addhealth.cpc.unc.edu/wp-content/uploads/docs/restricted_use/WaveVISample2MixedModeSurveyCodebook.pdf). The AID variable available in both data sets facilitates this linkage.

Hearing is commonly measured by pure-tone audiometry (PTA), where the lowest threshold (volume) at which an individual can detect tones across different frequencies (pitches) is obtained (Lin & Reed, 2021). Pure-tone audiometry is the criterion standard for defining hearing loss in epidemiologic studies and the basis of clinical audiometry (WHO, 1991). Importantly, it does not represent a measure of understanding or processing sound beyond detection and, as such, does not align perfectly with self-report hearing, which often reflects a research participant's perception of speech understanding rather than detection. The Add Health protocol assesses what is referred to as air-conduction audiometry, which requires the signal to move through the entire ear (outer and middle ear space) to the cochlea (organ of hearing) and could be impacted by rare cases of fully impacted cerumen (wax) in the ear canal or fluid in the middle ear space.

2.1 Equipment

Pure-tone audiometry was measured using the hearX hearTest™ application administered via a Samsung tablet with annually calibrated Sennheiser HD 280 PRO sound attenuating headphones. The hearTest™ application uses an automated protocol that replicates clinical best-practice to complete pure-tone audiometry. The Add Health protocol includes pure-tone thresholds, measured in decibels hearing level (dB HL) [volume], at 500, 1000, 2000, 4000, and 8000 Hertz (Hz) [frequencies] for each ear.

3. Frequency Thresholds and Pure Tone Averages

3.1 Rationale

Untreated hearing loss is considered a key modifiable risk factor for dementia, including Alzheimer's disease (Livingston et al., 2020). Hearing is a critical sensory function that plays a significant role in cognitive health and has been consistently linked to the risk of developing Alzheimer's disease in older populations. The auditory system is deeply connected to cognitive processes such as memory, attention, and problem-solving. When hearing is impaired, the brain receives less stimulation, which can lead to cognitive decline. In addition to direct impacts on processing and stimulation, there is evidence that hearing may influence cognition through social pathways (Maharani et al., 2019). Thus, maintaining hearing health is critical for preserving cognitive function and reducing the risk of Alzheimer's disease.

Research on the link between hearing and cognition in people under the age of 50 is scarce, with most studies focusing on older individuals. Specific research on early midlife hearing and cognition is missing, particularly in nationally representative studies. Further, most studies on hearing and cognition have not focused on diverse populations, including varied racial, ethnic, and socioeconomic groups, or urban-rural settings. Including hearTest^{TM} in the Add Health Wave VI protocol fills these important gaps in the literature.

3.2 Measurement and Protocol

During the test administration, interviewers first instructed the participant to raise their hand when they heard a tone during the test, then carefully placed headphones onto participants' ears. Test administration was completed by the interviewer while the interviewer stood behind the participant, out of the participant's peripheral view. This positioning helped prevent false responses due to a participant visually witnessing the interviewer touch the tablet screen to activate sound. Before the assessment began, a scan of the test environment for ambient noise levels that could interfere with the assessment was run by the hearTest Noise Check^{TM}. Interviewers were instructed to remove any noise source detected that could interfere with the assessment. Following ambient noise detection, the interviewer activated the hearing test protocol: pure-tone (i.e., single frequency) signals were presented at descending volumes until the participant could no longer detect the signal; then, pure-tone signals were presented at increasing volumes until the participant could detect the signal again. Thresholds were defined as the lowest level at which a participant repeatedly responded to the ascending (increasing volume) signal. The Add Health protocol includes pure-tone thresholds, measured in decibels hearing level (dB HL) [volume], at 500, 1000, 2000, 4000, and 8000 Hertz (Hz) [frequencies] for each ear. The decibel limits of the hearTest^{TM} portable audiometer are 0 dB HL to 95 dB HL for frequencies 500 through 4000 Hz, and 90 dB HL for 8000 Hz.

3.3 Quality Control & Audiologist Review

To ensure high-quality data collection, a quality control review of all data was performed to check for patterns consistent with those observed across previous studies with similar study populations. Following data collection, responses were flagged for the following potential concerns: ambient noise levels detected during the assessment that could interfere with testing, rapid (< 2 minutes) or long (> 10 minutes) test time, asymmetrical responses between ears, differences in threshold levels greater than 15 dB HL in adjacent frequencies in one ear (e.g., 0 dB HL at 1000Hz to 30 dB HL at 2000Hz), and known abnormal patterns of hearing (e.g., rising patterns going from worse to better hearing which is the reverse of the common pattern going from better to worse hearing in lower and higher frequencies, respectively). All flagged data were reviewed by an independent audiologist for confirmation that data was unreliable (e.g., data needing to be removed) or was a feasible response (e.g., data included). The conservative review protocol resulted in 1901 of 2440 tests sent for review. One participant's data was removed based on the audiologist review, leaving a final total of 2439 hearing tests with valid data.

3.4 Variable Construction

3.4.1 Left Ear Pure Tone Average [C6SB02_L]

An average of the decibels hearing level (volume) measured at each of the five frequencies, for the left ear.

3.4.2 Right Ear Pure Tone Average [C6SB02_R]

An average of the decibels hearing level (volume) measured at each of the five frequencies, for the right ear.

3.4.3 Hearing Thresholds [C6SB03_L – C6SB07_L; C6SB03_R – C6SB07_R)

The thresholds for left and right ear at each frequency (500, 1000, 2000, 4000, and 8000 Hz).

3.4.4 Noise Indicators [C6SB08_L – C6SB12_L; C6SB08_R – C6SB12_R)

The noise indicator for left and right ear at various frequencies (500, 1000, 2000, 4000, and 8000 Hz).

3.4.5 Duration [C6SB13]

The length of time it took to complete the hearing test, in seconds.

3.4.6 Qualitative Flag 1 [C6SBF1]

Tests were flagged with Qualitative Flag 1 if a distraction or interruption occurred during the test.

3.4.7 Qualitative Flag 2 [C6SBF2]

Tests were flagged with Qualitative Flag 2 when an interviewer capture issue was reported.

3.4.8 Qualitative Flag 3 [C6SBF3]

Tests were flagged with Qualitative Flag 3 when a technical issue occurred.

3.4.9 Qualitative Flag 4 [C6SBF4]

Tests were flagged with Qualitative Flag 4 when the respondent reported physical impairment or pain.

3.4.10 Qualitative Flag 5 [C6SBF5]

Tests were flagged with Qualitative Flag 5 when an administration or instruction issue occurred.

3.4.11 Qualitative Flag 6 [C6SBF6]

Tests were flagged with Qualitative Flag 6 when the respondent reported fatigue or displayed low effort.

3.4.12 Sensory Battery Duration – Seconds [C6SBTS]

The total amount of time it took for the administration of the hearing portion of the survey, including setup, in seconds.

3.4.13 Time Flag 1 [C6SBTF]

Tests were flagged with Time Flag 1 when there was an unexpectedly long or short test duration.

3.4.14 Time Flag 2 [H6SBT1*x*]

Flag assigned if duration is unexpectedly long or short for one of the following reasons:

- Technical difficulties [H6SBT1]
- Participant took a break [H6SBT2]
- Interruption [H6SBT3]
- Did not complete test [H6SBT4]
- Did not understand instructions [H6SBT5]
- Physical or cognitive disability [H6SBT6]
- Other [H6SBT7]
- Refused to participate [H6SBT8]

3.5 Interpretation Guidance

Data are available for threshold at each frequency (500, 1000, 2000, 4000, and 8000 Hz) for each ear. Lower levels represent 'better' hearing. The common metric for hearing in epidemiologic studies is the 4-frequency (500, 1000, 2000, and 4000 Hz) pure-tone average (e.g., an average of the thresholds at these 4 frequencies) in the better hearing ear (e.g., lower average between ears). These four frequencies represent the most important frequencies for speech understanding and, generally, the 4-frequency pure-tone average in the better hearing ear represents the lowest level at which a participant can detect speech in normal listening environments. The pre 2023 World Health Organization (WHO) and American Speech Language Hearing Association (ASHA) criteria, which is the most commonly used criteria for hearing loss categorization, considered a pure-tone average above 25 dB HL as "hearing loss". In 2023, the WHO lowered this threshold to 20 dB HL. Please see **Table 2** below for more information regarding the updated WHO criteria for hearing loss severity cutoffs. The Add Health protocol does not represent a diagnostic evaluation of hearing loss.

Table 2. Hearing impairment categories reproduced from World Health Organization. (1991). Report of the informal working group on prevention of deafness and hearing impairment Programme planning, Geneva, 18-21 June 1991.

Grade of impairment	Corresponding audiometric ISO value[a,b]	Performance	Recommendations	Comments added to the previous classification
0: No impairment	25 dB or better	No or very slight hearing problems. Able to hear whispers	None	20 dB also recommended. People with 15-20 dB levels may experience hearing problems. People with unilateral hearing losses may experience hearing problems even if better ear normal
1: Slight impairment	26-40 dB	Able to hear and repeat words spoken in normal voice at 1m	Counselling. Hearing aids may be needed	Some difficulty in hearing but can usually hear normal level of conversation
2: Moderate impairment	41-60 dB	Able to hear and repeat words using raised voice at 1m	Hearing aids usually recommended	None
3: Severe impairment	61-80 dB	Able to hear some words when shouted into better ear	Hearing aids needed. If no hearing aids available, lip-reading should be taught	Discrepancies between pure-tone thresholds and speech discrimination score should be noted
4: Profound impairment, including deafness	81 dB or greater	Unable to hear and understand even a shouted voice	Hearing aids may help in understanding words. Additional rehabilitation needed. Lip-reading and sometimes signing are essential.	Spoken speech distorted, the degree depending on the age at which hearing was lost

dB: decibel; Hz: Hertz; ISO: International Organization for Standardization; m: meter.
[a]In the better ear.
[b]Average of 500, 1000, 2000 and 4000 Hz.
Notes: Disabling hearing loss refers to hearing loss greater than 40 dB in the better hearing ear in adults (Grades 2, 3, and 4) and greater than 30 dB in the better hearing ear in children.

4. Self-reported hearing-related Screening Questions

Several screening questions were asked of Sample 2 Add Health participants relating to their sensory function, some of which determined participants' eligibility to complete the hearX hearTest.

4.1.1 Stuffy Nose [H6SB01]

Participants indicated yes (1) if they had a stuffy nose at the time of data collection.

4.1.2 Ear Infection [H6SB02]

Participants indicated yes (1) if they had an active ear infection or any drainage from their ears at the time of data collection. If a participant answered yes to this question, he/she was ineligible to take the hearing test.

4.1.3 Ear Pain [H6SB03]

Participants indicated yes (1) if they were currently experiencing any pain in or around their ears that would prevent them from taking a hearing test at the time of data collection. If a participant answered yes to this question, he/she was ineligible to take the hearing test.

4.1.4 Vertigo [H6SB04]

Participants indicated yes (1) if they were experiencing vertigo or dizziness at the time of data collection.

4.1.5 Cochlear Implant [H6SB05]

Participants indicated yes (1) if they were using a surgically implanted cochlear device, such as a cochlear implant, at the time of data collection.

4.1.6 Cochlear: Able to Remove [H6SB06]

Participants indicated yes (1) if they were able to remove their hearing implant for the hearing test, at the time of data collection.

4.1.7 Hearing Aid [H6SB07]

Participants indicated yes (1) if they were wearing a hearing aid at the time of data collection.

4.1.8 Hearing Aid: Able to Remove [H6SB08]

Participants indicated yes (1) if they were able to remove their hearing aid for the hearing test.

5. The Sensory Function Data File (acsb_6.sas7bdat)

5.1 Structure

The structure of the disseminated Sensory Function Data file is flat. This means that it is a respondent-level data file, wherein each respondent has one and only one record. The respondent identifier (AID) will appear in the data file only once.

5.2 Contents

The Sensory Function data file includes the variables below, which are described in the corresponding codebook documentation that also contains frequencies.

Variable Name	**Variable Description**
AID	Respondent Identifier
H6SB01	Current stuffy nose
H6SB02	Current ear infection
H6SB03	Current ear pain
H6SB04	Current vertigo
H6SB05	Current cochlear device use
H6SB06	Cochlear device: ability to remove
H6SB07	Current hearing aid use
H6SB08	Current hearing aid: ability to remove
C6SB01	Headset Model
C6SB02_L	Pure Tone Average, Left Ear
C6SB02_R	Pure Tone Average, Right Ear
C6SB03_L	Hearing Threshold at 500 Hz, Left Ear
C6SB03_R	Hearing Threshold at 500 Hz, Right Ear
C6SB04_L	Hearing Threshold at 1000 Hz, Left Ear

C6SB04_R	Hearing Threshold at 1000 Hz, Right Ear
C6SB05_L	Hearing Threshold at 2000 Hz, Left Ear
C6SB05_R	Hearing Threshold at 2000 Hz, Right Ear
C6SB06_L	Hearing Threshold at 4000 Hz, Left Ear
C6SB06_R	Hearing Threshold at 4000 Hz, Right Ear
C6SB07_L	Hearing Threshold at 8000 Hz, Left Ear
C6SB07_R	Hearing Threshold at 8000 Hz, Right Ear
C6SB08_L	Noise Indicator at 500 Hz, Left Ear
C6SB08_R	Noise Indicator at 500 Hz, Right Ear
C6SB09_L	Noise Indicator at 1000 Hz, Left Ear
C6SB09_R	Noise Indicator at 1000 Hz, Right Ear
C6SB10_L	Noise Indicator at 2000 Hz, Left Ear
C6SB10_R	Noise Indicator at 2000 Hz, Right Ear
C6SB11_L	Noise Indicator at 4000 Hz, Left Ear
C6SB11_R	Noise Indicator at 4000 Hz, Right Ear
C6SB12_L	Noise Indicator at 8000 Hz, Left Ear
C6SB12_R	Noise Indicator at 8000 Hz, Right Ear
C6SB13	Test Duration
C6SBF1	Distraction or interruption
C6SBF2	Field interviewer capture issues
C6SBF3	Technical issue
C6SBF4	Physical impairment or pain
C6SBF5	Administration or instruction
C6SBF6	Fatigue or low effort
C6SBTS	Sensory function battery duration, seconds
C6SBTF	Was the test duration as expected, shorter than expected, or longer than expected
H6SBT1	Technical difficulties
H6SBT2	Respondent took a break
H6SBT3	Interruption
H6SBT4	Did not complete test
H6SBT5	Did not understand instructions
H6SBT6	Physical or cognitive disability
H6SBT7	Other
H6SBT8	Refused to participate

6. Acknowledgement

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7. References

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