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Hearing Loss and Cognition: Public Health Insights

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09/24/2024

Optimal Aging Institute

Agenda -ish

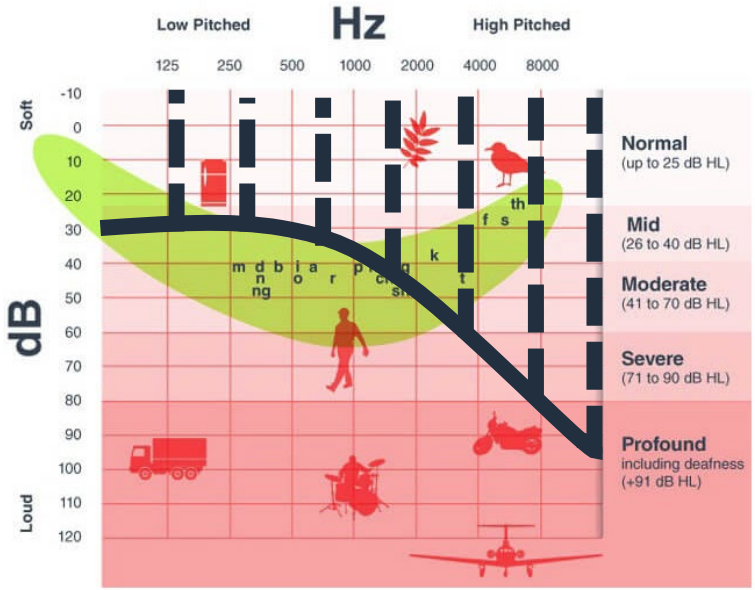
Hearing, cognition, and dementia (Nicholas S. Reed)

Defining hearing loss, prevalence, **shared sensory mechanisms**, epidemiologic insights on hearing loss and cognitive decline, recent trials

Vision, cognition, and dementia (Joshua R. Ehrlich)

Defining vision loss, prevalence, epidemiology of vision loss and neurocognition, **sensory loss and delirium**

Hearing Loss: Clarity Not Volume



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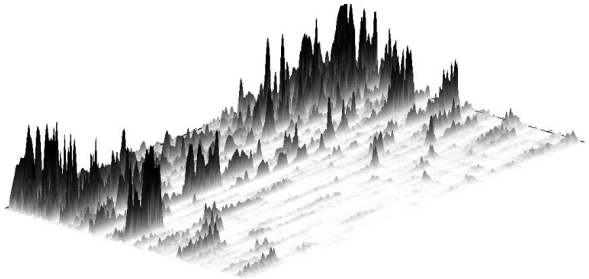
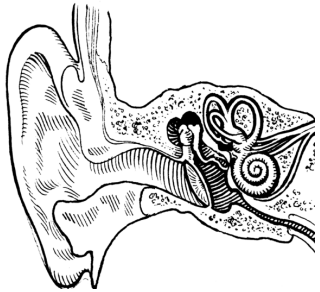
How We Hear: Peripheral Encoding & Central Decoding



“SUNDAY”

Peripheral Encoding in the Cochlea



Central Decoding in the Cochlea

Hearing Loss and Cochlear Impairment

Decreased sensitivity and distortion in sound encoding

“Effortful listening”

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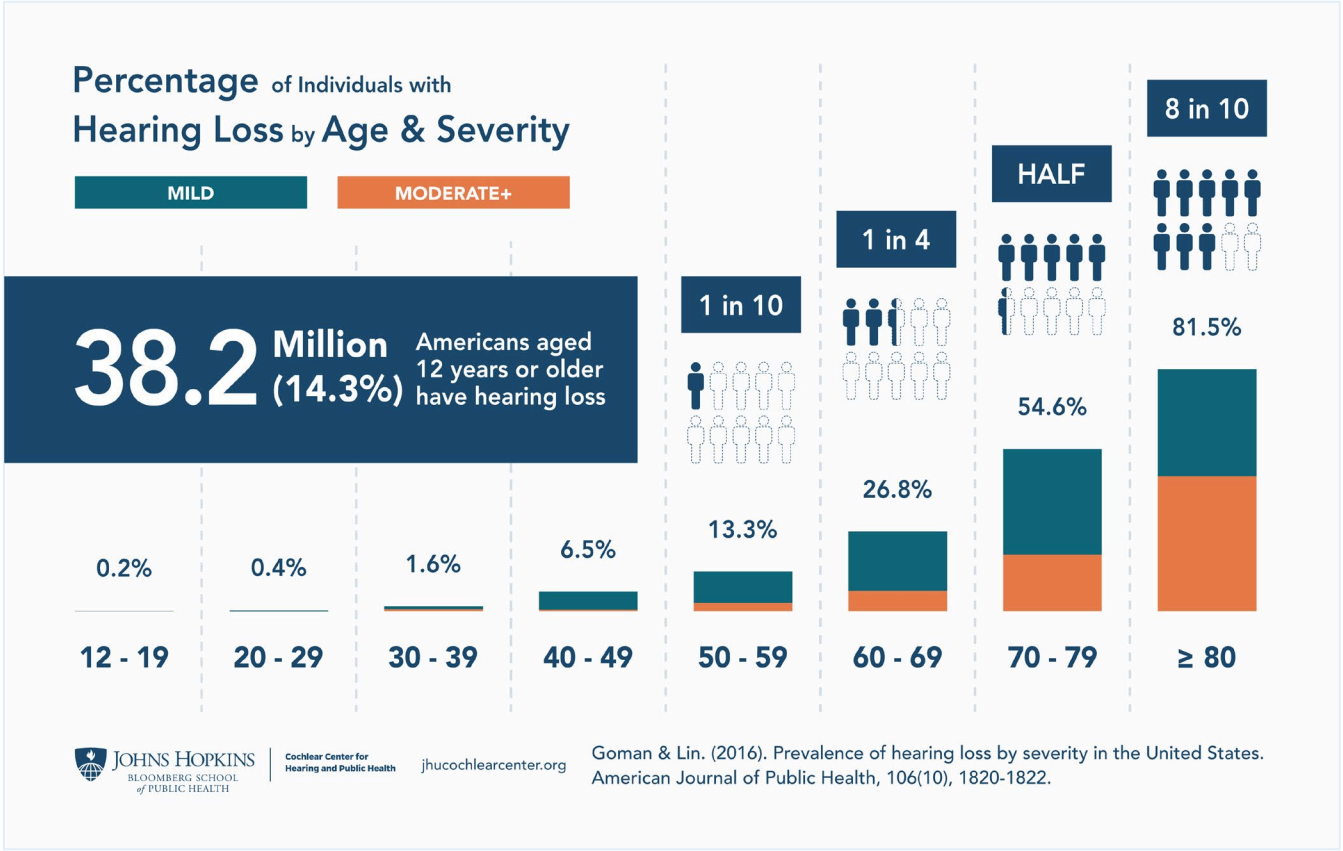
Hearing Loss and Age in the United States



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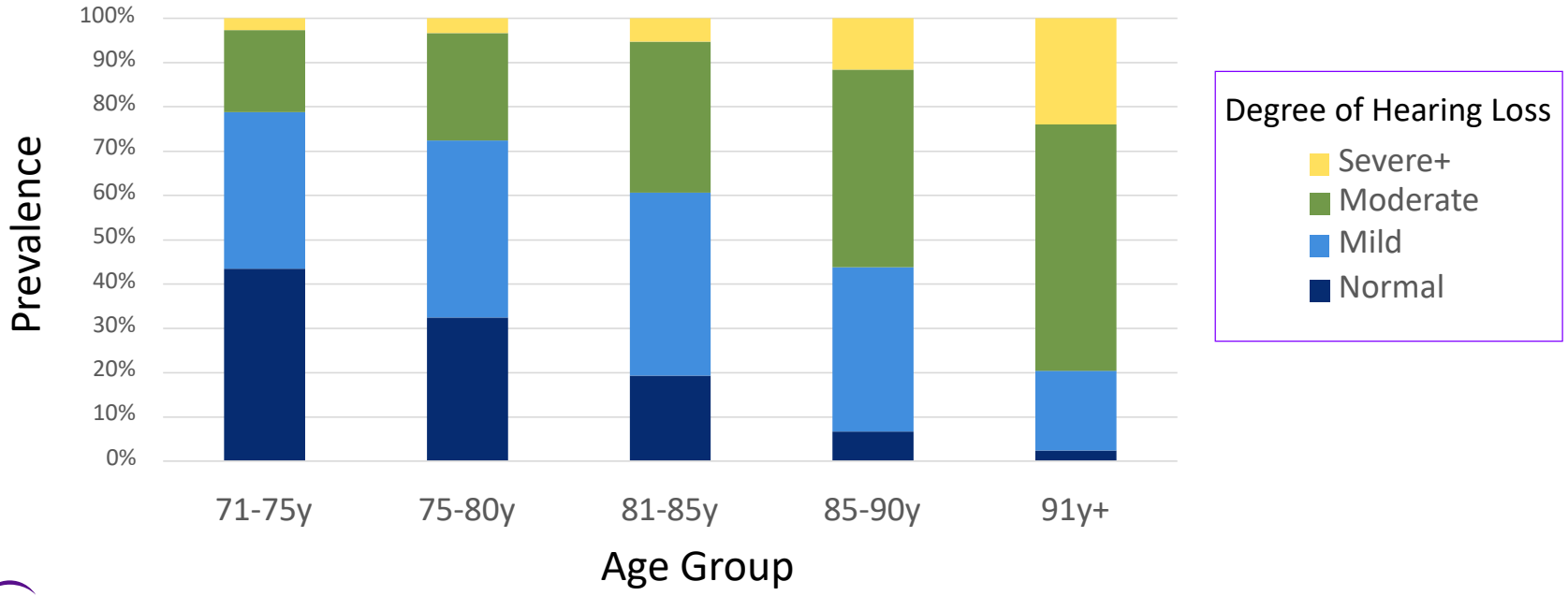
Prevalence of Hearing Loss in Adults Aged ≥71 Years in the United States: National Health & Aging Trends Study



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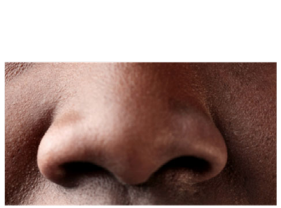
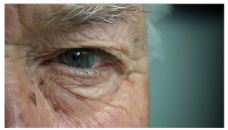
Reed NS, Garcia-Morales EE, Myers C et al. Prevalence of Hearing Loss and Hearing Aid Use Among US Medicare Beneficiaries Aged 71 Years and Older. JAMA Netw Open. 2023 Jul 3;6(7):e2326320. doi: 10.1001/jamanetworkopen.2023.26320.



Disease
(e.g., DM, HTN, etc.)

Risk Factors
(e.g., genetics, diet)



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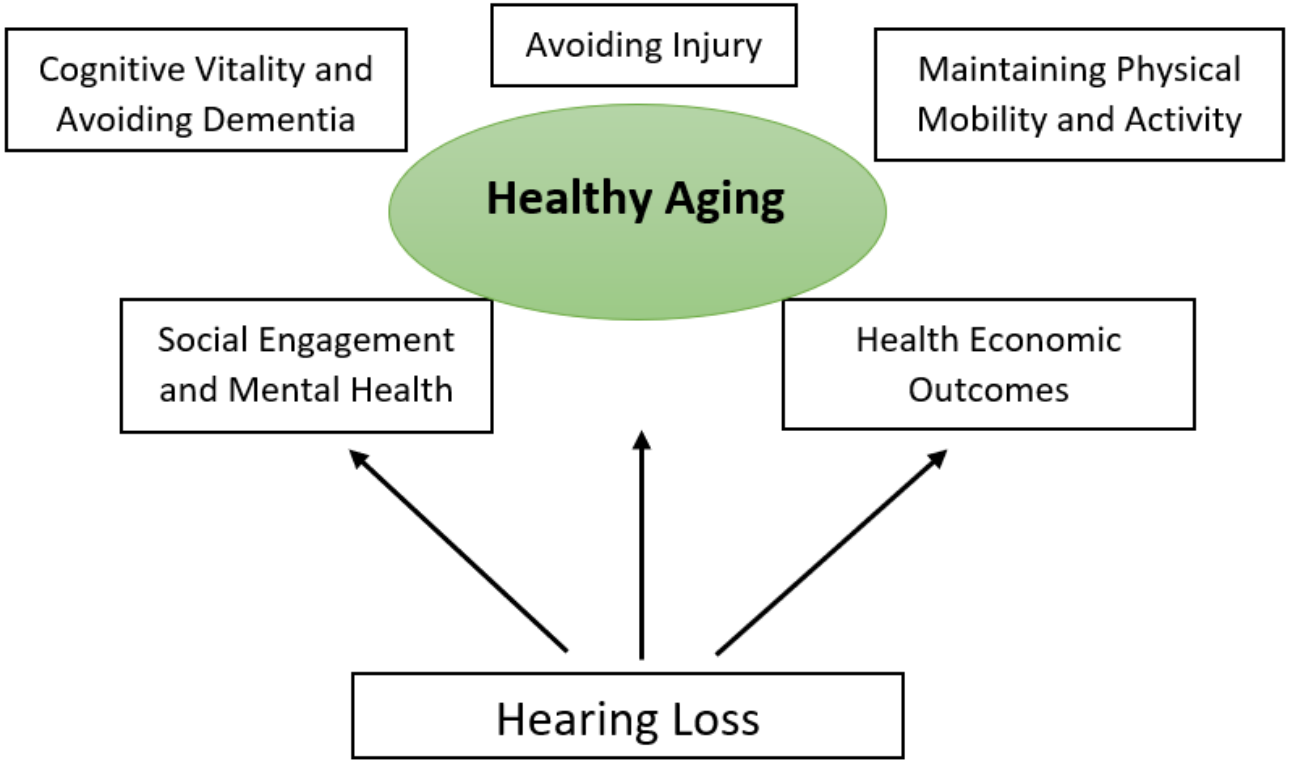
Healthy Aging & Hearing



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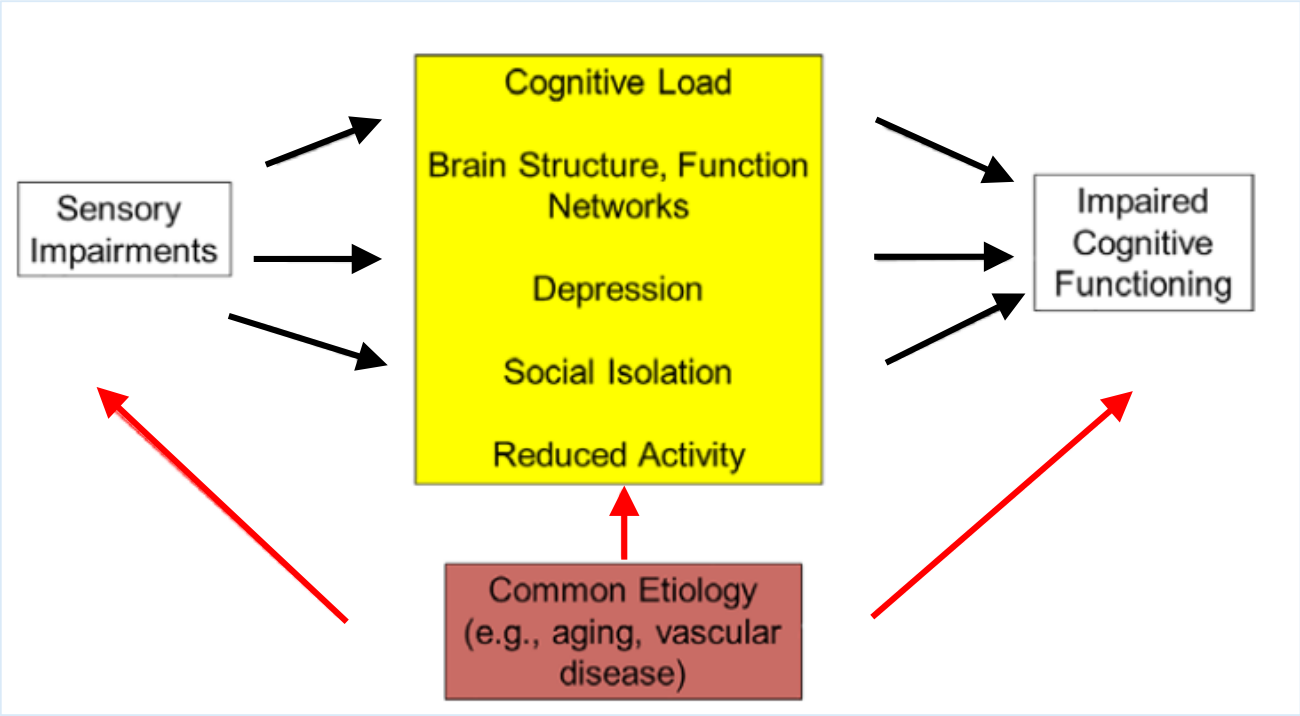
Linking Sensory Loss to Cognition & Dementia



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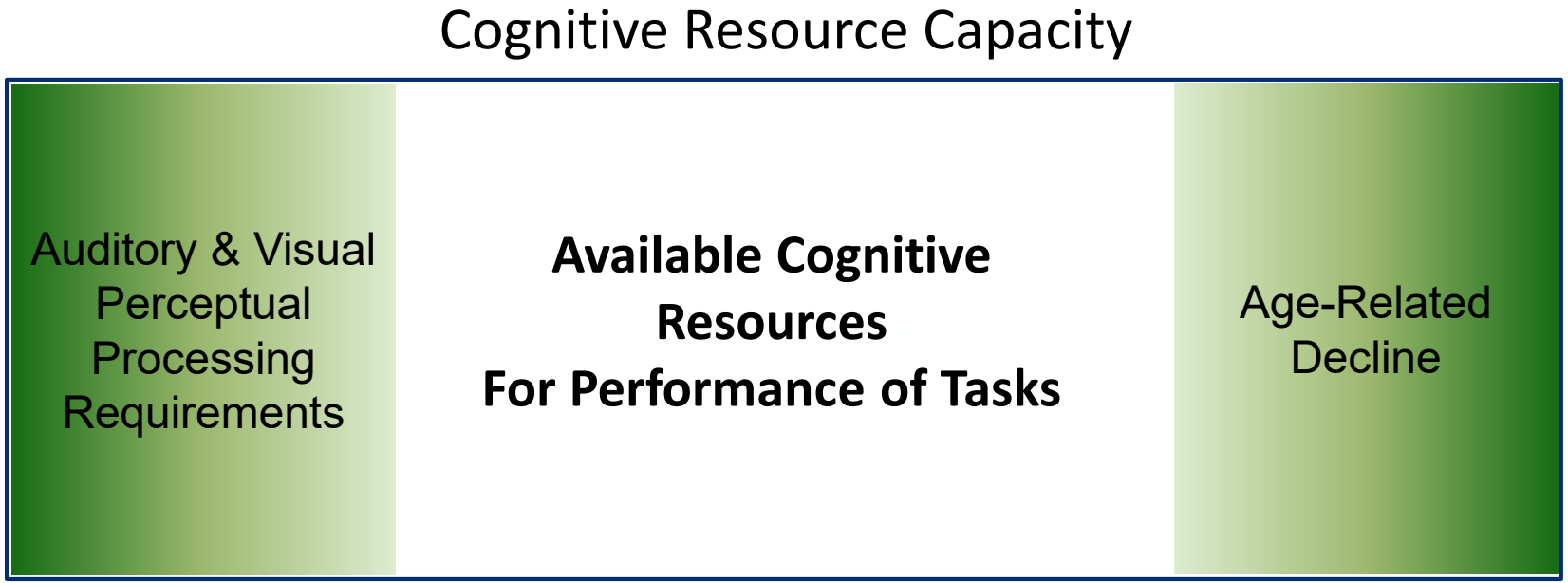
Whitson HE et al. American Geriatrics Society and National Institute on Aging Bench-to-Bedside Conference: Sensory Impairment and Cognitive Decline in Older Adults. J Am Geriatr Soc. 2018 Nov;66(11):2052-2058. doi: 10.1111/jgs.15506. Epub 2018 Sep 24.

Sensory Loss and Cognitive Load

Kahneman model of shared attention and resource capacity



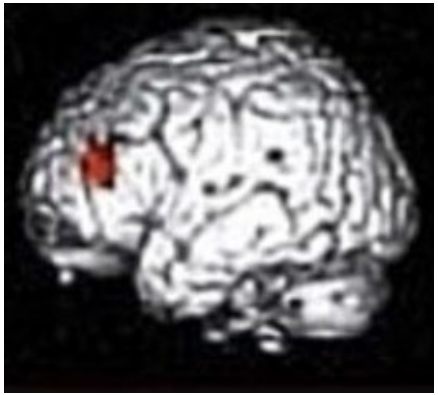
Kahneman D. Attention and effort. Prentice-Hall, Inc. 1973;1063:73-3375. doi:10.1.1.398.5285.
https://scholar.princeton.edu/sites/default/files/kahneman/files/attention_hi_quality.pdf

Hearing Loss & Cognitive Load

Poorer hearing is associated with:

A. Reduced language-driven activity in primary auditory pathways

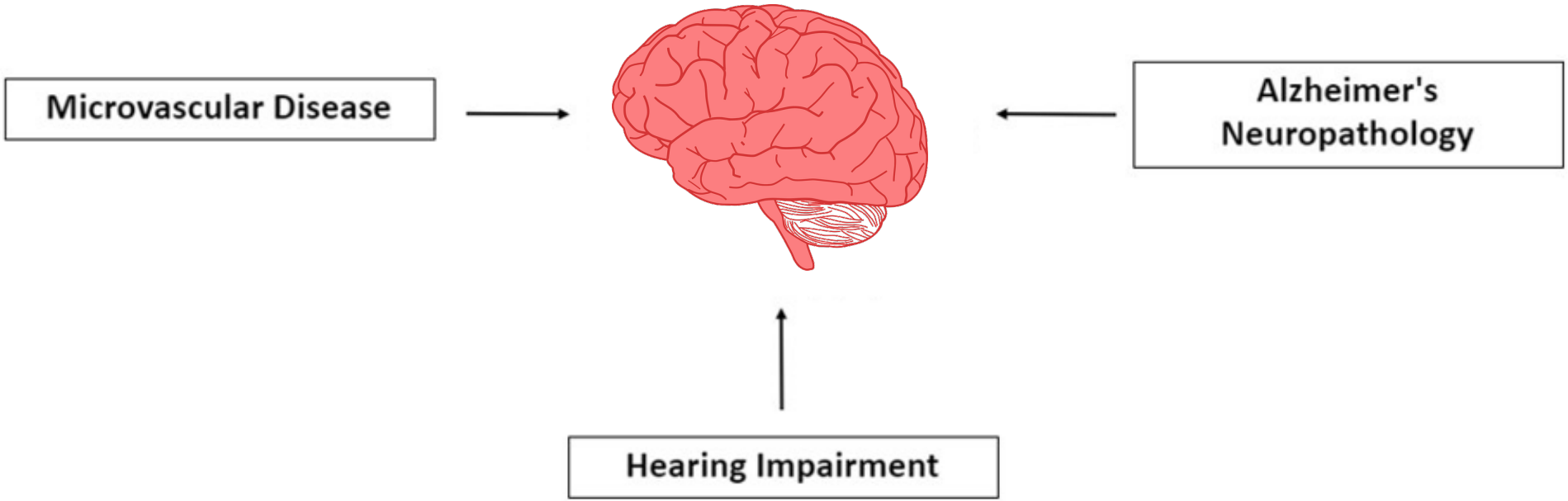
B. Increased compensatory language-driven activity in pre-frontal cortical areas



Cooke A, Zurif E, DeVita C, et al. Neural basis for sentence comprehension: Grammatical and short-term memory components. *Human Brain Mapping*. 2001;15(2):80-94. doi:10.1002/hbm.10006

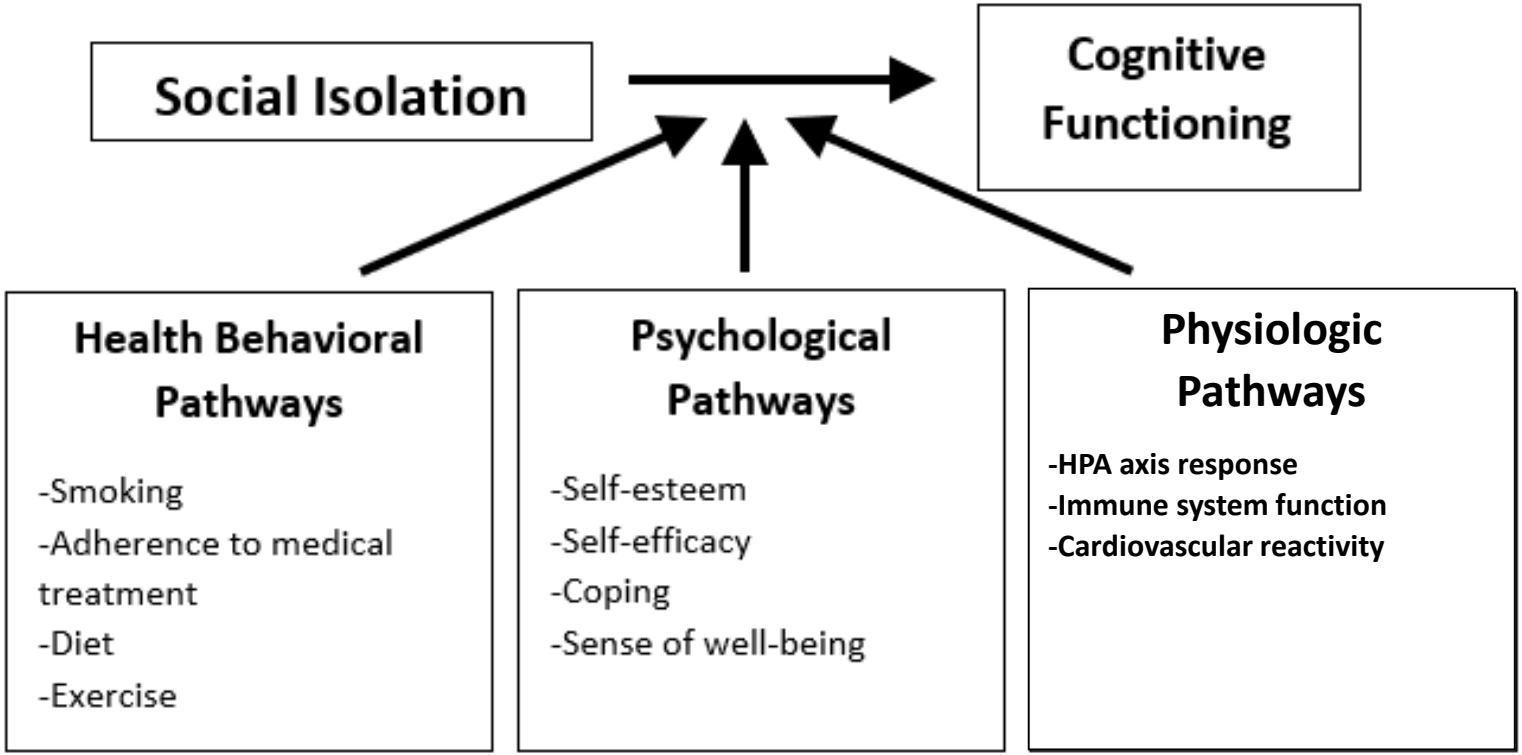
Peelle JE, Troiani V, Grossman M, Wingfield A. et al. Hearing Loss in Older Adults Affects Neural Systems Supporting Speech Comprehension. *The Journal of Neuroscience.* 2011;31(35):12638 –12643. https://www.jneurosci.org/content/jneuro/31/35/12638.full.pdf

Risk Factors for Dementia: Multi-Hit Theoretical Model



Lin FR, Albert M. Hearing loss and dementia – who is listening? *Aging & Mental Health.* 2014;8(6):671-673. doi: 10.1080/13607863.2014.915924.

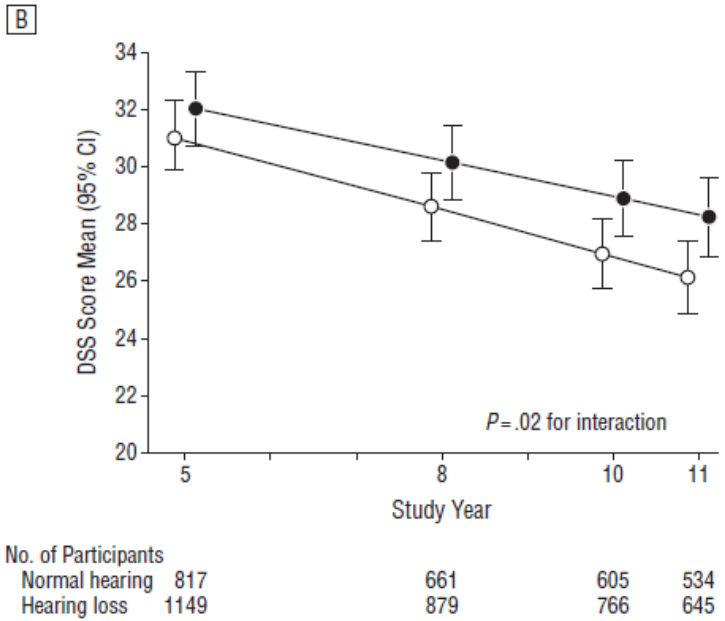
Sensory Loss and Cognition: Social Isolation



Berkman LF, Glass T, Brissette I, Seeman TE. From social integration to health: Durkheim in the new millennium. *Soc Sci Med*. 2000;51(6):843-857. doi:10.1016/s0277-9536(00)00065-4

Hearing Loss & Cognitive Decline *HealthABC*

Adjusted 3MS & DSS scores by years of follow-up and hearing loss status in 1,966 adults > 70 years followed for 6 years



32% faster rate of cognitive decline in DSS scores in HL vs. NH

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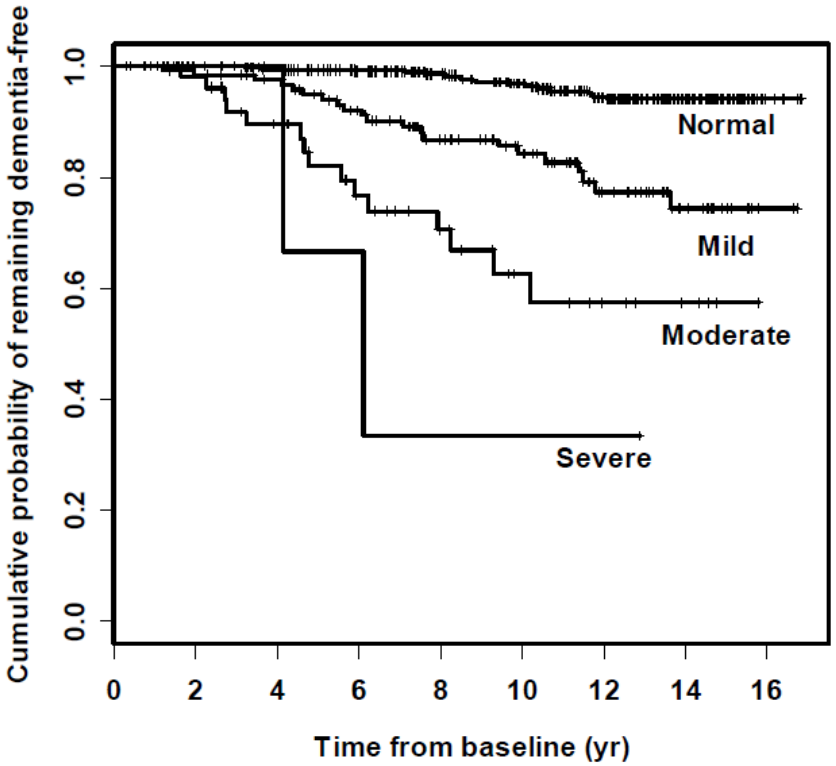
Adjusted for age, sex, race, education, study site, smoking status, hypertension, diabetes, and stroke history

Lin et al. JAMA Int Med. 2013

Hearing Loss & Incident Dementia



639 adults followed for >10 years Baltimore Longitudinal Study on Aging

Risk of All-Cause Dementia*			
	HR	95% CI	p
Mild	1.89	1.00 – 3.58	0.05
Moderate	3.00	1.43 – 6.30	.004
Severe	4.94	1.09 – 22.4	.04

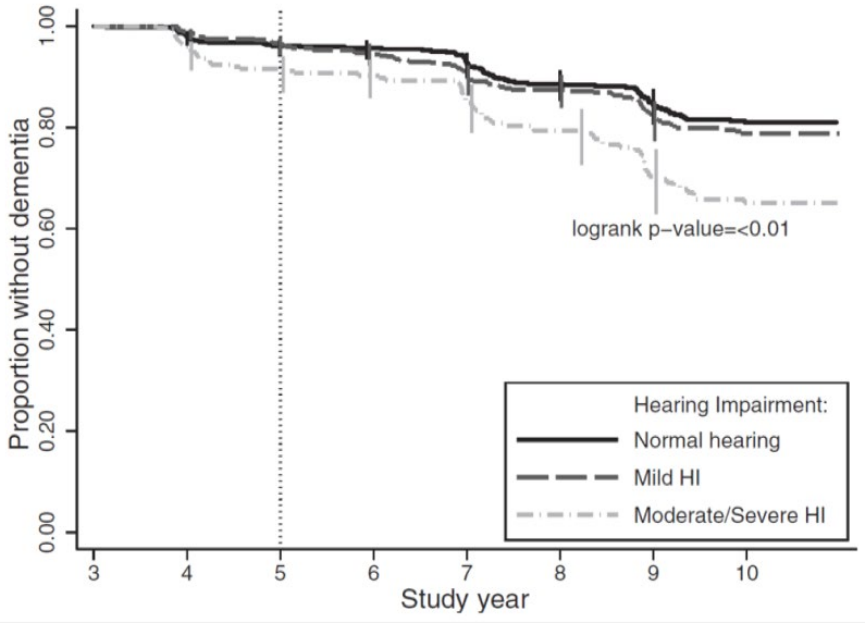
*Compared to normal hearing

Adjusted for age, sex, race, education, diabetes, smoking, & hypertension

Lin FR, Metter EJ, O'Brien RJ, Resnick SM, Zonderman AB, Ferrucci L. Hearing loss and incident dementia. *Arch Neurol*. 2011;68(2):214-220. doi:10.1001/archneurol.2010.362

Hearing Loss & Incident Dementia

1889 adults followed for 9 years Health Aging and Body Composition Study



	Incident Dementia	Model 2†	
	$N_{incident}/N_{total}$ (%)	HR (95% CI)	*p* Value
Follow-up from 1999–2008 (primary analysis)‡			
Normal hearing	80/786 (10)	Referent	—
Mild HI	79/716 (11)	1.02 (0.75, 1.40)	.89
Moderate/severe HI	70/387 (18)	1.55 (1.10, 2.19)	.01
P-trend	—	—	.02
PTA continuous (per 10 dB increase)	—	1.14 (1.03, 1.26)	.01

Adjusted for age, sex, race, education, study site, smoking status, hypertension, diabetes, stroke

Abbreviations: PTA, pure tone average

Deal JA, Betz J, Yaffe K, et al. Hearing Impairment and Incident Dementia and Cognitive Decline in Older Adults: The Health ABC Study. *J Gerontol A Biol Sci Med Sci*. 2017;72(5):703-709. doi:10.1093/gerona/glw069

Hearing Loss, Dementia, Hearing Aids in Observational Data

Table 2. Multivariable-Adjusted Association Between Hearing Loss, Hearing Aid Use, and Dementia, National Health and Aging Trends Study, Round 11, 2021

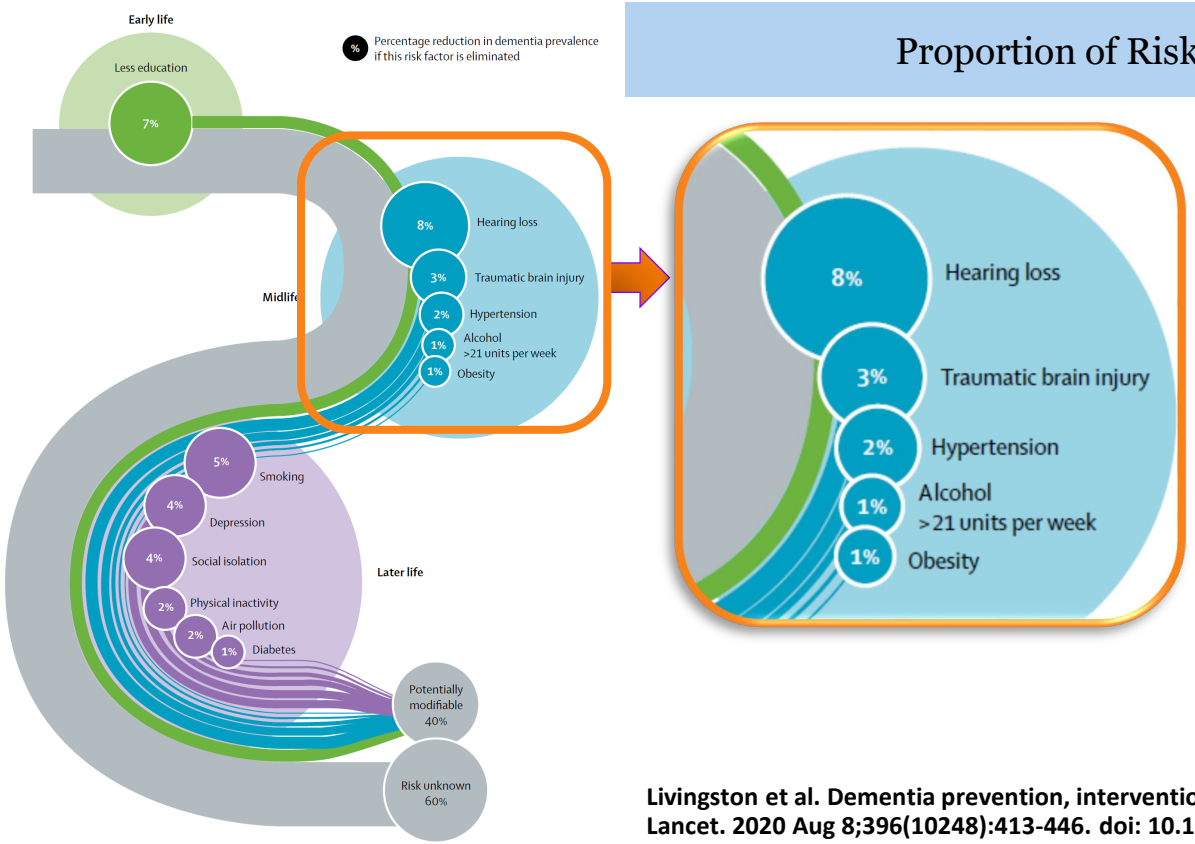
	Unweighted No.	Weighted prevalence of dementia (95% CI)	Prevalence ratio (95% CI)[a]	*P* value
Audiometric hearing	2413			
Normal hearing	674	6.19 (4.31-8.80)	[Reference]	
Mild hearing loss	886	8.93 (6.99-11.34)	1.08 (0.72-1.63)	.71
Moderate to severe hearing loss[b]	853	16.52 (13.81-19.64)	1.61 (1.09-2.38)	.02
P value for trend				.01
Per 10-dB worse hearing			1.16 (1.07-1.26)	<.001
Hearing aid use[c]	853			
No	439	21.53 (16.66-27.37)	[Reference]	
Yes	414	11.46 (8.79-14.82)	0.68 (0.47-1.00)	.05

Caution on Hearing Aids in Observational Data

- People with hearing loss who use hearing aids are different to those with hearing loss who do not use hearing aids
  - Income
  - Education
  - Health seeking behaviors
  - Perception of hearing loss

- Observational data can miss details (ownership ≠ use)

State of Dementia Prevention

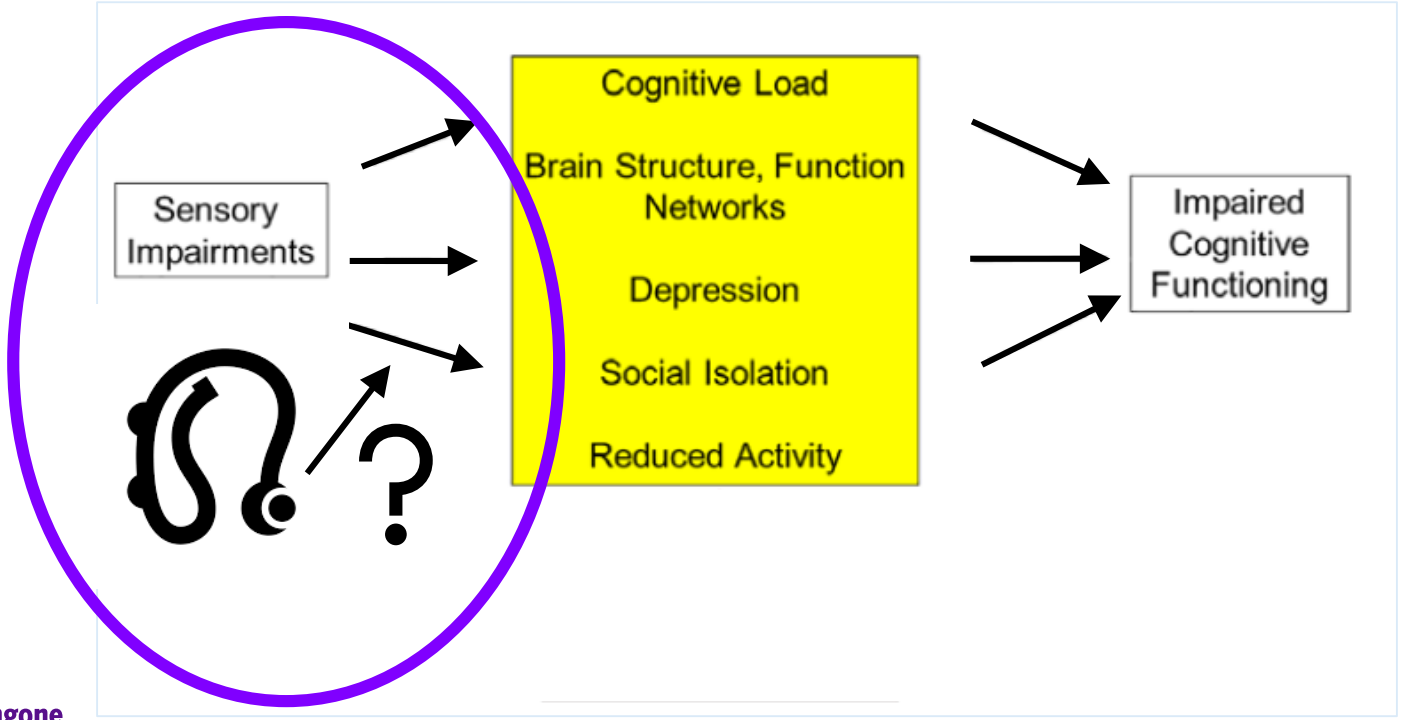


Proportion of Risk Due to Specific Factors

- **Hearing Loss – 8%**
- **Less education – 7%**
- **Smoking – 5%**
- **Depression, Social isolation – 4%**
- **Traumatic brain injury – 3%**
- **Air pollution, Physical inactivity, Hypertension – 2%**
- **Obesity, diabetes, heavy alcohol use – 1%**

Livingston et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. Lancet. 2020 Aug 8;396(10248):413-446. doi: 10.1016/S0140-6736(20)30367-6.

Does Treatment Impact These Pathways? It Should!



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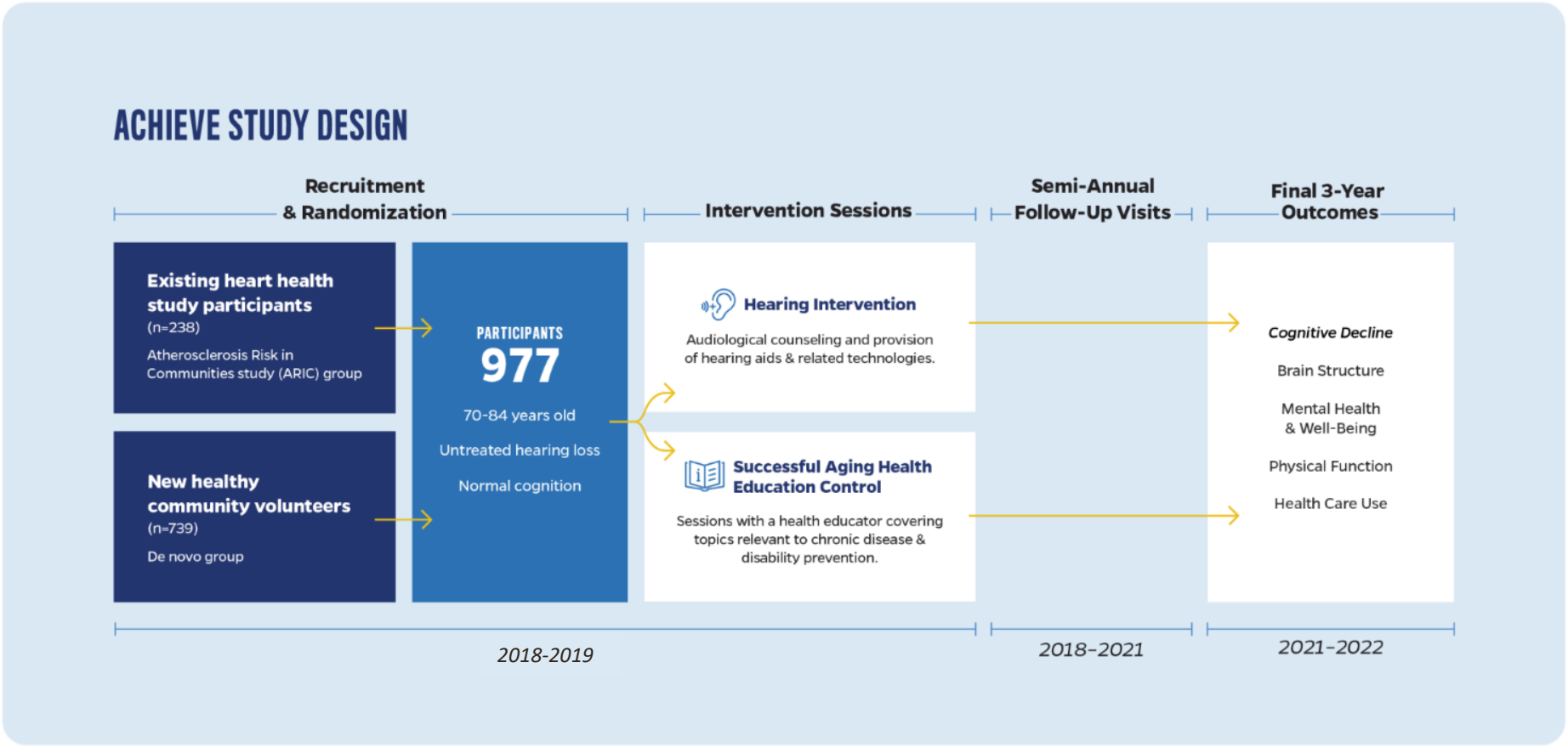


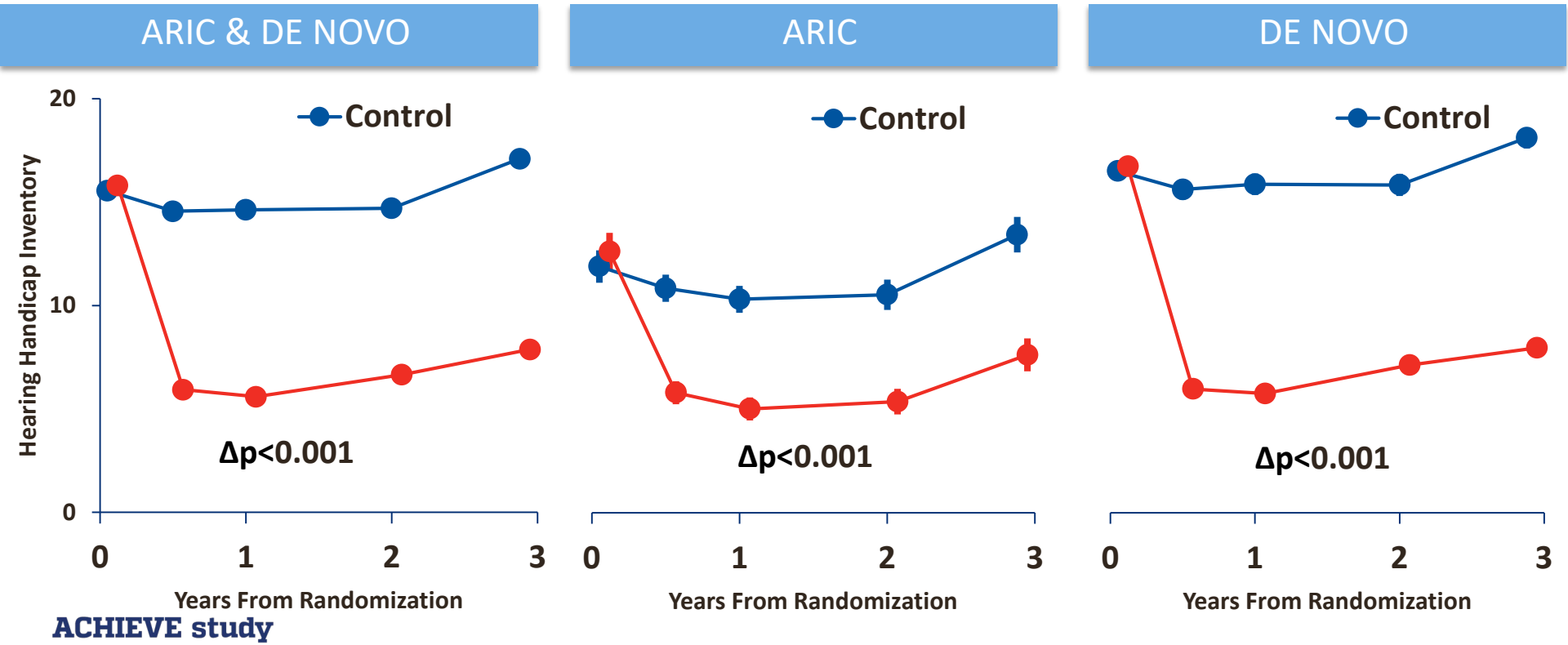
ACHIEVE study

Randomization

- Eligible participants randomized 1:1 to hearing intervention versus health education control, stratified by severity of hearing loss, recruitment source (ARIC vs de novo) & field site.

Hearing Intervention	Health Education Control
• Best-practices hearing intervention provision with a certified study audiologist • 4 sessions to receive hearing loss education and hearing aids & related technologies (streamers, remote mic, etc.) • Semiannual visits thereafter for 3 years to receive booster sessions	• Established program (10 Keys) to promote understanding of key health topics (nutrition, etc.) important for healthy aging • 4 sessions with a certified health educator to cover healthy aging topics • Semiannual visits thereafter for 3 years to receive booster sessions

Hearing Handicap Inventory Scores Over 3 Years



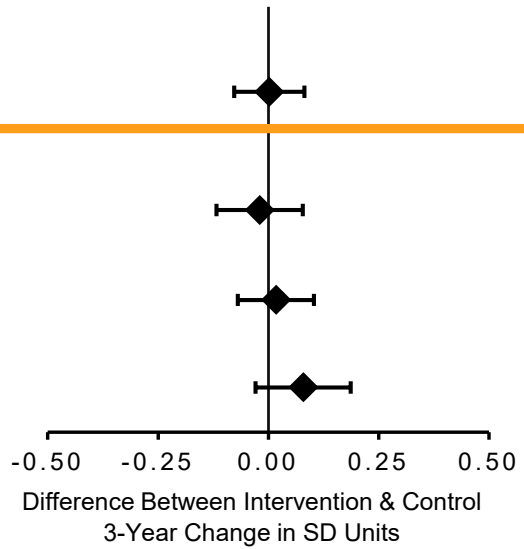
ACHIEVE study

3-Year Change in Global & Domain-Specific Cognition

Main Analysis of the Total Cohort (ARIC & De novo)

Primary & Secondary Outcomes

Total (N = 977^)	3-Year Change in SD Units ß (95% CI)	Difference Between Intervention & Control 3-Year Change in SD Units ß (95% CI)
Primary Outcome:		
Global Cognition		
Control	-0·202 (-0·258, -0·145)	0·002 (-0·077, 0·081)
Intervention	-0·200 (-0·256, -0·144)	p=0·96
Secondary Outcomes:		
Executive Function		
Control	-0·248 (-0·315, -0·181)	-0·020 (-0·118, 0·078)
Intervention	-0·268 (-0·339, -0·197)	p=0·69
Language		
Control	-0·155 (-0·214, -0·096)	0·017 (-0·070, 0·104)
Intervention	-0·138 (-0·199, -0·077)	p=0·70
Memory		
Control	-0·054 (-0·128, 0·020)	0·079 (-0·029, 0·187)
Intervention	0·025 (-0·053, 0·103)	p=0·15

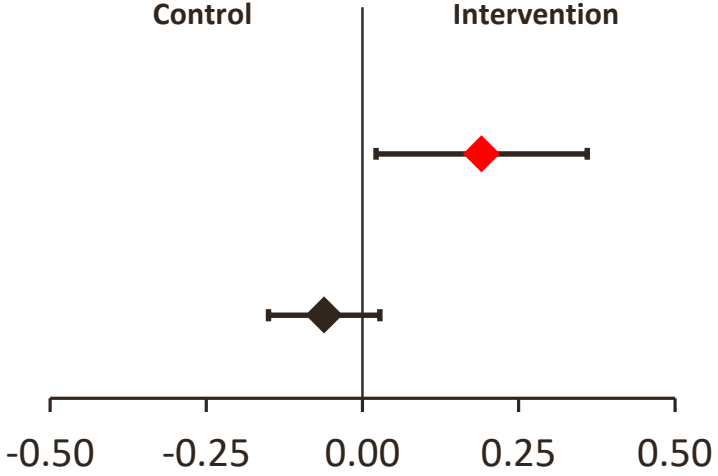


In the total combined cohort, hearing intervention had no effect on reducing cognitive decline within 3 years

ACHIEVE study

3-Year Change in Global Cognition (N=977)

	3-Year Change in SD Units β (95% CI)	Difference Between Intervention & Control 3-Year Change in SD Units β (95% CI)
ARIC (N=238)		
Control	-0.402 (-0.536, -0.267)	0.191 (0.022, 0.360)
Intervention	-0.211 (-0.349, -0.073)	p=0.027
De novo (N=739)		
Control	-0.151 (-0.215, -0.087)	-0.061 (-0.151, 0.028)
Intervention	-0.213 (-0.277, -0.148)	p=0.18



Baseline Characteristics by Recruitment Source

ARIC cohort at increased risk for cognitive decline compared to De novo

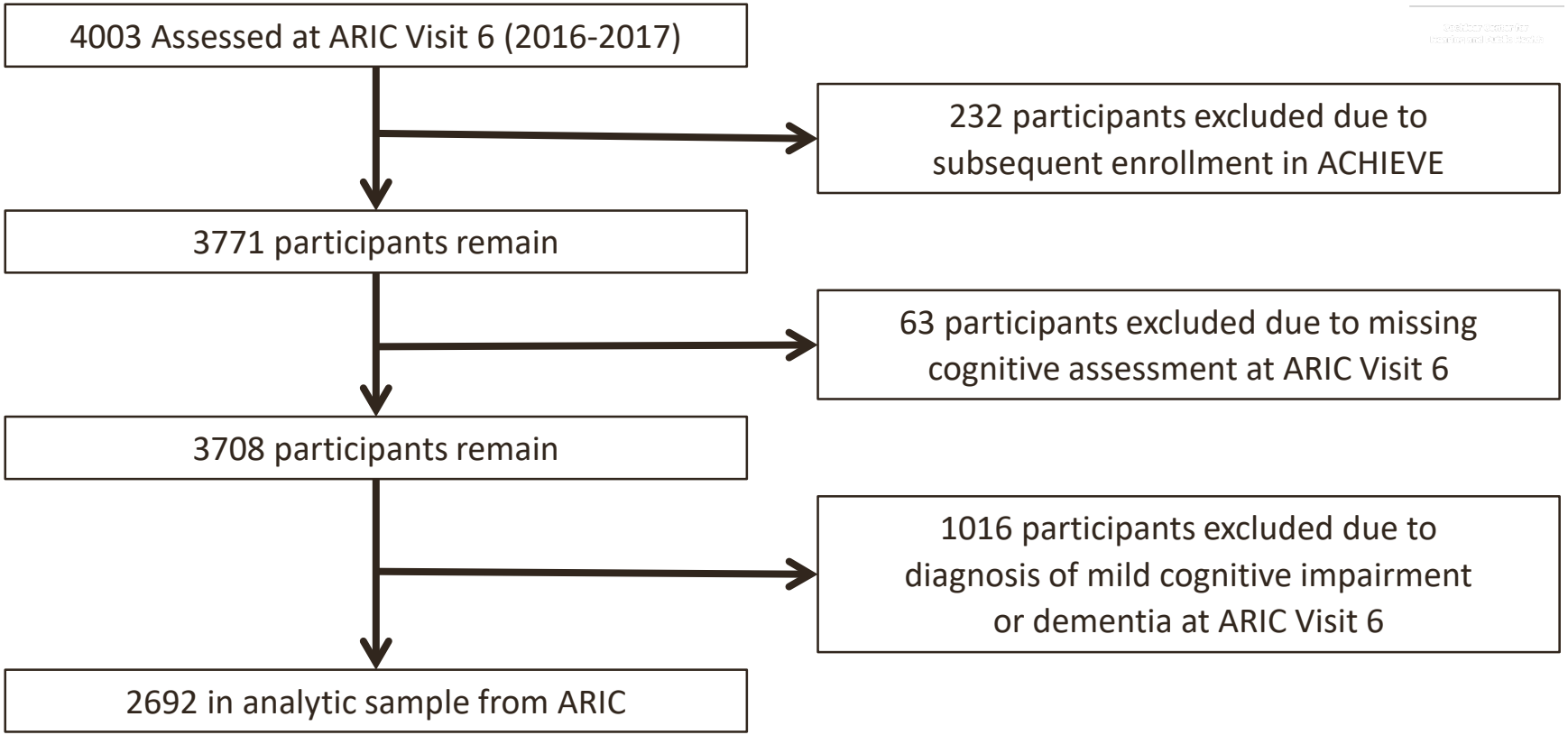
Baseline characteristics	All Participants (N=977)	ARIC Cohort (N=238)	De novo Cohort (N=739)
***Age, mean (SD), y**	**76.8 (4.0)**	**78.9 (2.9)**	**76.1 (4.0)**
*Female sex, No. (%)	523 (53.5)	147 (61.8)	376 (50.9)
*Black race, No. (%)	112 (11.5)	68 (28.6)	44 (6.0)
***Education, No. (%)**			
Less than high school	**37 (3.8)**	**22 (9.3)**	**15 (2.0)**
High school, GED, or vocational school	**418 (42.8)**	**96 (40.5)**	**322 (43.6)**
College, graduate, or professional school	**521 (53.4)**	**119 (50.2)**	**402 (54.4)**
One or more apolipoprotein E ε4 alleles, No. (%)	224 (24.7)	59 (25.7)	165 (24.3)
***Mini-mental state exam, mean (SD)**	**28.2 (1.6)**	**28.0 (1.8)**	**28.3 (1.6)**
***Global cognition, mean (SD)**	**0.000 (0.926)**	**-0.379 (1.042)**	**0.123 (0.851)**

**indicates statistically significant difference between groups*

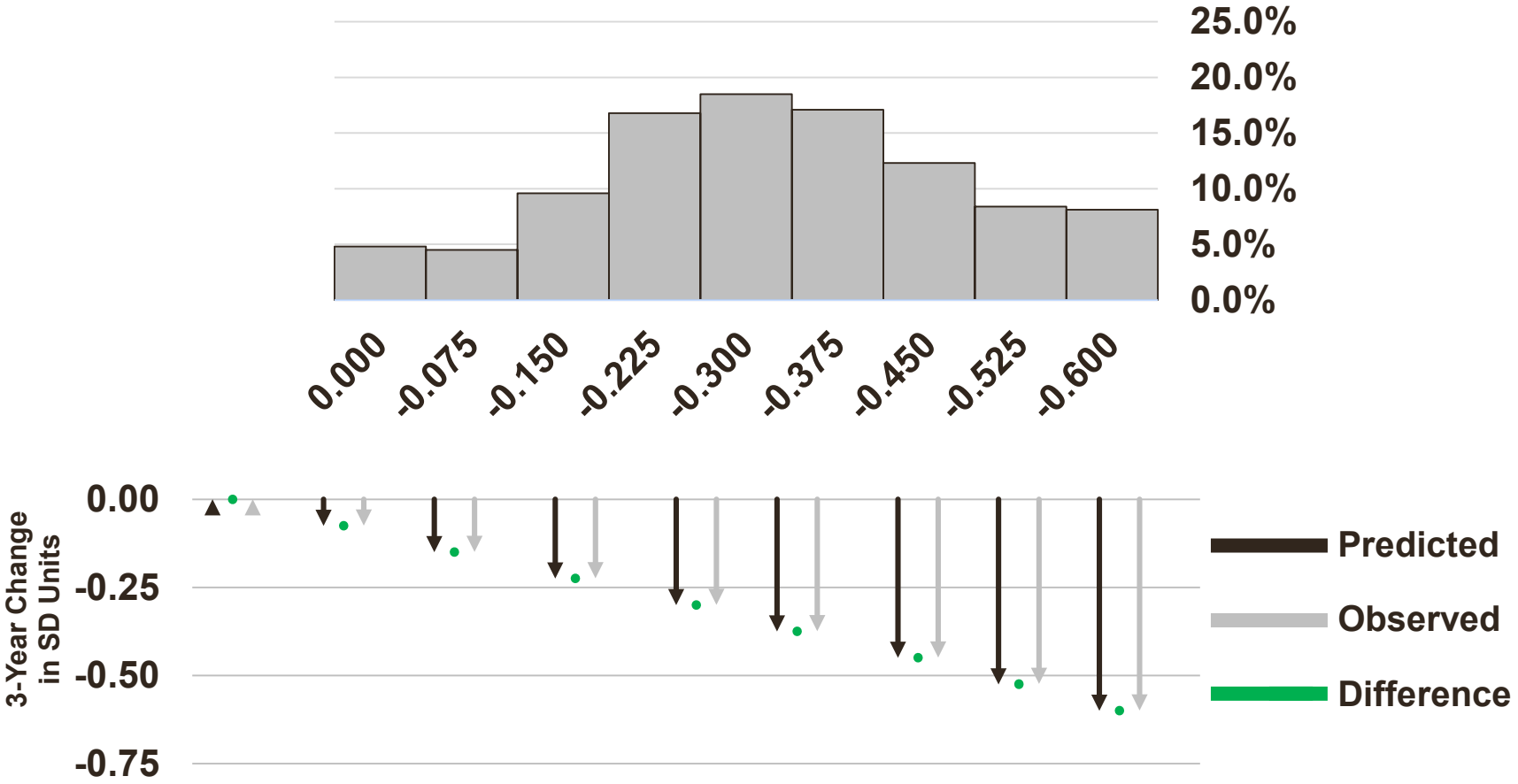
Predicted Risk vs. Observed Effect

- Goal: Use the parent ARIC study (population-based epidemiologic study of each site) to inform predicted risk scores of cognitive decline to apply to ACHIEVE design
- Hypothesis: Participants with the ***greatest risk*** who were randomized to the hearing intervention will have the ***greatest reduction*** in cognitive decline compared to participants randomized to the health education control.

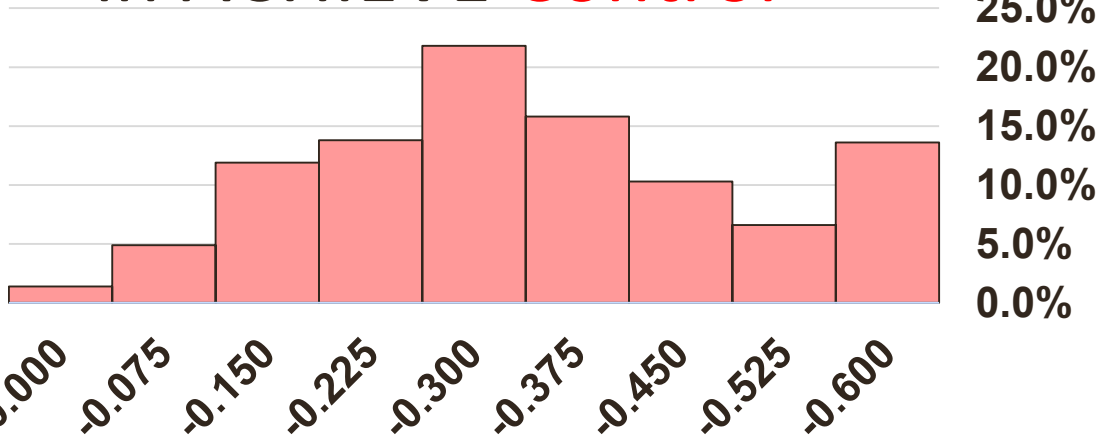
Using the ARIC Cohort to Predict Risk of Cognitive Decline

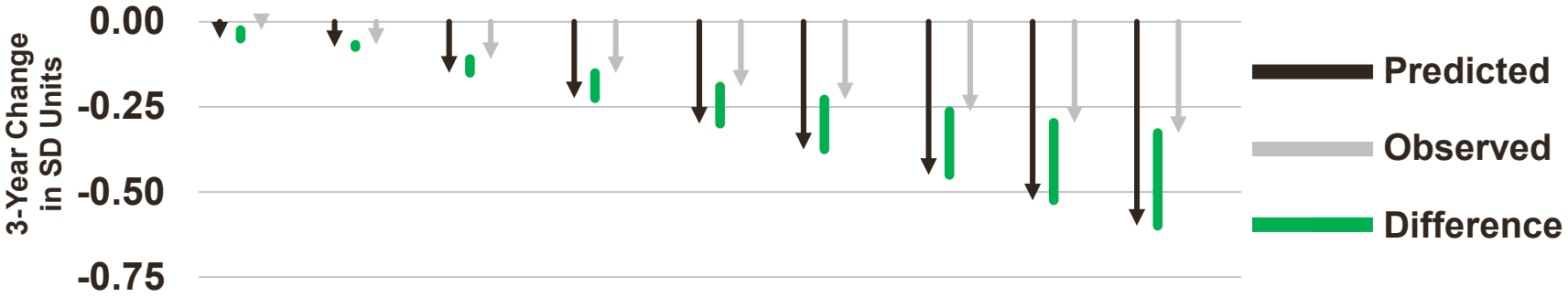


Predicted Versus Observed Change in ARIC

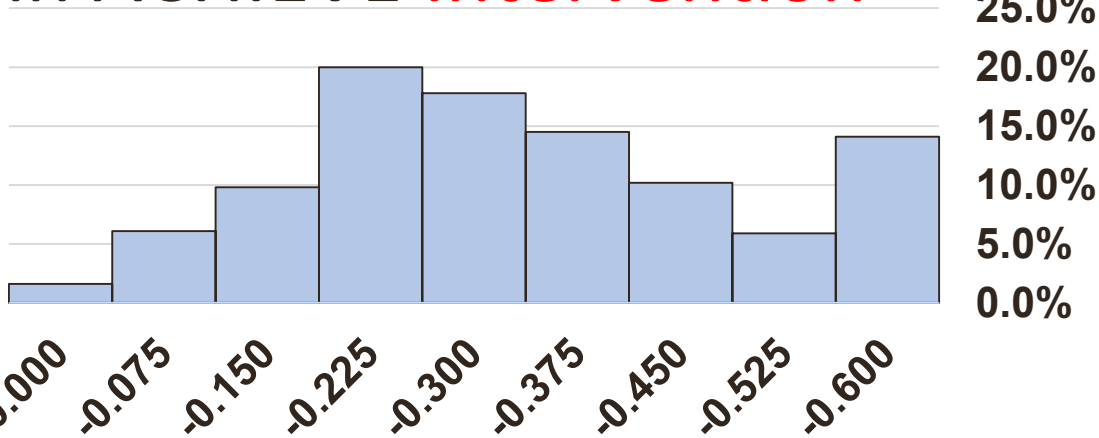


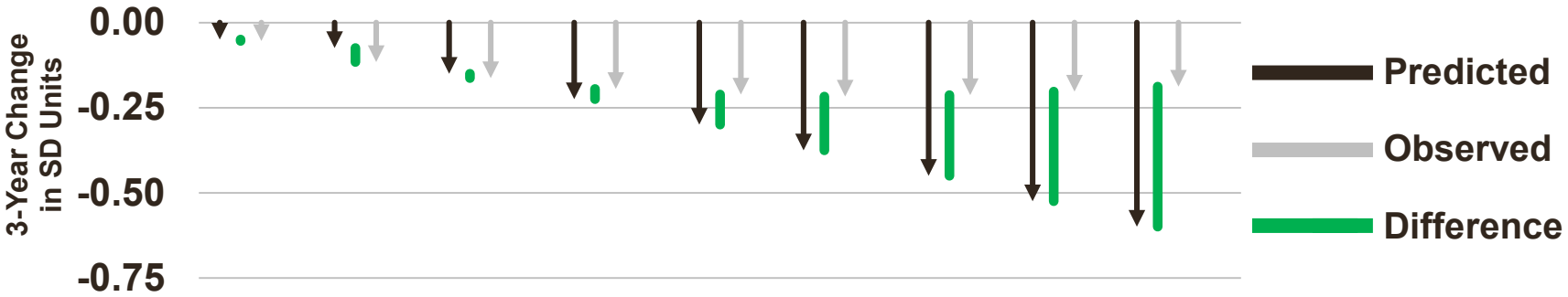
Predicted Versus Observed Change in ACHIEVE Control



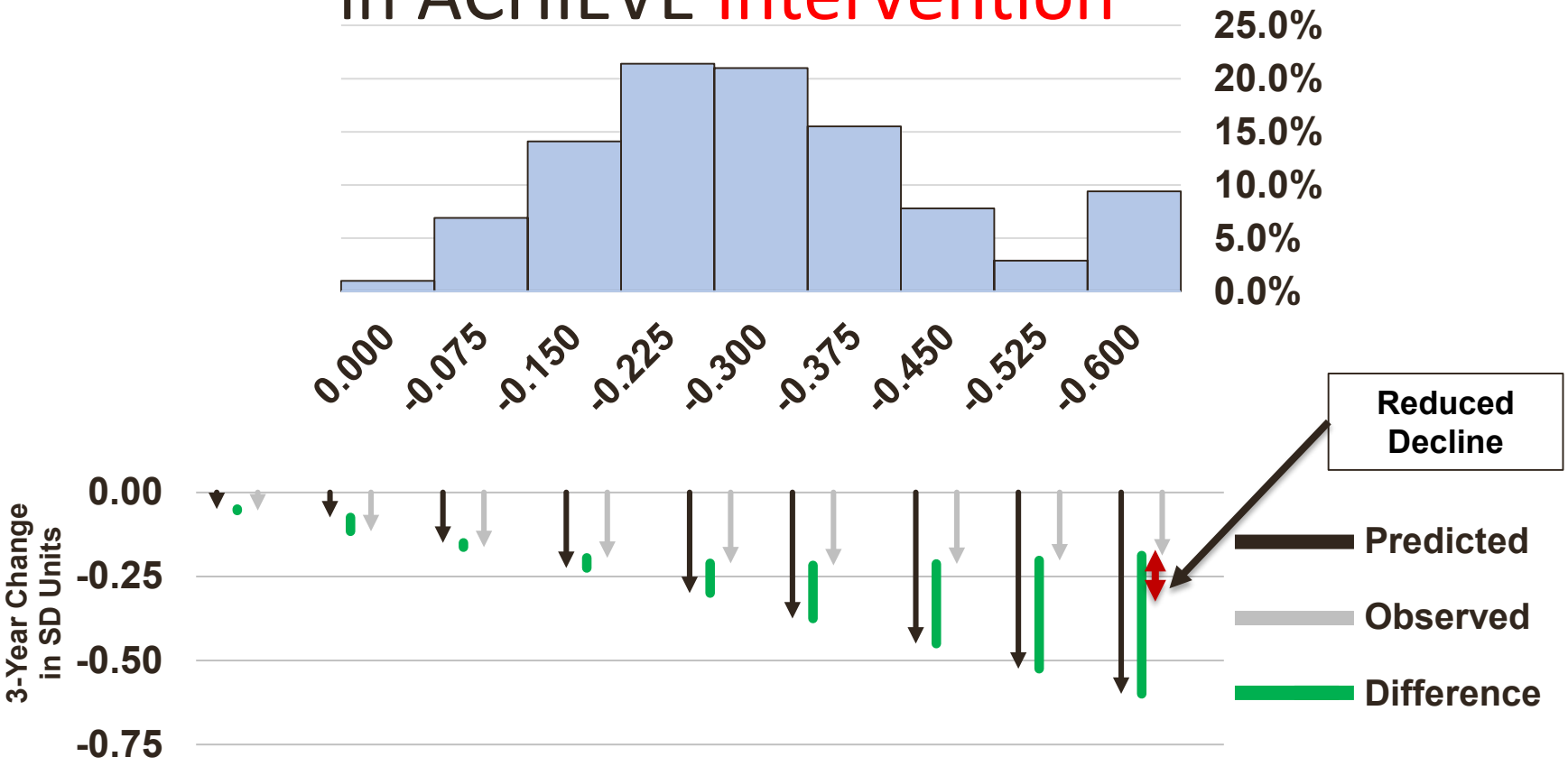


Predicted Versus Observed Change in ACHIEVE Intervention

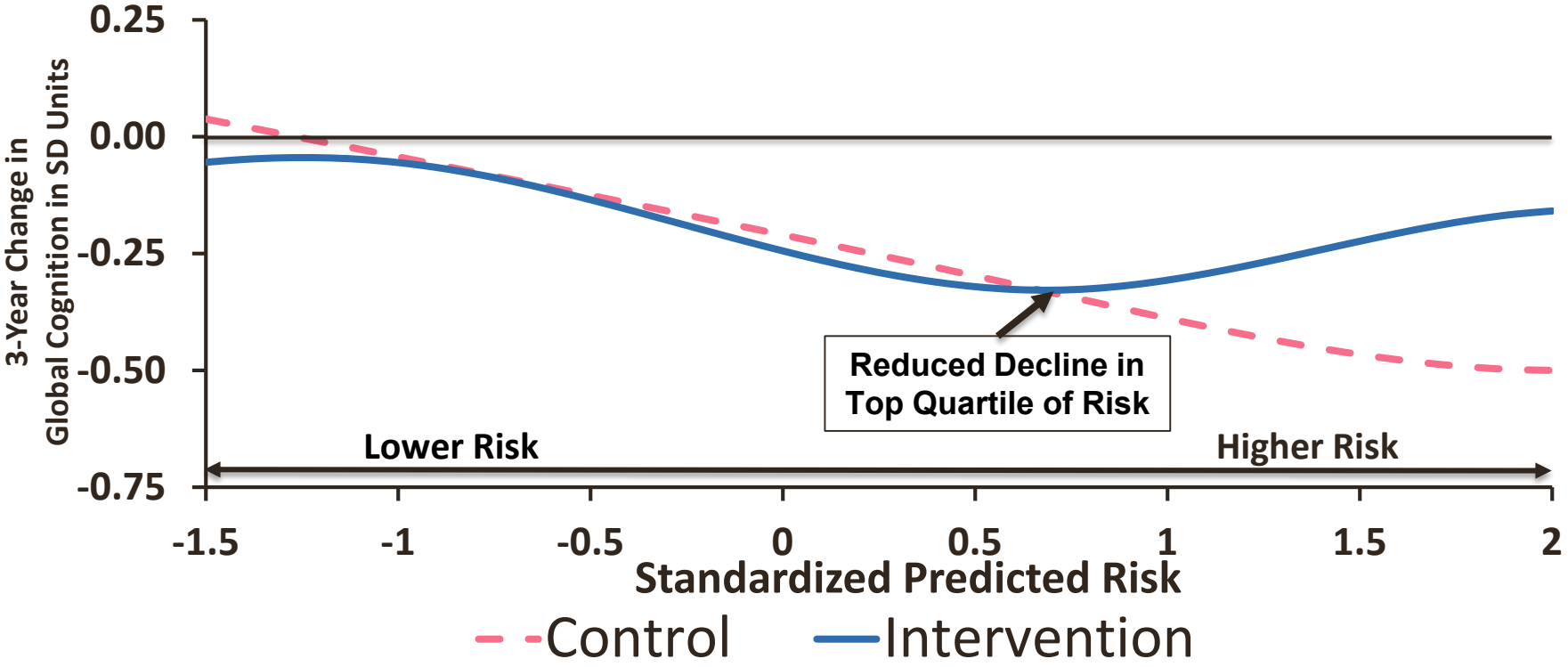




Predicted Versus Observed Change in ACHIEVE Intervention



Cognitive Decline in ACHIEVE Estimated From Mixed Effects Model Examining Nonlinear Interaction Between Intervention and Predicted Risk



3-Year Change in Global Cognition

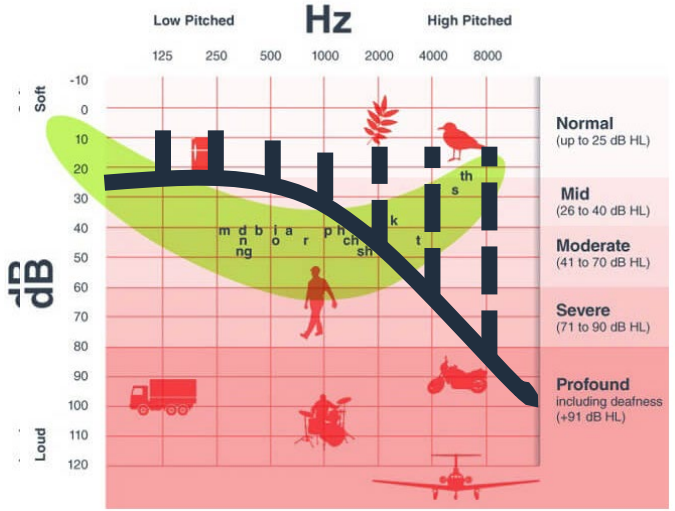
	Unadjusted 3-Year Change in SD Units ß (95% CI)	p	Covariate-Adjusted 3-Year Change in SD Units ß (95% CI)	p
Intervention X Time	-0.038 (-0.132, 0.057)	0.43	-0.047 (-0.141, 0.047)	0.32
Top Quartile of Risk X Time	-0.307 (-0.443, -0.172)	<0.0001	-0.265 (-0.408, -0.122)	<0.0001
3-Way Interaction	**0.202 (0.012, 0.392)**	**0.03**	**0.208 (0.020, 0.397)**	**0.03**

Among participants in the top quartile of risk, cognitive decline in the intervention group was 61.6% (95% CI 33.7%, 94.1%) slower than the control group

ACHIEVE Study Take Away

- Hearing and cognition derives from population-based studies and should not be interpreted or messaged on an individual level
- The ACHIEVE trial is null and should be framed as such
- Secondary analyses suggest a signal exists for a non-linear association between hearing intervention and cognitive trajectory
    - Need for work on bi-directional synergies, increased diversity, and consideration for objective markers

Amplifier Alone Won’t Do The Job



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Tips for Addressing Hearing Loss

Addressing Hearing Loss Checklist		
Technologic Considerations		
☐	Handheld Amplification	Simple handheld devices, such as the Pocket Talker (Williams Sound, Eden Prarie, MN) or SuperEar (Sonic Technology Products, Nevada County, CA), allow users use standard headphones and easily amplify sound to their desire with the volume control to improve communication.
☐	Amplified and Caption Telephones	These telephones are specially designed for persons with hearing loss and provide increased amplification and captioned conversation
☐	In-Room Videoconferencing	Leveraging video technology to communicate with patients may seem like it would pose barriers; however, it allows for providers to speak clearly and show their mouth for lip-reading. In addition, technology companies can amplify frequencies important for speech and use speech to text to caption the video in real time.
☐	Speech to Text	Speech to test applications, such as the software provided by Google (Mountain View, CA), are increasingly available. These applications can provide live transcription of conversation to assist those with hearing loss.
☐	Smartphone Amplification	Applications, such as Google Sound Amplifier (Mountain View, CA), offer high quality noise reduction algorithms and amplification in personal smartphones. These may represent an option when handheld amplifiers are not available.

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Tips for Addressing Hearing Loss

Environmental Modifications		
☐	Remove Background Noise	Reducing background noise by turning down the television and closing the door to noisy areas can improve communication.
☐	Improve Room Lighting	Proper lighting helps persons with hearing loss visualize the speaker to aid in lip-reading, but overwhelming lighting (such a window reflection) can be distracting.
☐	Preprepared Placards	Preprinted placards of common phrases, questions, and comments used throughout the hospital stay or outpatient visit can be helpful. Using large font with high contrast color can further help older adults.
☐	Whiteboards or Tablets	Although it can be cumbersome, using whiteboards to write out conversation or tablets to type out conversational items represents a last resort option.

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Tips for Addressing Hearing Loss

Communication Considerations		
☐	Ensure Attention	Conversation and communication require both parties to be attentive and ready.
☐	Face-to-Face Communication	Ensuring that the listener can see your face to leverage lip-reading skills is important. This also ensures sound is being directed at the listener rather than in another direction. This means looking up from charts and away from computers when possible to communicate.
☐	Visualization of the Mouth When Possible	Covering the mouth area is a must to prevent spread of the COVID-19 virus. However, any opportunity possible to use clear masks or distance videoconferencing without masks can help people who consciously and subconsciously lip-read
☐	Speak Slow and Low	Age-related hearing loss generally occurs in higher frequencies and limits the clarity of speech. Slowing down and using a slightly lower tone can help listeners with hearing loss follow the conversation.
☐	Do Not Shout	Most age-related hearing loss is an issue of clarity rather than volume. Although some increased volume helps, shouting often further distorts information.
☐	Give Context to Conversation	By placing the conversation in context, it helps the listener decipher and fill in the gaps of difficult to hear words. This means adding supporting information like common descriptions or actions associated with topics and adding redundancy to information presented.
☐	Rephrase Rather than Repeat	Rephrasing can help the listener gain new context about the conversation and use words that are easier to hear. Repeating can create a frustrating negative feedback loop.

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Thank you

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