JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health

Hearing Loss & Dementia in Older Adults

Alison R. Huang, PhD MPH

Senior Research Associate

Department of Epidemiology | Cochlear Center for Hearing and Public Health

Johns Hopkins Bloomberg School of Public Health

Outline

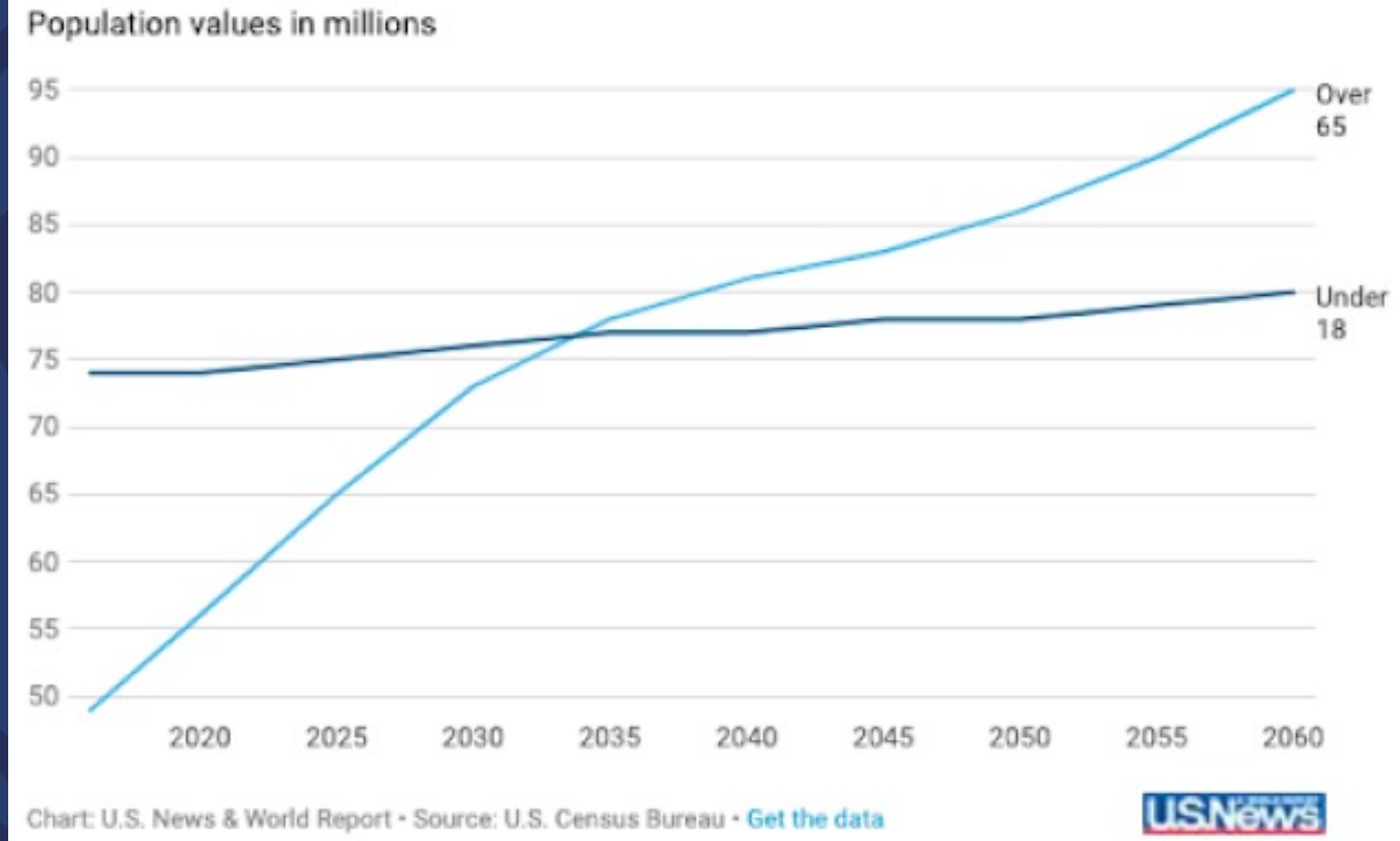
JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health

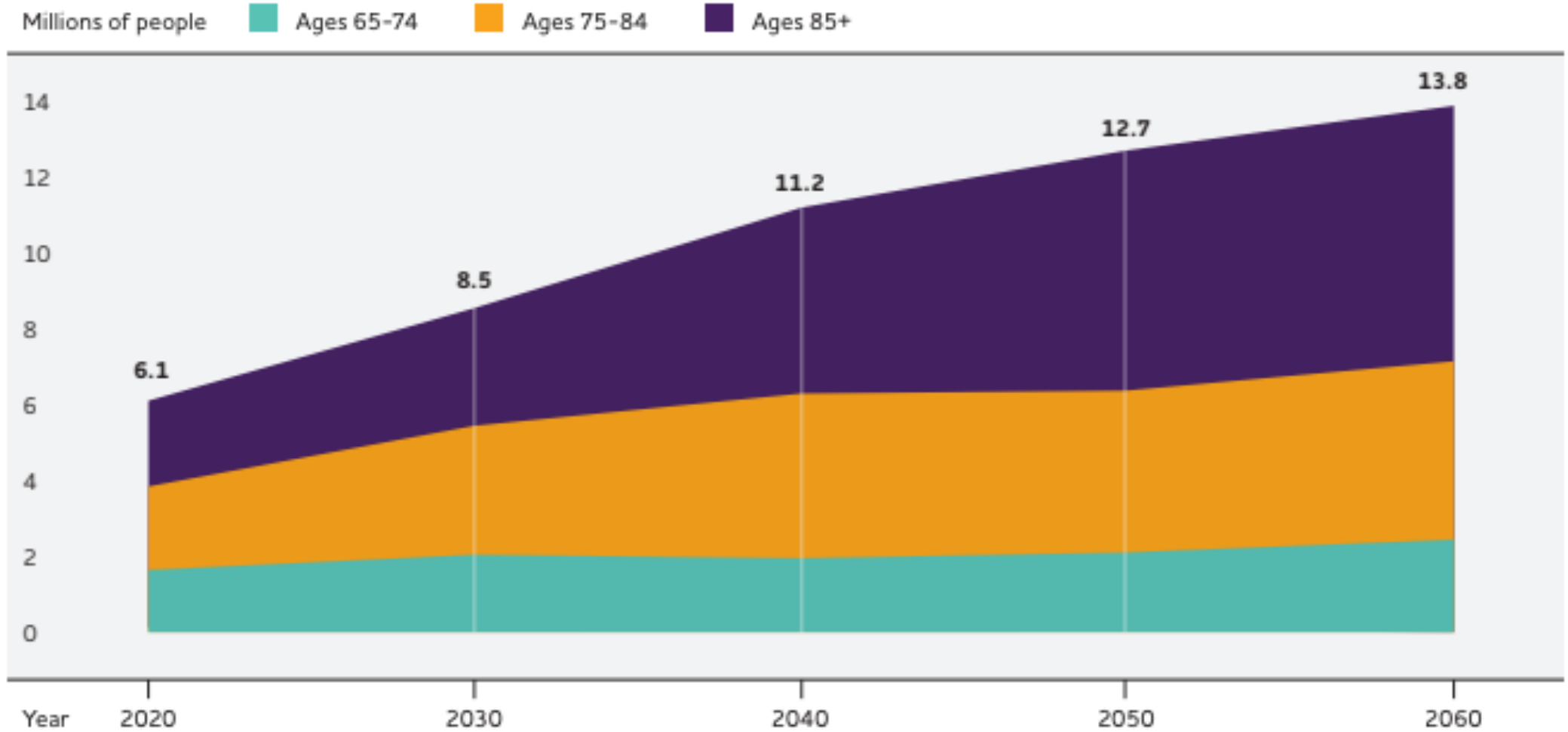
- Background, general definitions/principles
- Hearing loss and dementia: current evidence
- Mechanistic pathways
- Future directions

Poll Question 1

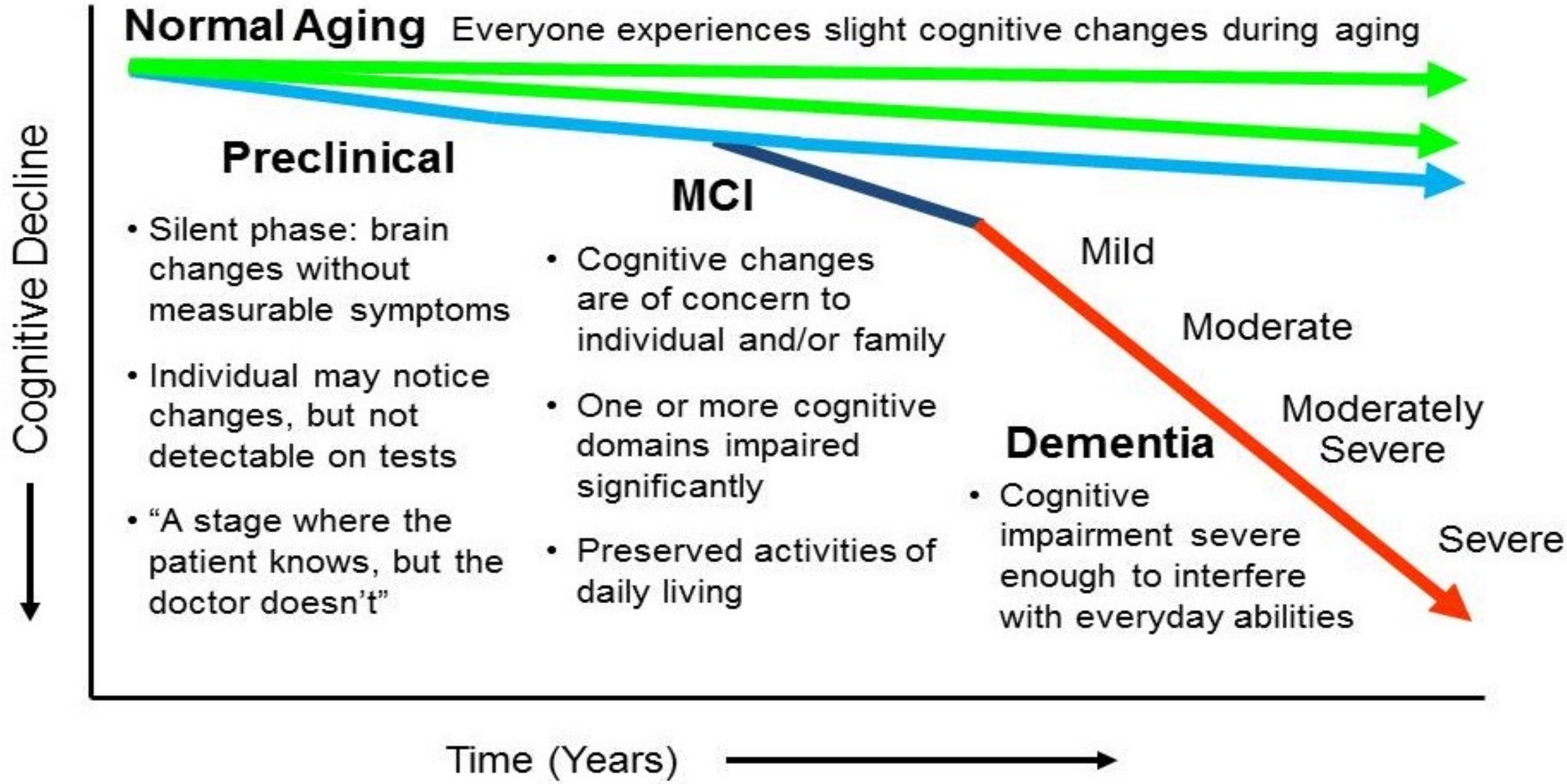
U.S. Population Predictions for Seniors and Children



Projected Number of People Age 65 and Older (Total and by Age) in the U.S. Population with Alzheimer's Dementia, 2020 to 2060

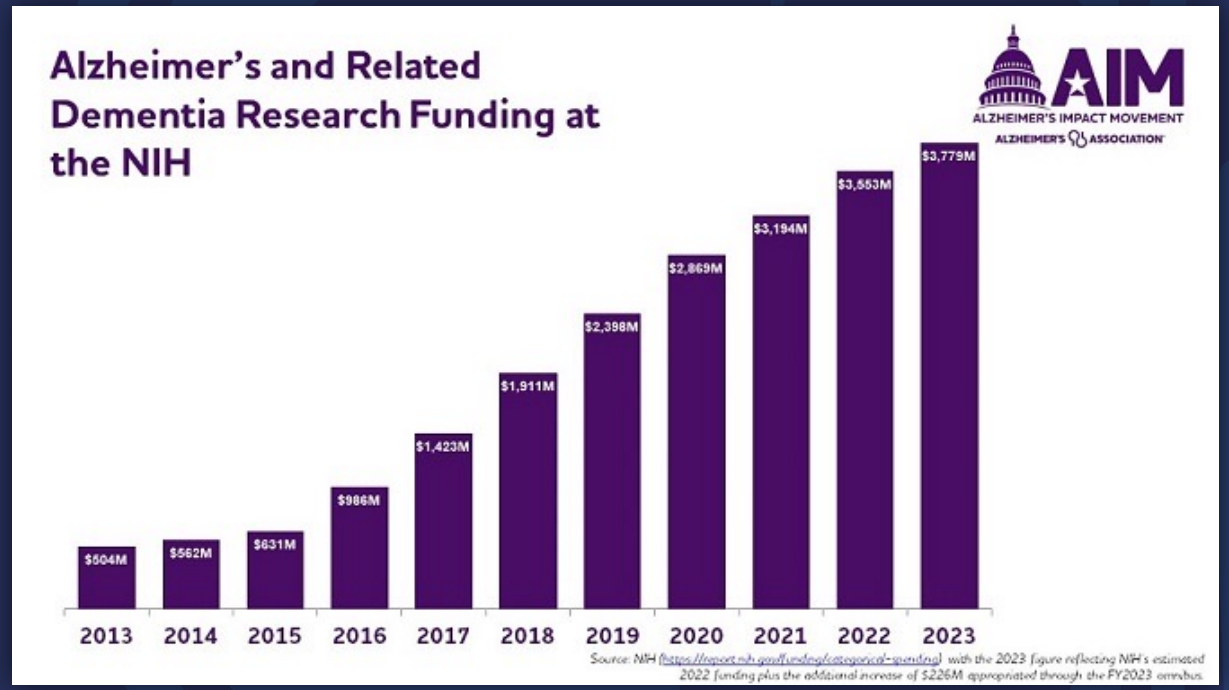


Alzheimer's Association. 2023 Alzheimer's Disease Facts and Figures. Alzheimers Dement 2023;19(4). DOI 10.1002/alz.13016. c


Normal Aging
Everyone experiences slight cognitive changes during aging
Preclinical
• Silent phase: brain changes without measurable symptoms
• Individual may notice changes, but not detectable on tests
• "A stage where the patient knows, but the doctor doesn't"
MCI
• Cognitive changes are of concern to individual and/or family
• One or more cognitive domains impaired significantly
• Preserved activities of daily living
Dementia
• Cognitive impairment severe enough to interfere with everyday abilities
Mild
Moderate
Moderately Severe
Severe
Cognitive Decline
Time (Years)

Dementia is a public health priority

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health



- Dementia affects quality of life
  - 2nd most feared condition among adults
  - Loss of communication, independence
- Dementia is costly
  - Global cost of dementia ($818 B in 2015) will increase as prevalence increases
  - "A family disease"

Harvard School of Public Health/Alzheimer Europe Five Country Alzheimer's Disease Survey, 2011
Livingston, G., Sommerlad, A., Orgeta, V., Costafreda, S. G., Huntley, J., Ames, D., ... & Mukadam, N. (2017). Dementia prevention, intervention, and care. *The lancet*, *390*(10113), 2673-2734.
https://alzimpact.org/research

Critical Public Health Questions

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Lack of accessible and effective treatments → Focus on prevention

- What are the modifiable risk factors for dementia?
- What are the mechanistic pathways?
- What interventions can modify the mechanistic pathways to reduce risk of dementia?

Critical Public Health Questions

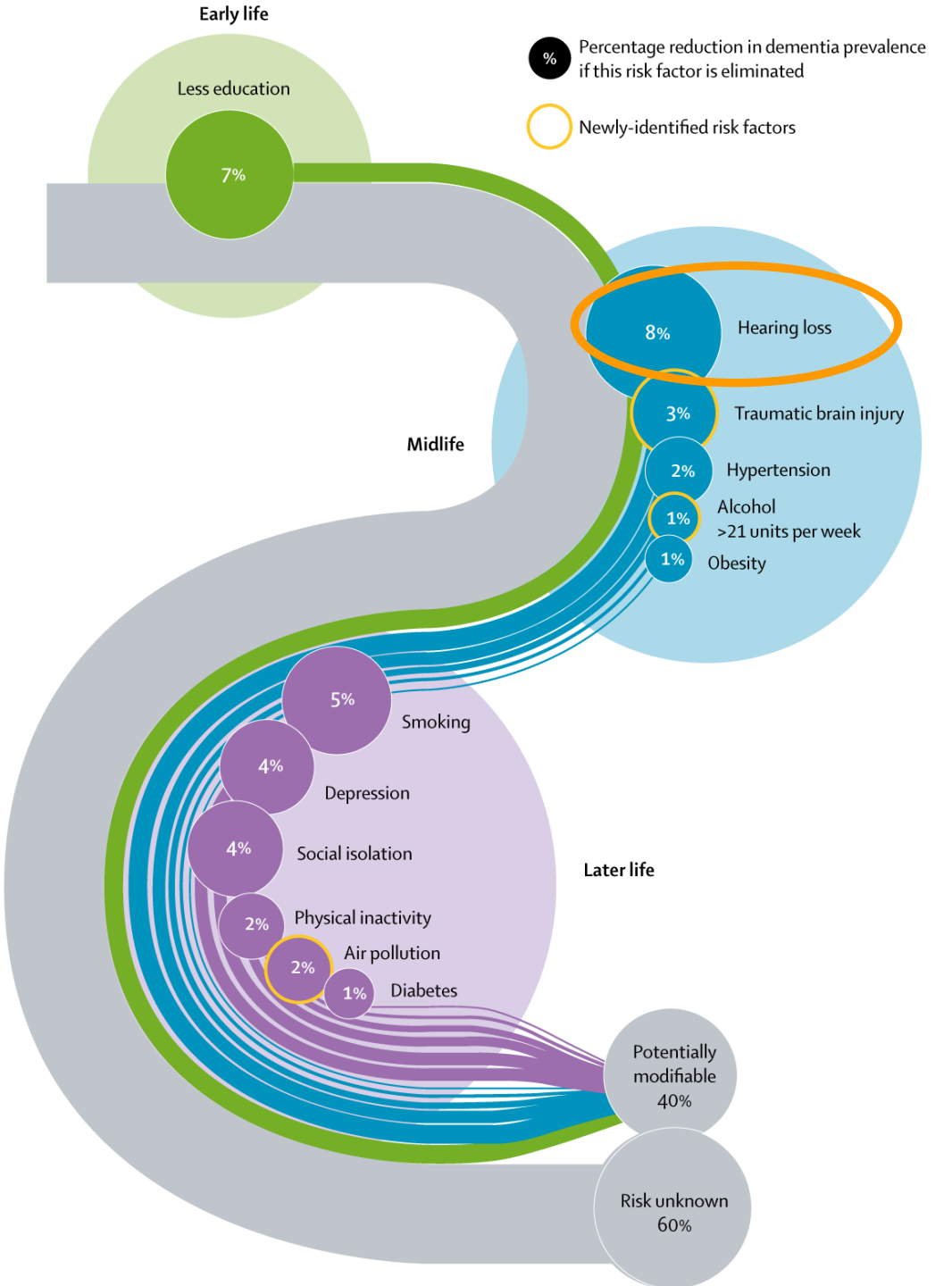
JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Lack of accessible and effective treatments → Focus on Prevention

- What are the modifiable risk factors for dementia?
- What are the mechanistic pathways?
- What interventions can modify the mechanistic pathways to reduce risk of dementia?

Lancet Commission on Dementia Prevention, Intervention & Care, 2020

Potentially Modifiable Risk Factors for Dementia



Hearing loss in mid & late life identified as the single largest modifiable risk factor for dementia

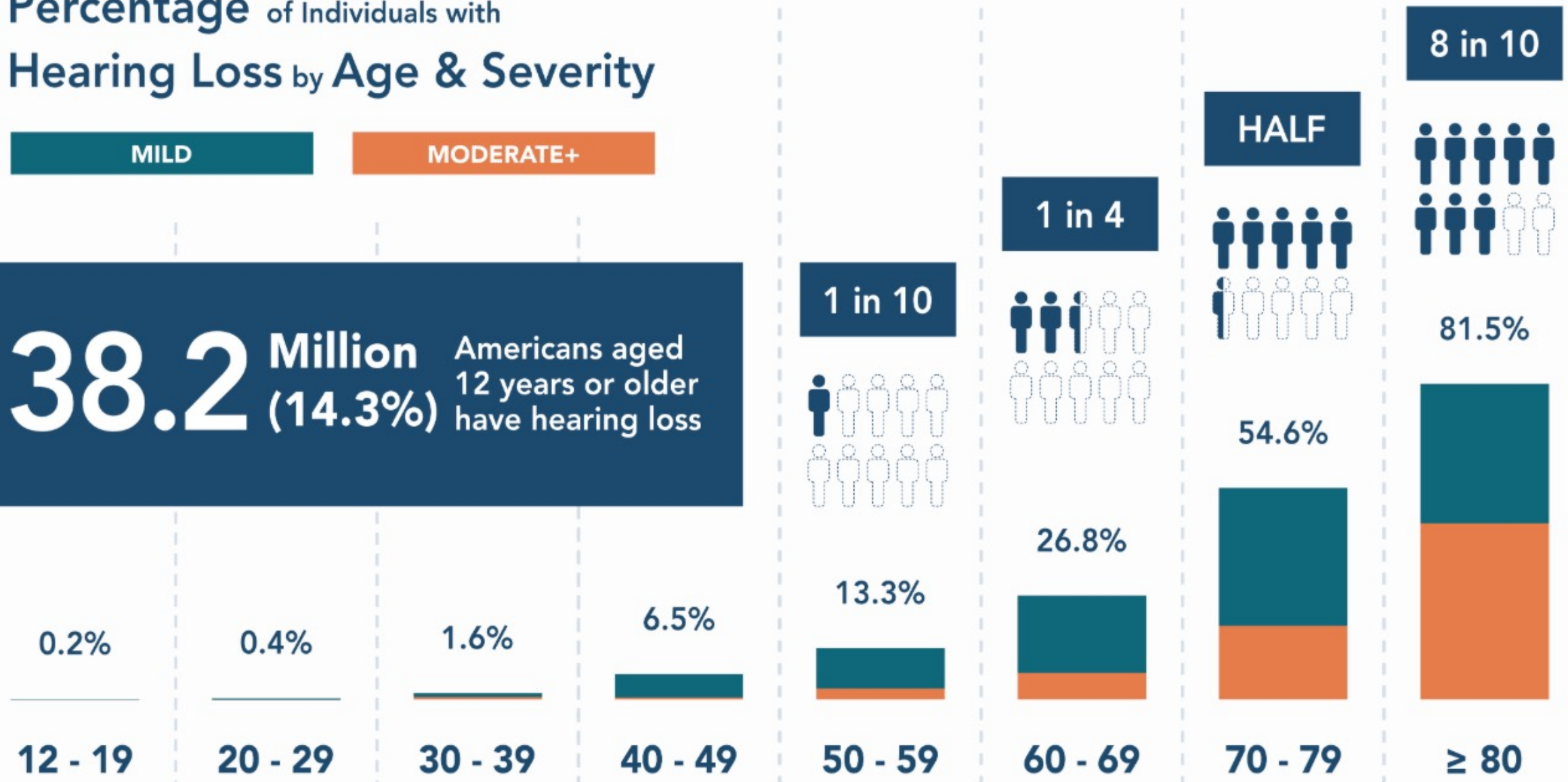
Livingston, Gill, et al. "Dementia prevention, intervention, and care: 2020 report of the Lancet Commission." *The Lancet* 396.10248 (2020): 413-446.

Poll Question 2

Percentage of Individuals with Hearing Loss by Age & Severity

MILD | MODERATE+

38.2 Million (14.3%) Americans aged 12 years or older have hearing loss

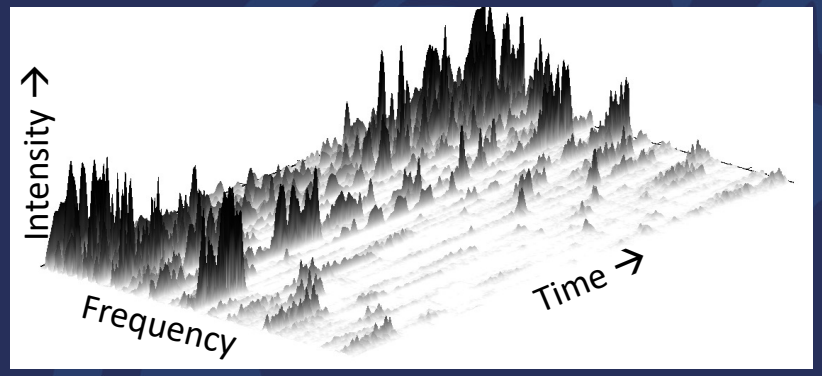


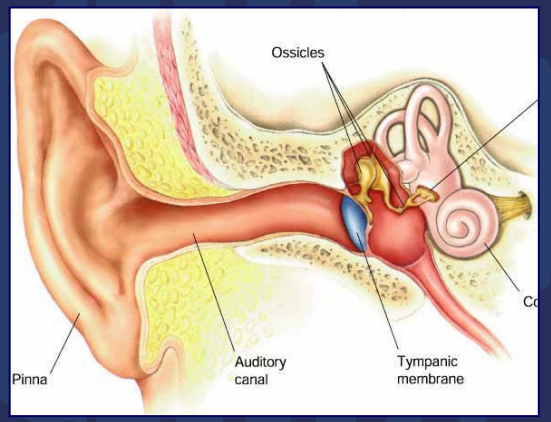
JOHNS HOPKINS BLOOMBERG SCHOOL of PUBLIC HEALTH | Cochlear Center for Hearing and Public Health

jhucochlearcenter.org

Goman & Lin. (2016). Prevalence of hearing loss by severity in the United States. American Journal of Public Health, 106(10), 1820-1822.

Hearing depends on *peripheral auditory encoding* and *central auditory decoding*





Peripheral auditory transduction (encoding)

Central auditory processing (decoding)

Levels of Auditory Processing

Central Cortical Functioning

Subjective Hearing & Communicative Function

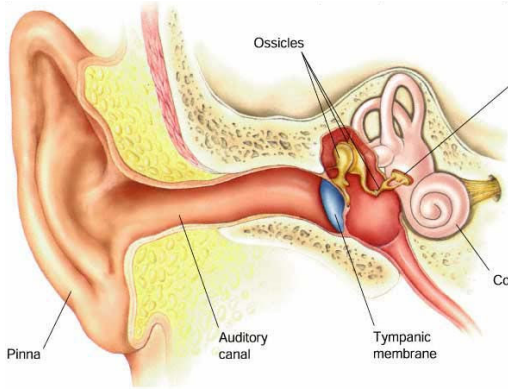
Central Auditory Measures (Speech in Noise, Dichotic Listening Tasks)

Word Recognition in Quiet

Pure Tone Audiometry

Otoacoustic Emissions (OAE)

Peripheral cochlear function



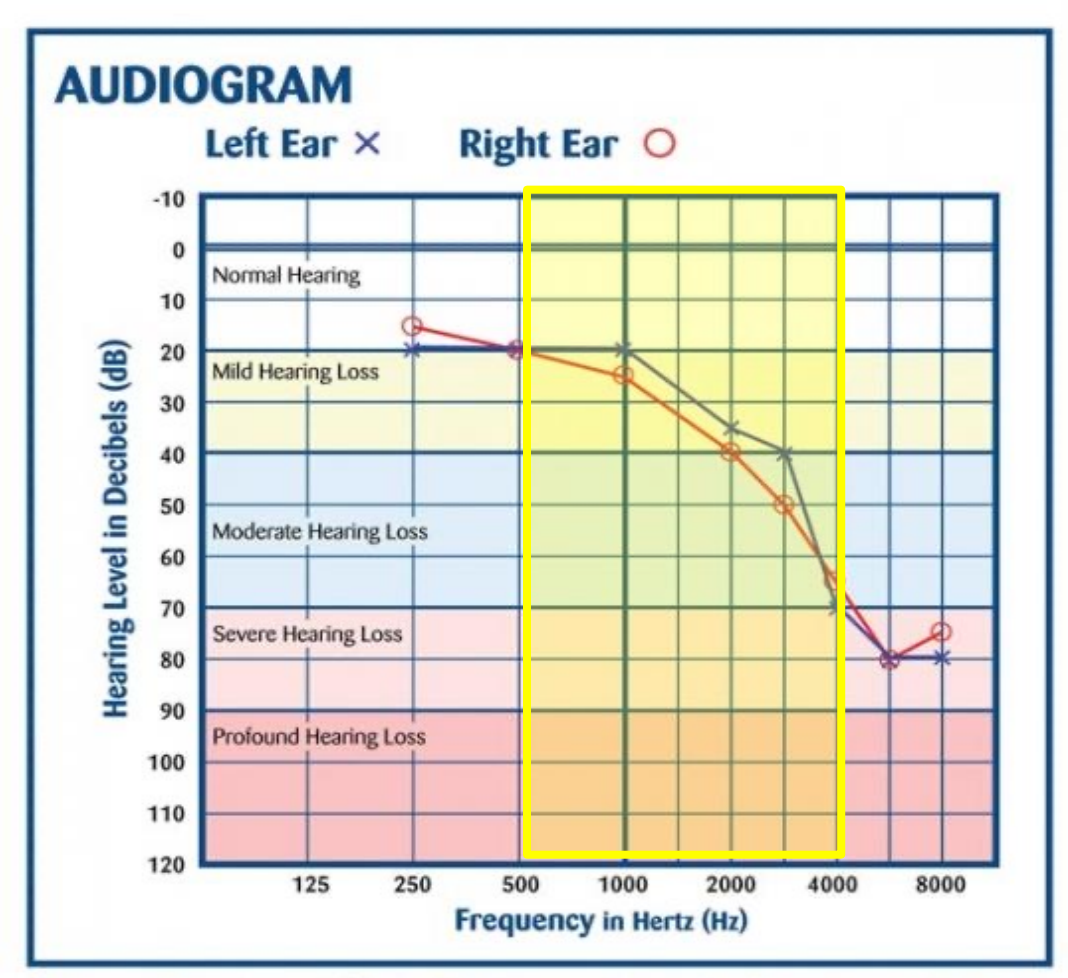
Age-Related Hearing Loss

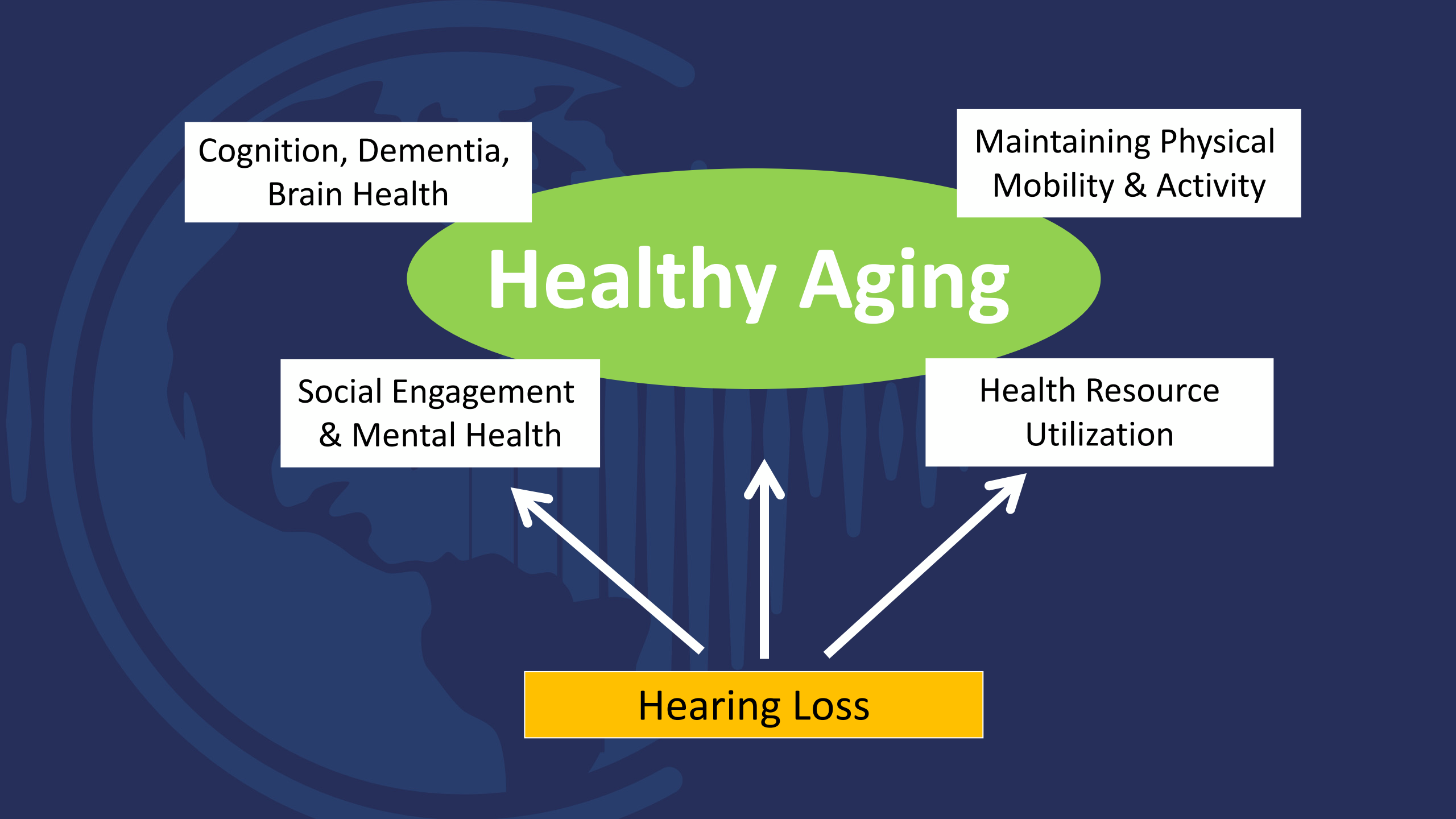
JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

- Results from multiple etiologic processes that can progressively damage the cochlea

- Status of the cochlea is most commonly measured with pure tone audiometry

Pure tone average (PTA) of 0.5, 1, 2, & 4 kHz tones in the better-hearing ear



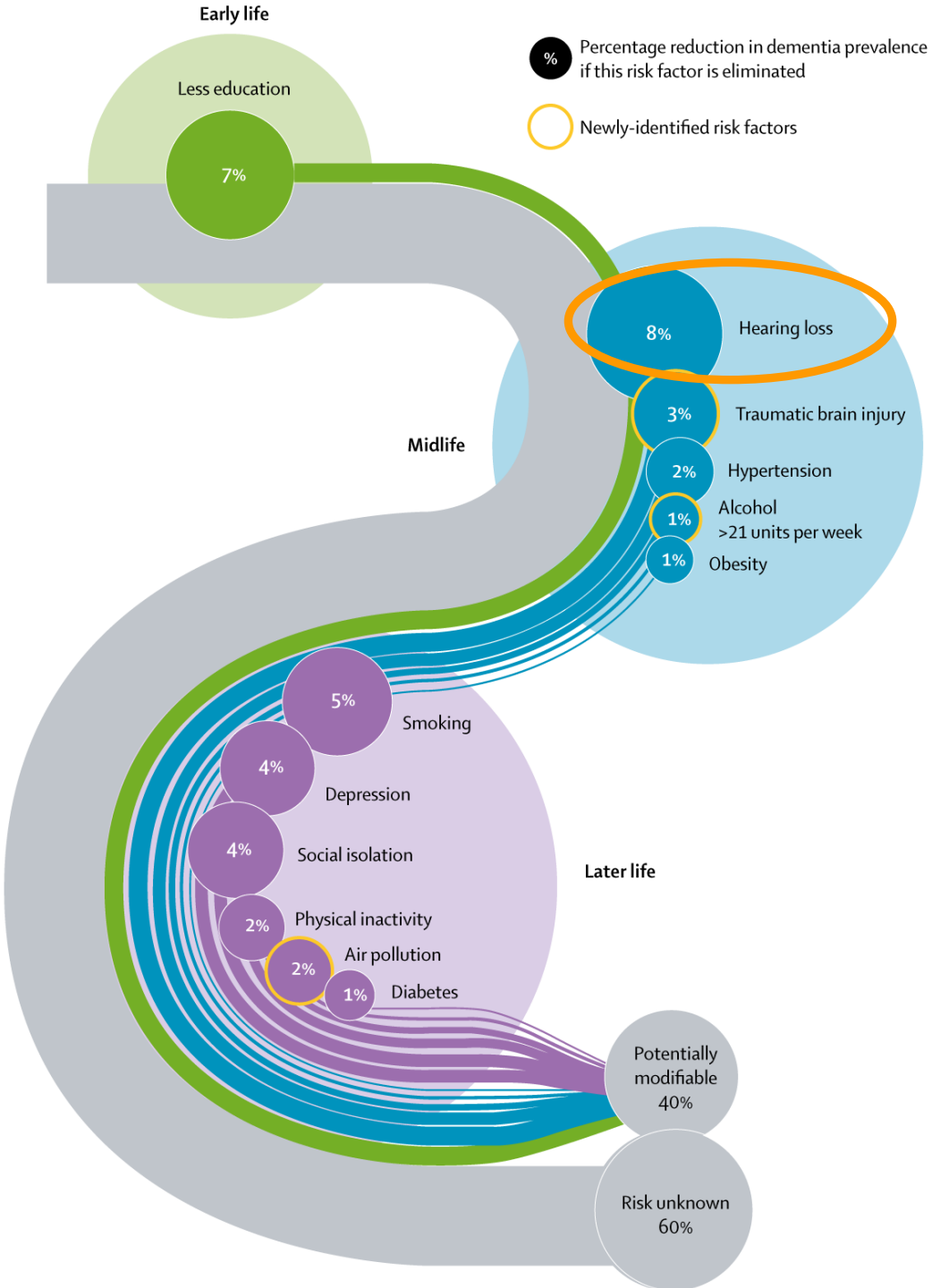

Cognition, Dementia, Brain Health
Maintaining Physical Mobility & Activity
Healthy Aging
Social Engagement & Mental Health
Health Resource Utilization
Hearing Loss

Hearing Loss and Dementia: Current Evidence

Lancet Commission on Dementia Prevention, Intervention & Care

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health



Study	RR (95% CI)	Weight % (random)	Risk ratio
Lin et al (2011)[66]	2·32 (1·32–4·07)	27·3%	
Gallacher et al (2012)[67]	2·67 (1·38–5·17)	21·3%	
Deal et al (2016)[65]	1·55 (1·10–2·19)	51·4%	
Random effects model	**1·94 (1·38–2·73)**	**100%**	

Heterogeneity: I^2=29%, tau^2=0·0278, p=0·2445

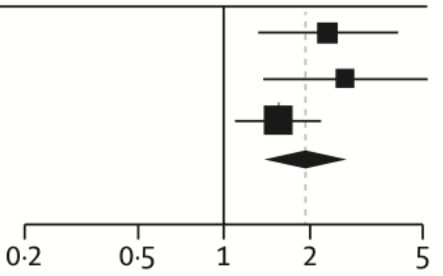


Figure 3: **Forest plot of the effect of hearing loss on incidence of dementia 9–17 years later in cognitively healthy people**

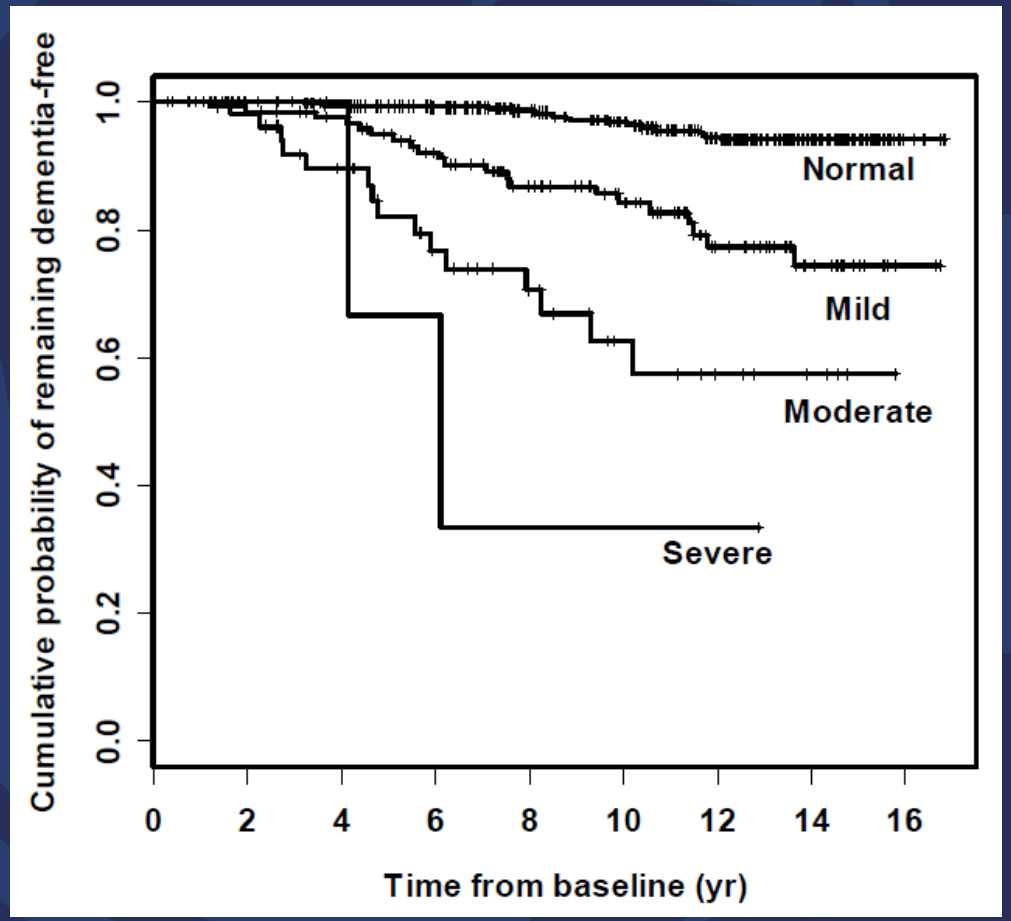
Hearing loss was measured by pure-tone audiometry. RR=risk ratio.

Livingston, Gill, et al. "Dementia prevention, intervention, and care: 2020 report of the Lancet Commission." *The Lancet* 396.10248 (2020): 413-446.

BLSA BALTIMORE LONGITUDINAL STUDY OF AGING

Hearing Loss & Incident Dementia

Dementia incidence in 639 adults followed for >10 years in the BLSA



Risk of incident all-cause dementia (compared to normal hearing)[a]

	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

[a] Adjusted for age, sex, race, education, DM, smoking, & hypertension

Lin, Frank R., et al. "Hearing loss and incident dementia." *Archives of neurology* 68.2 (2011): 214-220

Hearing Loss & Incident Dementia

Dementia Incidence in 1057 Men Followed for 17 years in the Caerphilly Prospective Study (U.K.)

Cognitive impairment	Model 1: adjusted for age, OR[a] (95% CI), *p* value	Model 2: adjusted for age, social class, anxiety, OR[a] (95% CI), *p* value	Model 3: adjusted for age, social class, anxiety, premorbid intelligence, OR[a] (95% CI), *p* value
All dementia (n = 79)	4.07 (2.21-7.50), <0.001	3.26 (1.71-6.21), <0.001	2.67 (1.38-5.18), 0.004
Vascular dementia (n = 38)	3.83 (1.69-8.65), 0.001	2.93 (1.24-6.94), 0.015	2.40 (0.99-5.83), 0.05
Nonvascular dementia (n = 41)	4.20 (1.84-9.55), 0.001	3.58 (1.50-8.51), 0.004	2.96 (1.21-7.22), 0.017
CIND (n = 146)	2.32 (1.50-3.59), <0.001	1.72 (1.09-2.74), 0.021	1.24 (0.77-2.01), 0.38
All dementia (n = 46), omitting men with evidence of early cognitive decline	2.23 (1.04-4.77), 0.039	1.64 (0.72-3.73), 0.24	1.32 (0.57-3.12), 0.52

Abbreviations: CI = confidence interval; CIND = cognitive impairment no dementia; OR = odds ratio; PTA = pure-tone average (threshold).

[a] Odds ratio is the effect per 10-dB_A rise in usual PTA.

Neurology 79 October 9, 2012

Gallacher, J., Ilubaera, V., Ben-Shlomo, Y., Bayer, A., Fish, M., Babisch, W., & Elwood, P. (2012). Auditory threshold, phonologic demand, and incident dementia. *Neurology*, *79*(15), 1583-1590.

Hearing Loss & Incident Dementia

Dementia risk in 1,889 older adults followed for 9 years in the HealthABC Study

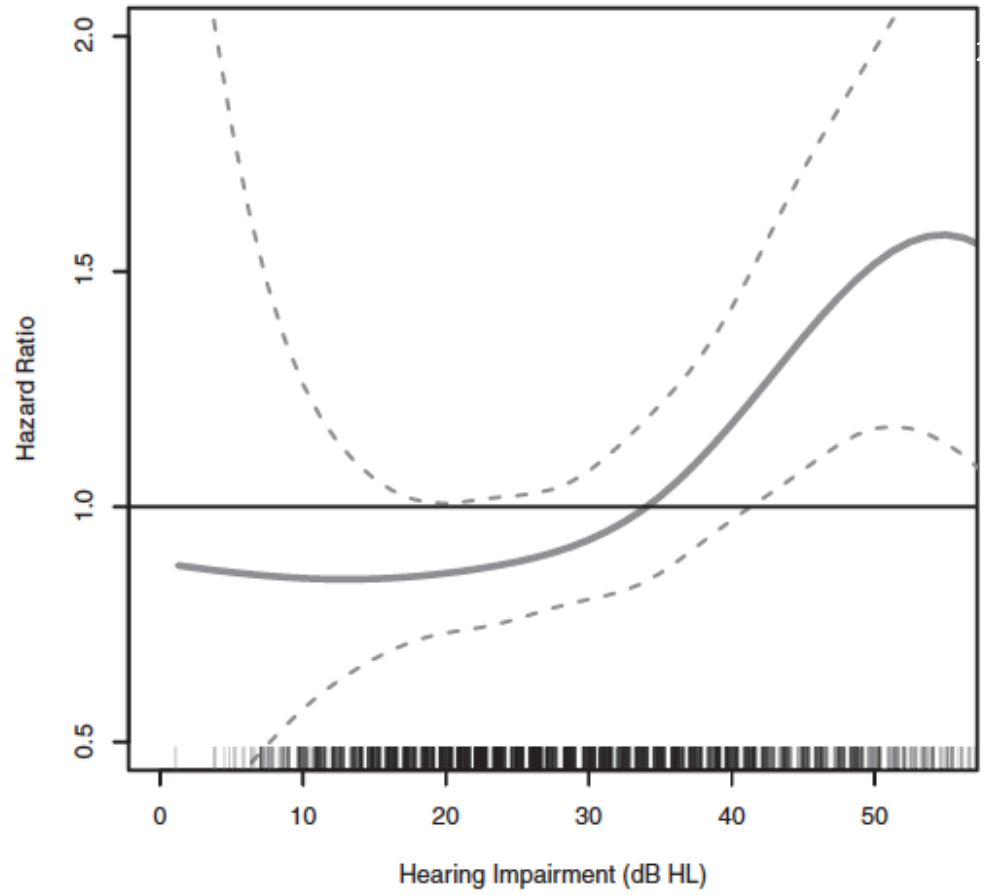


Figure 2. Multivariable-adjusted association between PTA and incident dementia, Health ABC Study, *N* = 1,889, 1999–2008. HR of incident dementia associated with PTA (in dBHL) when modeled continuously using penalized splines (used to allow for smooth, nonlinear effects in regression models). Adjusted for age (year), sex, race, education (less than high school/highs school/postsecondary), study site (Memphis or Pittsburgh), smoking status (never/former/current), hypertension, diabetes, and history of stroke. dBHL = decibels hearing level; Health ABC = Health, Aging and Body Composition; HI = hearing impairment; HR: hazard ratio; PTA, pure-tone average.

Deal, Jennifer A., et al. "Hearing impairment and incident dementia and cognitive decline in older adults: the health ABC study." *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences* 72.5 (2017): 703-709.

Estimates from more representative samples needed

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

- Potentially limited generalizability given:
  - Specific samples
    - Healthy older adults, volunteer cohort (BLSA)
    - From specific areas of the U.S.
    - Limited to men (Gallacher et al., 2012)
  - Clinic-based data collection

Research Letter

January 10, 2023

Hearing Loss and Dementia Prevalence in Older Adults in the US

Alison R. Huang, PhD[1]; Kening Jiang, MHS[1]; Frank R. Lin, MD, PhD[1]; et al

» Author Affiliations

JAMA. 2023;329(2):171-173. doi:10.1001/jama.2022.20954

Strength: Representativeness

Huang, Alison R., et al. "Hearing Loss and Dementia Prevalence in Older Adults in the US." *JAMA* 329.2 (2023): 171-173.

National Health and Aging Trends Study (NHATS)

Nationally representative cohort study

- Community dwelling, Medicare beneficiaries (65 + years) in the U.S.
- Annual data collection since 2011

Greater inclusion of older adults typically underrepresented in epidemiologic studies

- Home visit data collection
- Oversampling of oldest old (90+ years), Black older adults

Objectively measured hearing (pure tone average) and dementia

Hearing Loss and Prevalent Dementia

National Health and Aging Trends Study, 2021, N=2,413

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

Every 10 dB worse hearing associated with 16% greater prevalence of dementia

Huang, Alison R., et al. "Hearing Loss and Dementia Prevalence in Older Adults in the US." *JAMA* 329.2 (2023): 171-173.

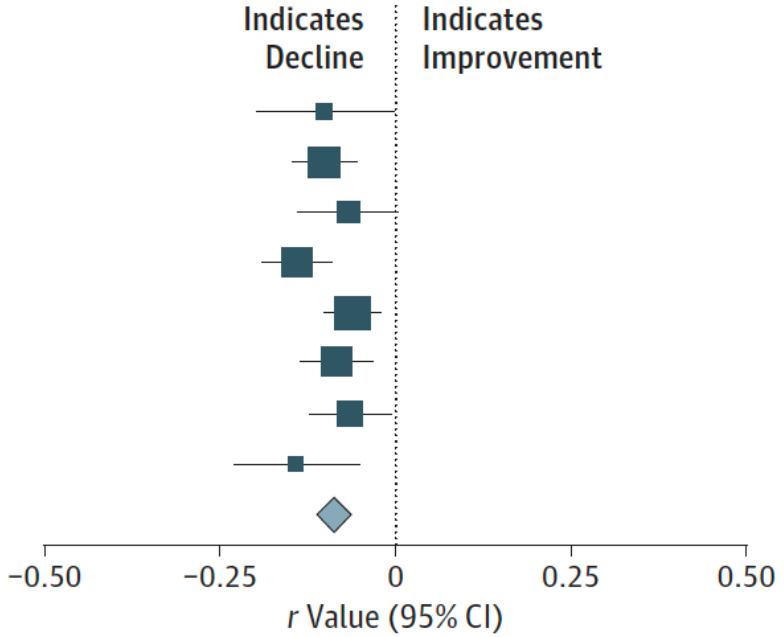
Hearing Loss and Cognition

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Meta-analysis, N=9 cohort studies

Figure 3. Forest Plot of Correlations for Cognition Cohort Outcomes

Outcome	No. of Participants/ Events	*r* Value (95% CI)
Attention	391/1	−0.10 (−0.20 to 0.00)
Delayed recall	1774/4	−0.10 (−0.15 to −0.05)
Fluency	1233/4	−0.07 (−0.14 to 0.01)
Global cognition	4227/6	−0.14 (−0.19 to −0.09)
Immediate recall	4225/6	−0.06 (−0.10 to −0.02)
Processing speed	6462/10	−0.08 (−0.14 to −0.03)
Reasoning	1057/1	−0.06 (−0.12 to 0.00)
Semantic memory	707/1	−0.14 (−0.23 to −0.05)
Summary	8233/33	−0.09 (−0.11 to −0.07)



Loughrey, D. G., Kelly, M. E., Kelley, G. A., Brennan, S., & Lawlor, B. A. (2018). Association of age-related hearing loss with cognitive function, cognitive impairment, and dementia: a systematic review and meta-analysis. *JAMA otolaryngology–head & neck surgery*, *144*(2), 115-126.

Does hearing loss impact cognitive measurement?

Assessing bias in cognitive testing for older adults with sensory impairment: an analysis of differential item functioning in the Baltimore Longitudinal Study on Aging (BLSA) and the Atherosclerosis Risk in Communities Neurocognitive Study (ARIC-NCS)

E. Nichols[1], J.A. Deal[1,2], B.K. Swenor[1,3], A.G. Abraham[1,4], N.M. Armstrong[5], M.C. Carlson[6], M. Griswold[7], F.R. Lin[1,2,6], T.H. Mosley[7], P.Y. Ramulu[3], N.S. Reed[1,2], S.M. Resnick[8], A.R. Sharrett[1], A.L. Gross[1]

Cognitive Test	ARIC	BLSA	Primary Sensory Modality
Language			
Category fluency	X	X	Hearing
Phonemic fluency	X	X	Hearing
Boston Naming Task	X	X	Vision
Memory			
Figural memory		X	Vision
Delayed free recall	X	X	Both
Logical memory	X		Hearing
Incidental learning	X		Vision
Attention			
Trail making test A	X	X	Vision
WAIS-R Digits Forward		X	Hearing
Executive			
WAIS-R Digits Backwards	X	X	Hearing
Digit Symbol Substitution	X	X	Vision
Trail making test B	X	X	Vision
Similarities Task		X	Hearing
Card rotation Task		X	Vision
Visuospatial Ability			
Clock Drawing		X	Vision

"…..no instances of [differential item functioning] which resulted in bias of greater than 1 standard error of measurement in estimated cognitive scores in participants with and without vision and hearing impairment…"

Nichols, E., et al. "Assessing bias in cognitive testing for older adults with sensory impairment: an analysis of differential item functioning in the Baltimore Longitudinal Study on Aging (BLSA) and the Atherosclerosis Risk in Communities Neurocognitive Study (ARIC-NCS)." *Journal of the International Neuropsychological Society* 28.2 (2022): 154-165.

Effects of hearing and vision impairments on the Montreal Cognitive Assessment

Kate Dupuis[a]*, M. Kathleen Pichora-Fuller[a,b,c], Alison L. Chasteen[a], Veronica Marchuk[a], Gurjit Singh[a,b,d] and Sherri L. Smith[e,f]

"….HL affects performance on the MoCA. Furthermore, the effect of HL on MoCA scores can be compounded by the effect of vision impairment. Neglecting to take sensory impairments into account when conducting cognitive screening may, at least in some cases, lead to cognitive impairment being overestimated…"

Dupuis, Kate, et al. "Effects of hearing and vision impairments on the Montreal Cognitive Assessment." *Aging, Neuropsychology, and Cognition* 22.4 (2015): 413-437.

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

What can we do?

- No standardized guidelines for testing cognition in older adults with sensory loss
- Provide optimal conditions, remind participants to bring sensory aids
- Measure hearing, modified administration (HI-MoCA), sensitivity analyses
- Ensuring Speech Understanding (ESU) test
  - Confirms participant can hear spoken instructions and testing items
  - Determine if accommodations needed

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

What can we do?

- No standardized guidelines for testing cognition in older adults with sensory loss
- Provide optimal conditions, remind participants to bring sensory aids
- Modified administration (HI-MoCA), sensitivity analyses
- Ensuring Speech Understanding (ESU) test
  - Confirms participant can hear spoken instructions and testing items
  - Determine if accommodations needed

Critical Public Health Questions

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Lack of accessible and effective treatments → Focus on Prevention

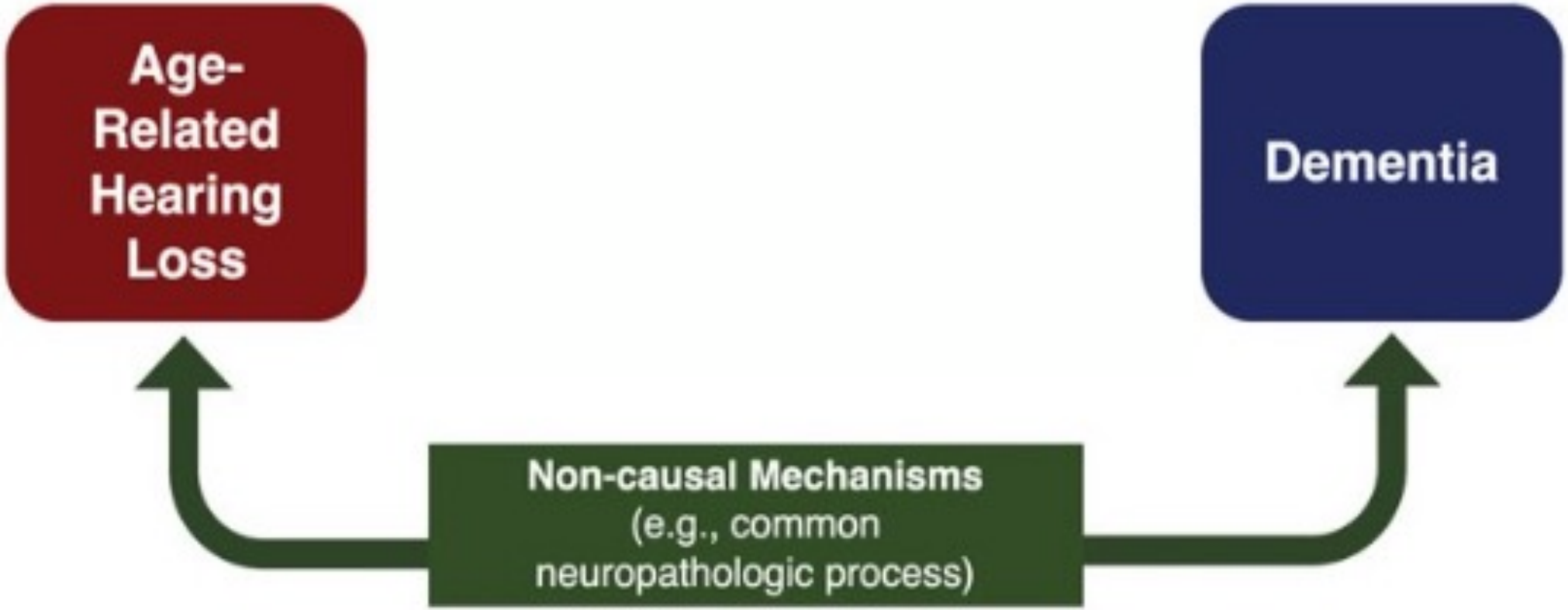
- What are the modifiable risk factors for dementia?
- What are the mechanistic pathways?
- What interventions can modify the mechanistic pathways to reduce risk of dementia?

Hearing Loss and Dementia

Common Cause or Modifiable Risk Factor?

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health



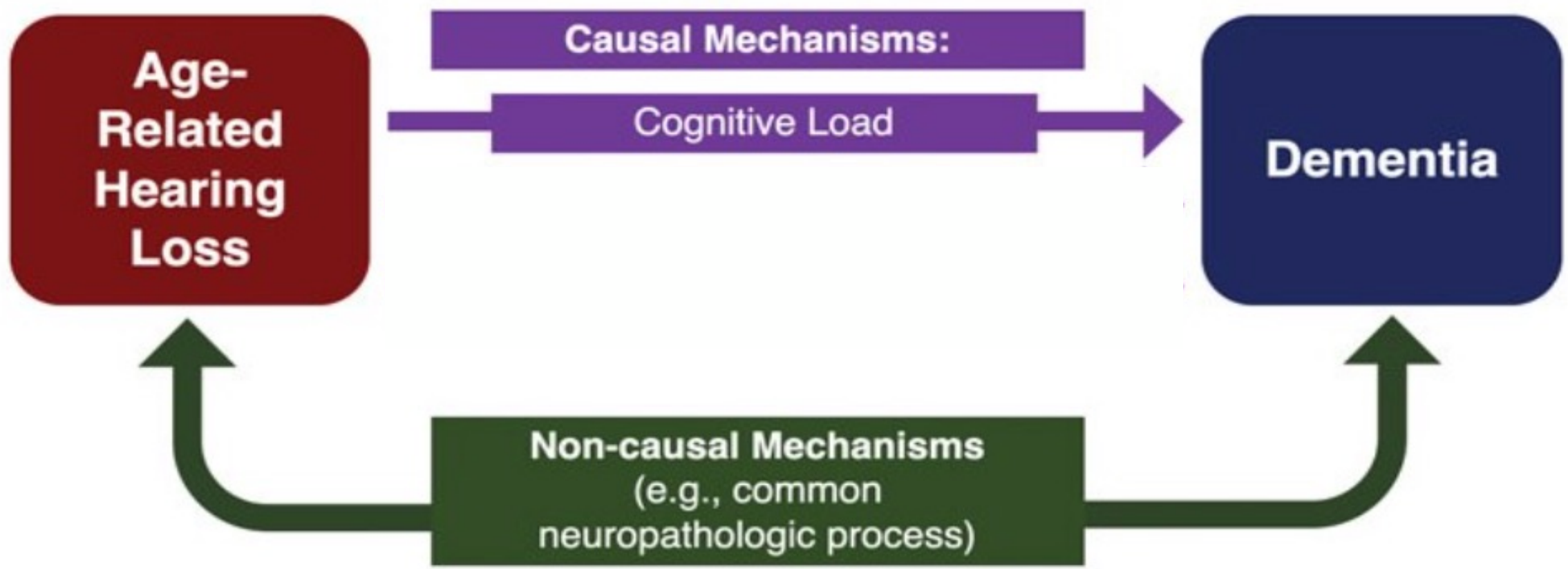
Modified from https://www.entandaudiologynews.com/features/audiology-features/post/hearing-loss-and-cognition-something-to-think-about
Whitson, Heather E., et al. "American Geriatrics Society and National Institute on Aging bench-to-bedside conference: sensory impairment and cognitive decline in older adults." *Journal of the American Geriatrics Society* 66.11 (2018): 2052-2058.

Hearing Loss and Dementia

Common Cause or Modifiable Risk Factor?

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health



Modified from https://www.entandaudiologynews.com/features/audiology-features/post/hearing-loss-and-cognition-something-to-think-about

Whitson, Heather E., et al. "American Geriatrics Society and National Institute on Aging bench-to-bedside conference: sensory impairment and cognitive decline in older adults." *Journal of the American Geriatrics Society* 66.11 (2018): 2052-2058.

Cognitive Load

Information degradation hypothesis

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health

- With hearing loss, speech is heard as garbled --- > "effortful listening"
- Greater cognitive resources allocated to auditory processing
- Fewer resources for other cognitive tasks

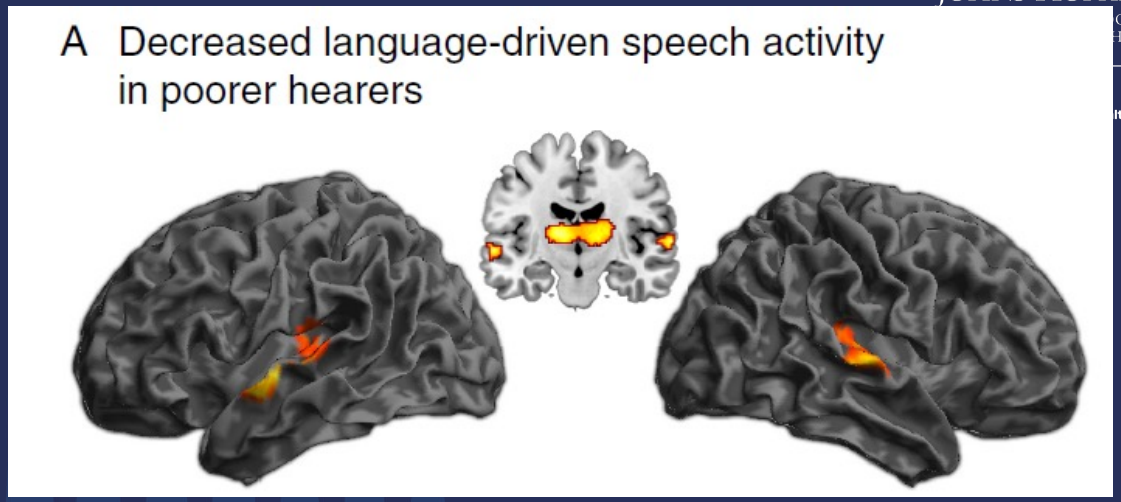
Lin FR, Albert M. Hearing loss and dementia - who is listening? Aging Ment Health. 2014;18(6):671-3. doi: 10.1080/13607863.2014.915924

Hearing Loss & Cognitive Load

JOHNS HOPKINS

Poorer hearing is associated with:

- Reduced language-driven activity in primary auditory pathways



Peelle et al, J. Neurosci, 2011

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

Grossman et al, Brain Lang, 2002

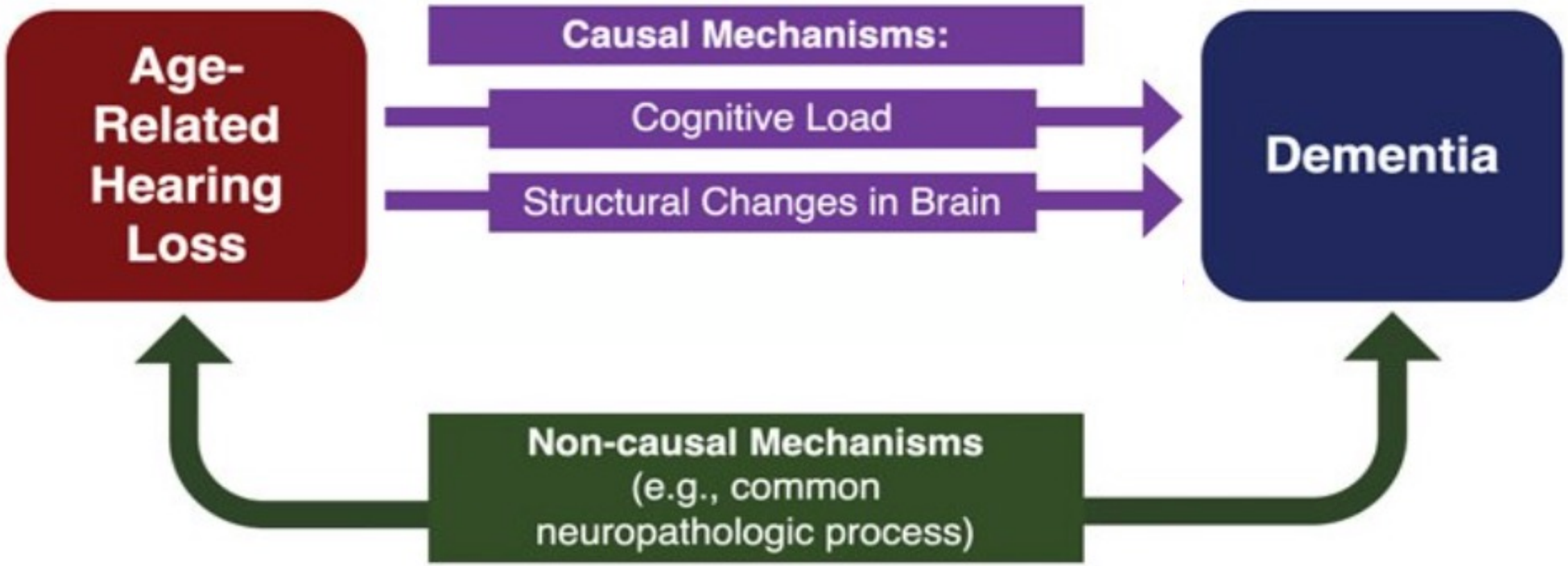
Peelle, J. E., Troiani, V., Grossman, M., & Wingfield, A. (2011). Hearing loss in older adults affects neural systems supporting speech comprehension. *Journal of neuroscience*, *31*(35), 12638-12643.
Grossman, Murray, et al. "Sentence processing strategies in healthy seniors with poor comprehension: an fMRI study." *Brain and Language* 80.3 (2002): 296-313.

Hearing Loss and Dementia

Common Cause or Modifiable Risk Factor?

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health



Modified from https://www.entandaudiologynews.com/features/audiology-features/post/hearing-loss-and-cognition-something-to-think-about

Whitson, Heather E., et al. "American Geriatrics Society and National Institute on Aging bench-to-bedside conference: sensory impairment and cognitive decline in older adults." *Journal of the American Geriatrics Society* 66.11 (2018): 2052-2058.

Hearing Loss & Brain Structural Atrophy

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health

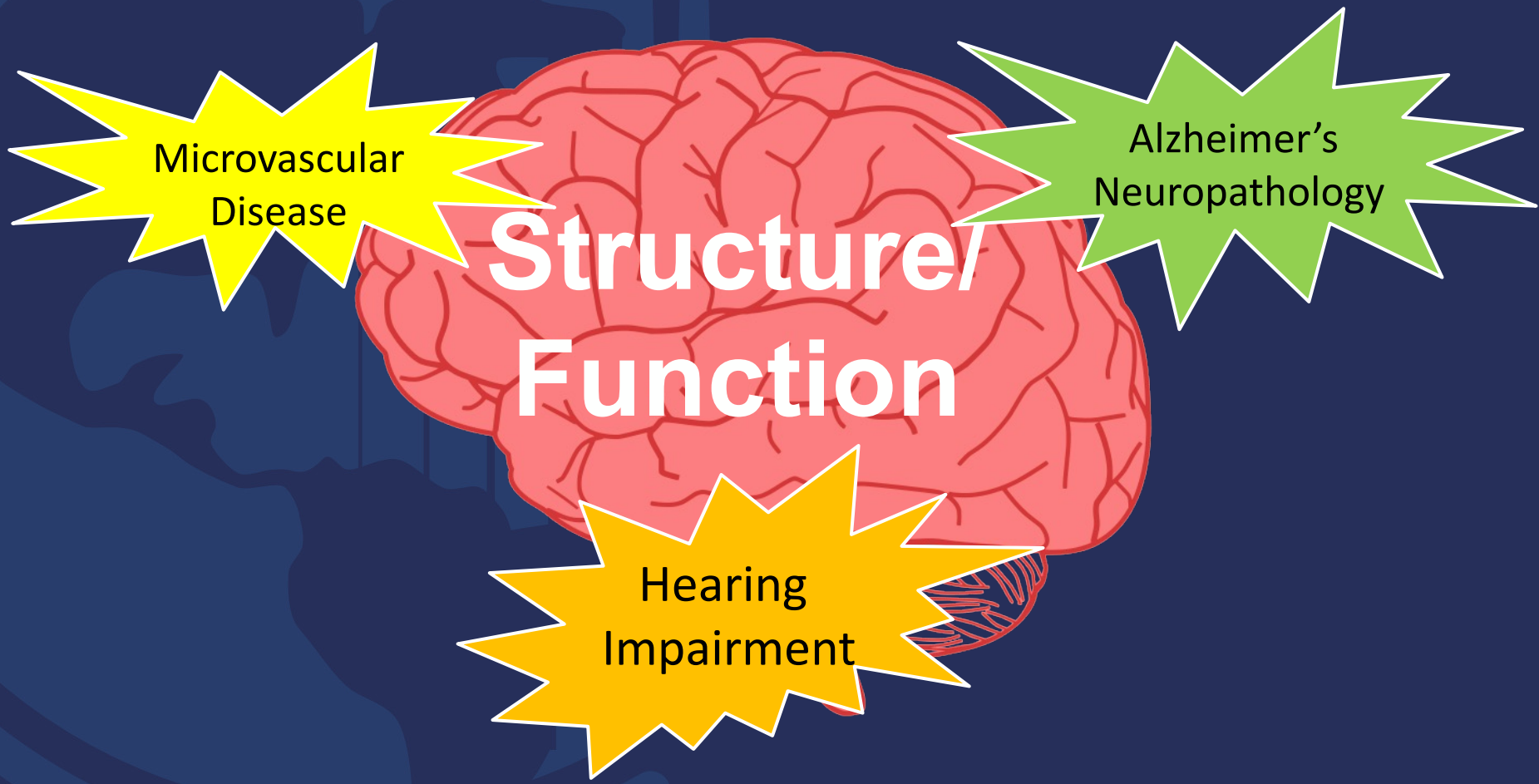
In animals, hearing loss associated in *longitudinal studies* with:

- Tonotopic reorganization of auditory cortex (Kakigi 2000, Audiology; Cheung 2009, J. Neurosci)
- Morphologic changes in central neuronal structures (Groschel 2010, Neurotrauma)

In prospective human studies (i.e., hearing measured at baseline followed by serial MRI scans over years):

- Accelerated atrophy over the temporal lobe over 7 years of follow-up (Lin, Neuroimage 2014)
- Mid-life hearing loss associated with accelerated late-life volume atrophy in temporal lobe and hippocampus (Armstrong 2019, JAMA Oto)

Multi-Hit Theoretical Model

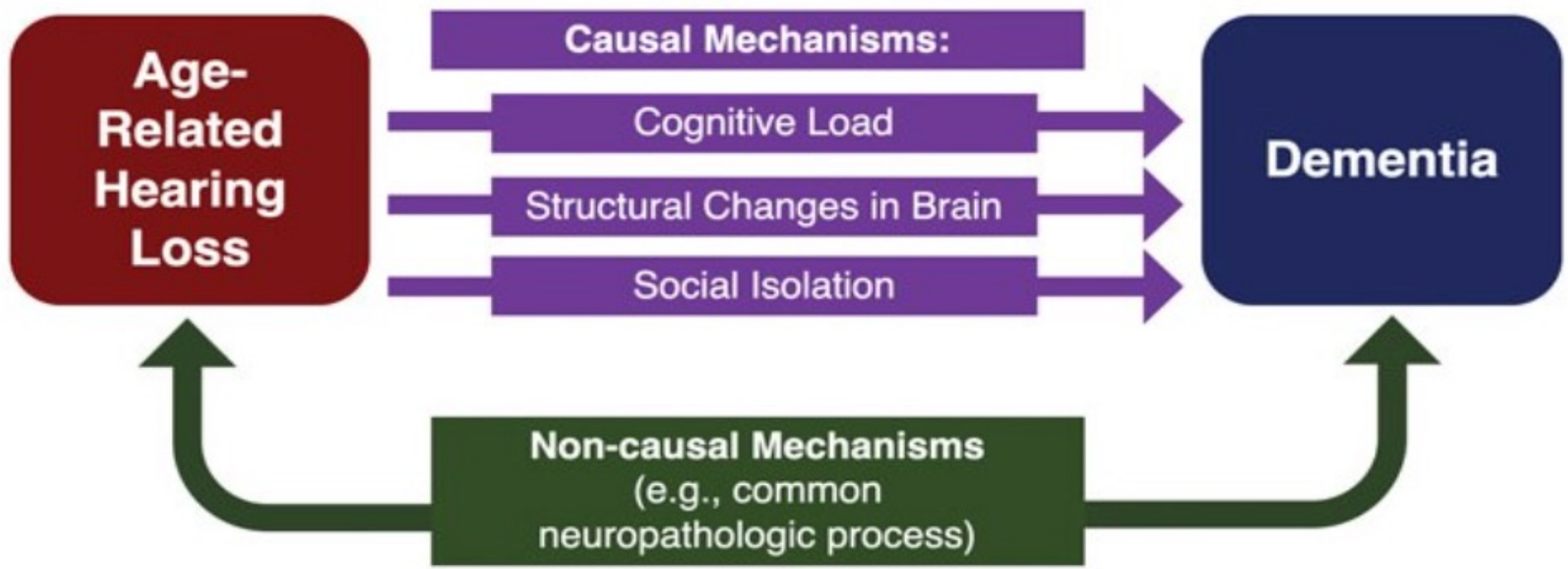


Lin, Frank R., and Marilyn Albert. "Hearing loss and dementia–who is listening?." *Aging & mental health* 18.6 (2014): 671-673.

Hearing Loss and Dementia

Common Cause or Modifiable Risk Factor?

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health



Modified from https://www.entandaudiologynews.com/features/audiology-features/post/hearing-loss-and-cognition-something-to-think-about
Whitson, Heather E., et al. "American Geriatrics Society and National Institute on Aging bench-to-bedside conference: sensory impairment and cognitive decline in older adults." *Journal of the American Geriatrics Society* 66.11 (2018): 2052-2058.

Hearing Loss, Social Isolation, and Loneliness

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Hearing Loss, Loneliness, and Social Isolation: A Systematic Review

Aishwarya Shukla, MPH[1,2], Michael Harper[1], Emily Pedersen, MPH[2], Adele Goman, PhD[2,3], Jonathan J. Suen, AuD[2,4], Carrie Price, MLS[5], Jeremy Applebaum[1], Matthew Hoyer[1], Frank R. Lin, MD, PhD[2,3,6], and Nicholas S. Reed, AuD[2,3,6]

Abstract

Objective. Social isolation and loneliness are associated with increased mortality and higher health care spending in older adults. Hearing loss is a common condition in older adults and impairs communication and social interactions. The objective of this review is to summarize the current state of the literature exploring the association between hearing loss and social isolation and/or loneliness.

Data Sources. PubMed, Embase, CINAHL Plus, PsycINFO, and the Cochrane Library.

Review Methods. Articles were screened for inclusion by 2 independent reviewers, with a third reviewer for adjudication. English-language studies of older adults with hearing loss that used a validated measure of social isolation or loneliness were included. A modified Newcastle-Ottawa Scale was used to assess the quality of the studies included in the review.

Results. Of the 2495 identified studies, 14 were included in the review. Most of the studies (12/14) were cross-sectional. Despite the heterogeneity of assessment methods for hearing status (self-report or objective audiometry), loneliness, and social isolation, most multivariable-adjusted studies found that hearing loss was associated with higher risk of loneliness and social isolation. Several studies found an effect modification of gender such that among women, hearing loss was more strongly associated with loneliness and social isolation than among men.

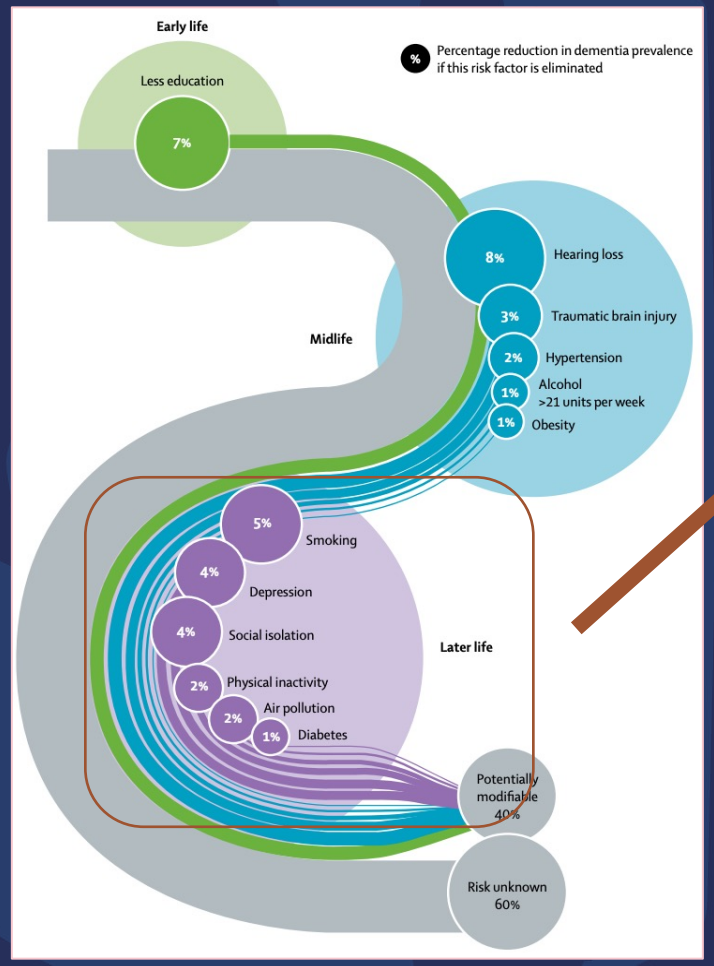
Conclusions. Our findings that hearing loss is associated with loneliness and social isolation have important implications for the cognitive and psychosocial health of older adults. Future studies should investigate whether treating hearing loss can decrease loneliness and social isolation in older adults.

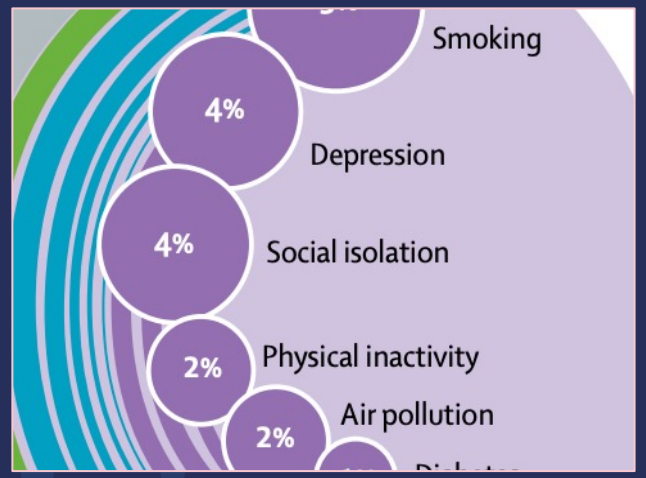
Shukla et al. Hearing Loss, Loneliness, and Social Isolation: A Systematic Review. Otolaryngol Head Neck Surg. 2020 May;162(5):622-633. doi: 10.1177/0194599820910377.

Social isolation is a modifiable risk factor for dementia

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

Cochlear Center for
Hearing and Public Health





Social isolation associated with 28% higher risk of dementia

Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., ... & Costafreda, S. G. (2020). Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet*, *396*(10248), 413-446.
Huang, Alison R., et al. "Social isolation and 9-year dementia risk in community-dwelling Medicare beneficiaries in the United States." *Journal of the American Geriatrics Society* (2023).

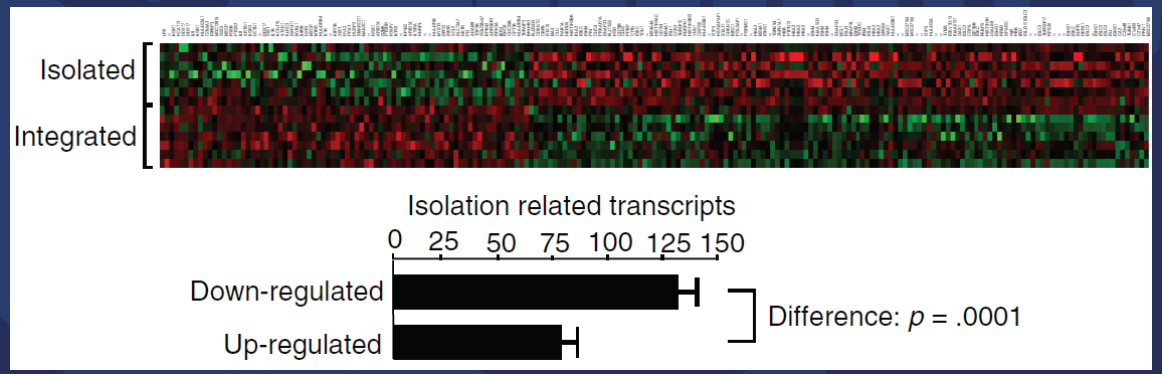
Social Isolation

Cognitive Impairment & Dementia

Health Behavioral Pathways
- Smoking
- Adherence to medical tx
- Diet
- Exercise

Psychological Pathways
- Self-esteem
- Self-efficacy
- Coping
- Sense of well-being

Physiologic Pathways
- HPA axis response
- Immune system fxn
- Cardiovascular reactivity



Social isolation is associated with upregulation of pro-inflammatory genes & increased inflammation

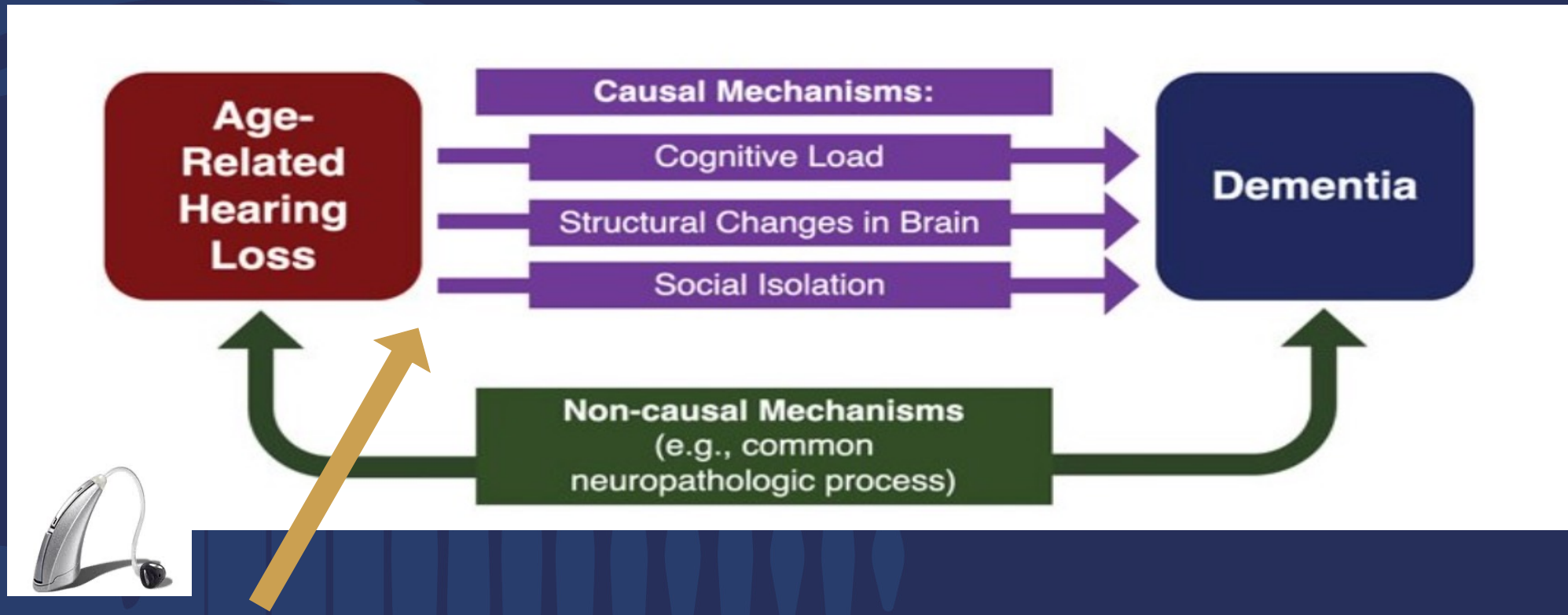
Cole, Steve W., et al. "Social regulation of gene expression in human leukocytes." *Genome biology* 8 (2007): 1-13.
Cole, Steven W., et al. "Transcript origin analysis identifies antigen-presenting cells as primary targets of socially regulated gene expression in leukocytes." *Proceedings of the National Academy of Sciences* 108.7 (2011): 3080-3085.

Critical Public Health Questions

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Lack of accessible and effective treatments → Focus on Prevention

- What are the modifiable risk factors for dementia?
- What are the mechanistic pathways?
- What interventions can modify the mechanistic pathways to reduce risk of dementia?



Hearing loss intervention could:

- Reduce the cognitive load of processing degraded sound
- Provide increased brain stimulation
- Improve social engagement

Poll Question 3

Can hearing treatment delay cognitive decline and reduce dementia risk?

Short answer: We don’t know yet

Observational studies

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

National Health and Aging Trends Study, 2011, N=2,413

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

Hearing aid use associated with 32% lower prevalence of dementia

Huang, Alison R., et al. "Hearing Loss and Dementia Prevalence in Older Adults in the US." *JAMA* 329.2 (2023): 171-173.

Observational studies

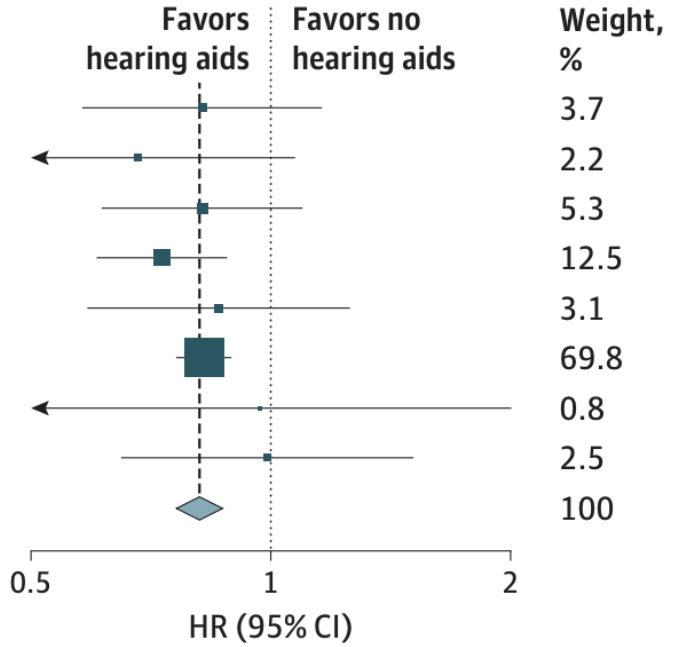
JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Meta-analysis, N=8 studies

Figure 2. Longitudinal Association of Hearing Aid Use and Any Cognitive Decline

Source	TE	seTE	HR (95% CI)	Weight, %
Lin et al,[27] 2013	-0.20	0.1768	0.82 (0.58-1.16)	3.7
Sugiura et al,[39] 2022	-0.39	0.2326	0.68 (0.43-1.07)	2.2
Tai et al,[40] 2021	-0.20	0.1481	0.82 (0.61-1.10)	5.3
Bucholc et al,[6] 2021	-0.31	0.0964	0.73 (0.60-0.88)	12.5
Amieva et al,[7] 2018	-0.15	0.1936	0.86 (0.59-1.26)	3.1
Mahmoudi et al,[28] 2019	-0.19	0.0408	0.82 (0.76-0.89)	69.8
Lin,[29] 2011	-0.03	0.3703	0.97 (0.47-2.00)	0.8
Davies et al,[8] 2017	-0.01	0.2156	0.99 (0.65-1.51)	2.5
Random-effects model			0.81 (0.76-0.87)	100

Heterogeneity: $\tau^2 = 0$ ($P = .88$); $I^2 = 0\%$



Yeo, Brian Sheng Yep, et al. "Association of Hearing Aids and Cochlear Implants With Cognitive Decline and Dementia: A Systematic Review and Meta-analysis." *JAMA neurology* (2022).

Findings from observational studies are encouraging, but…

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

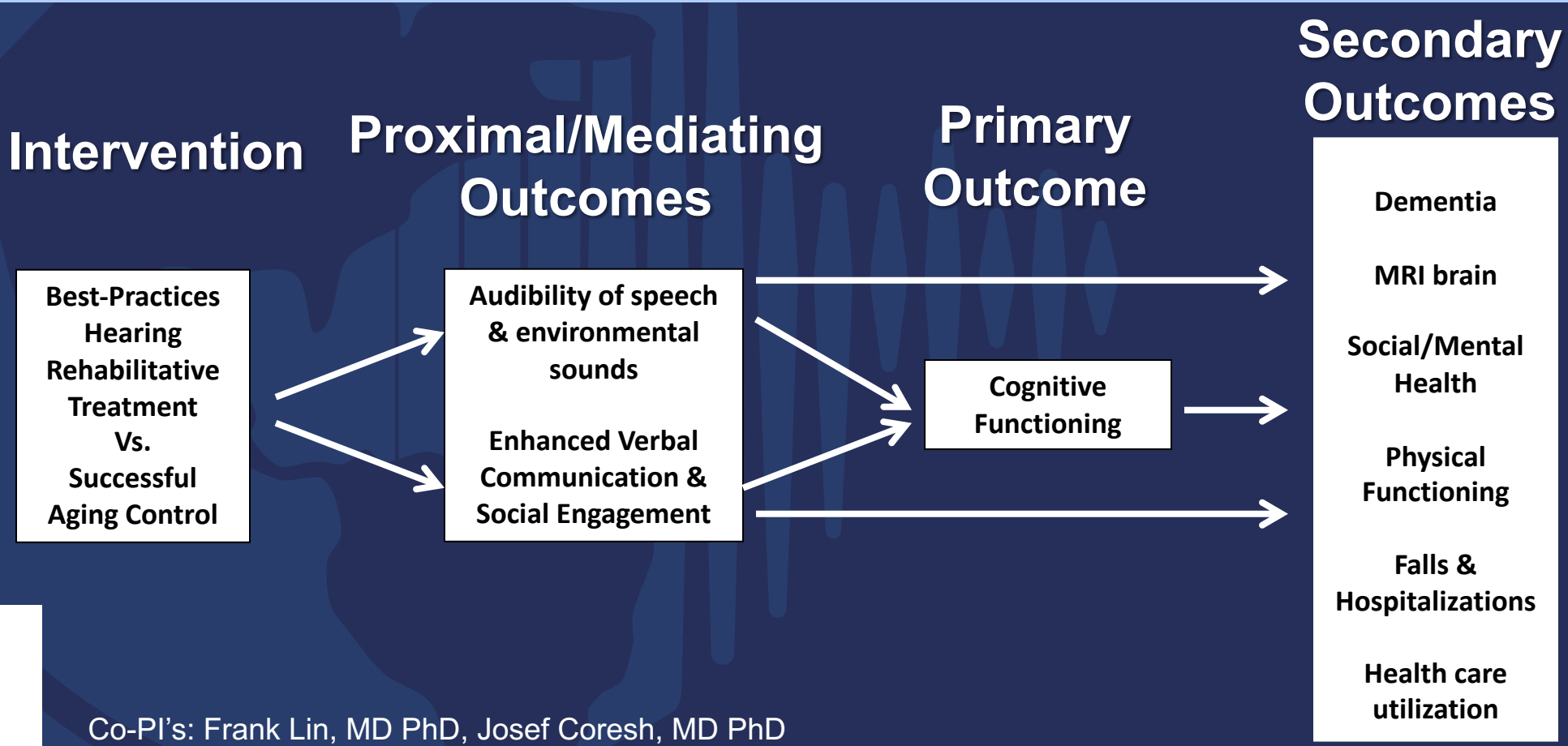
- Cannot disentangle whether observed potential benefit of hearing aids is due to the device or other factors tied to hearing aid use (confounding by indication)

- Hearing aid users tend to have higher SES, health care access

Randomized controlled trials are needed

Aging & Cognitive Health Evaluation in Elders (ACHIEVE) Randomized Trial

2018/2019 – 2022, N=977



ACHIEVE
HEALTHY AGING

Co-PI's: Frank Lin, MD PhD, Josef Coresh, MD PhD
Johns Hopkins University
Supported by National Institute on Aging: R01AG055426, R01AG060502, R34AG046548

The ACHIEVE Study Interventions

ACHIEVE HEALTHY AGING

Cochlear Center for Hearing and Public Health

Hearing Intervention

University of South Florida (Chisolm, Sanchez)

4 sessions with a study audiologist to receive hearing loss education & hearing devices

Health Education Control

University of Pittsburgh (Glynn))

4 sessions with a health educator to cover the 10 Keys™ program

Established program that helps promote understanding of key health topics (nutrition, etc.) important for healthy aging

Semiannual visits for 3 years to receive booster sessions

Supported by National Institute on Aging: R01AG055426, R01AG060502, R34AG046548

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

The ACHIEVE Study

- Results expected later this year
- Whether positive or null, findings will have implications for public health
- Stay tuned!

ACHIEVE
HEALTHY AGING

Summary

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

- What are the modifiable risk factors for dementia?

Risk factors for dementia are multi-factorial. Hearing loss is a prevalent and strong and modifiable risk factor.

- What are the mechanistic pathways between hearing loss and dementia?

Increased cognitive load, direct changes to brain structure and function, social isolation, common cause (non-causal)

- What interventions can modify the mechanistic pathways to reduce risk of dementia?

Hearing treatment, potentially, but no definitive evidence yet

Thank You!

ahuang31@jhu.edu

Supplemental Slides

Hearing Number

Know Your Hearing Number™

Introducing the Hearing Number—a sound metric that can help you engage with life.

www.hearingnumber.org

Participants

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH
Cochlear Center for
Hearing and Public Health

Inclusion Criteria

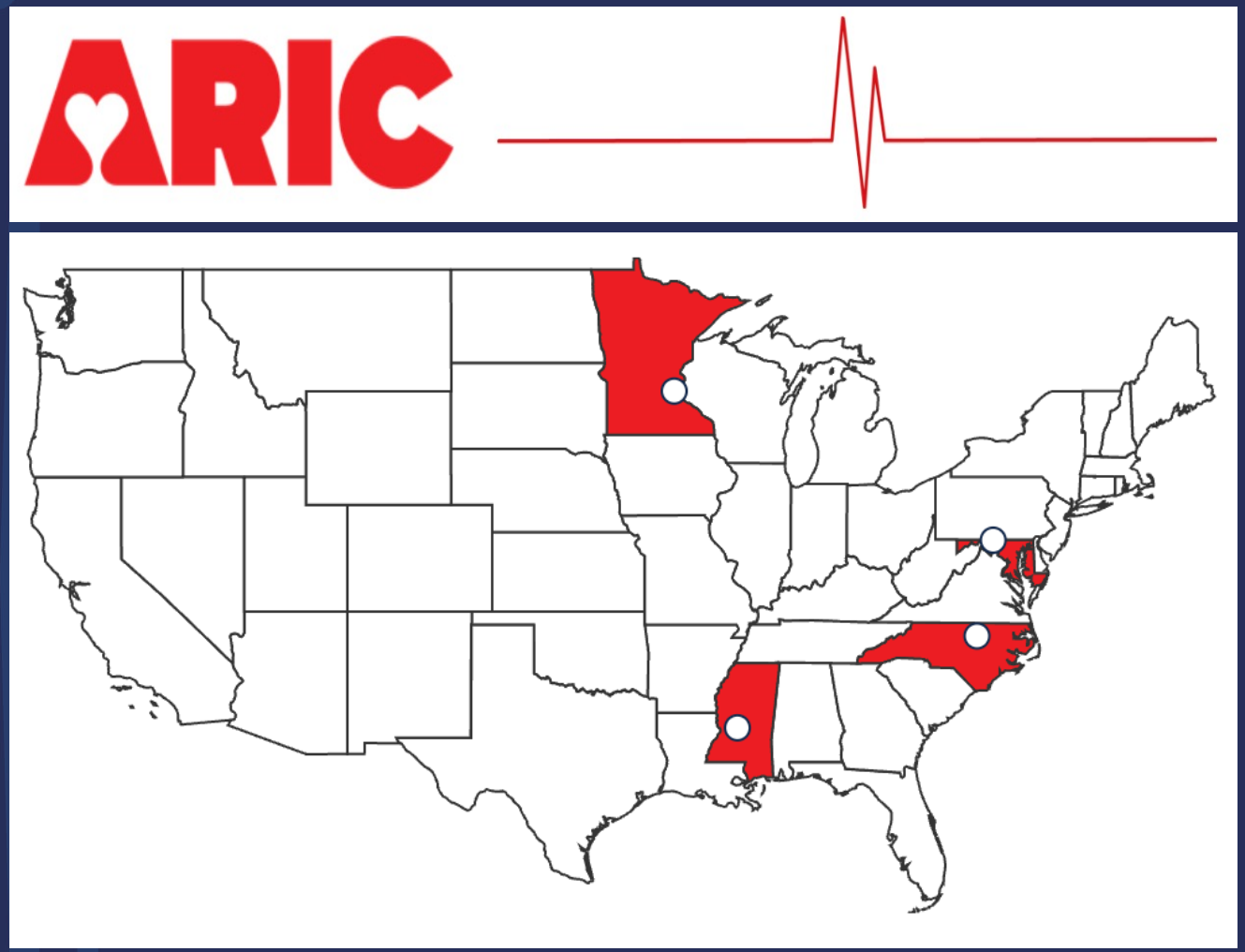
- Community dwelling
- Aged 70-84 years
- Untreated, audiometric hearing loss (PTA ≥30 and <70 dB HL)
- Without dementia

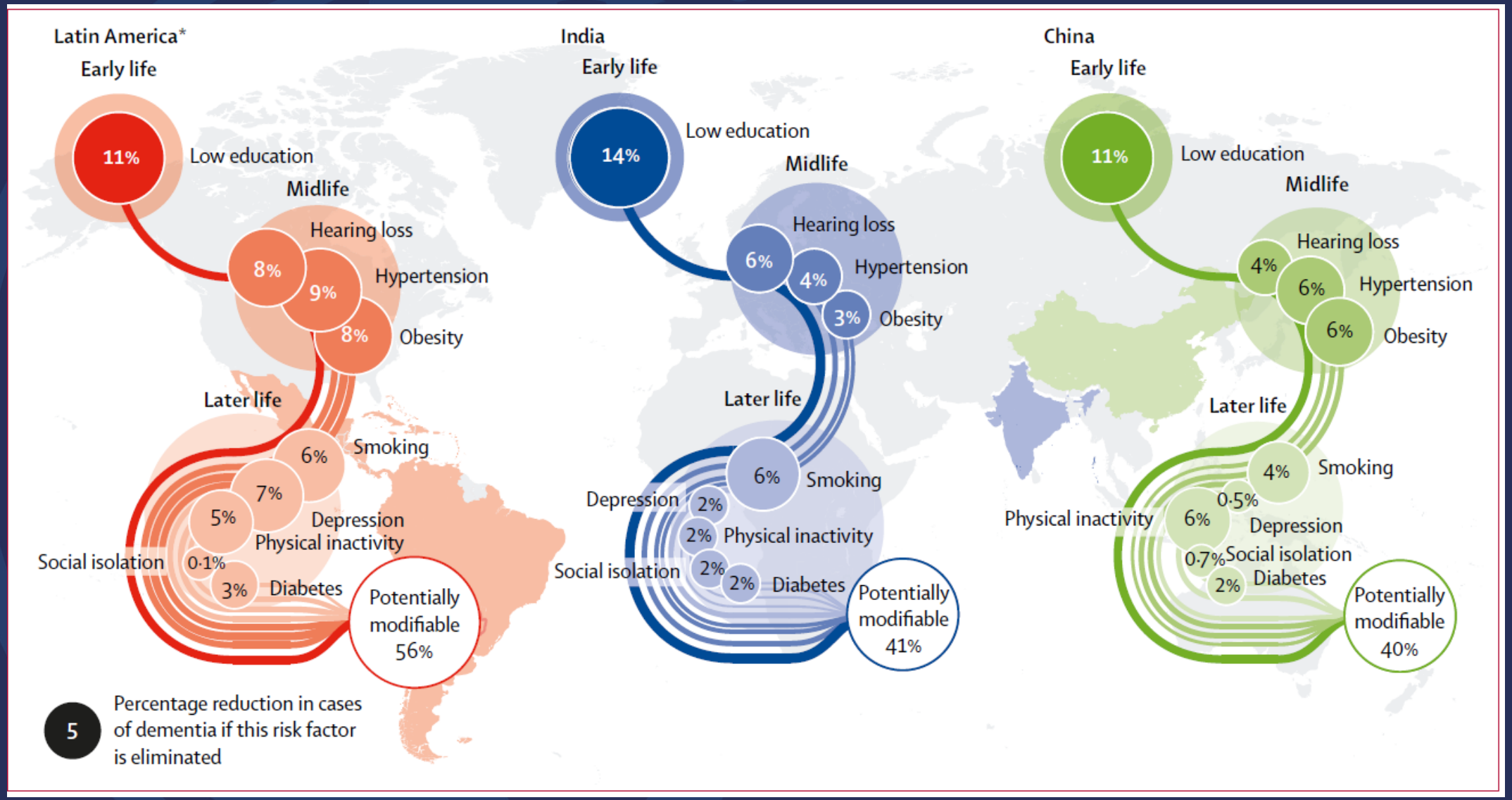
Exclusion Criteria

- Self-reported difficulty in two or more activities of daily living
- Vision loss
- Ineligible for the hearing treatment

Participants

- Partially nested within the the Atherosclerosis Risk in Communities Study (ARIC)
- From 4 US communities
- Recruited from the ARIC Study (24%) and *de novo* (76%)





Mukadam N, Sommerlad A, Huntley J, Livingston G. Population attributable fractions for risk factors for dementia in low-income and middle-income countries: an analysis using cross-sectional survey data. *Lancet Glob Health*. 2019;7(5):e596-e603. doi:10.1016/S2214-109X(19)30074-9