

Cognitive And Hearing State Transitions In Later Life: Results From Alzheimer’s Disease Research Center Volunteers



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Hearing loss (HL) has been consistently linked to dementia and cognitive decline in epidemiological studies, with up to 8% of all global dementia cases potentially attributable to HL [1]. In the United States, approximately 63% of adults aged 70 and older experience hearing loss [1,2].

Because the causal relationship between hearing and cognition remains unclear, it is essential to describe how hearing states evolve and to identify factors associated with these transitions, so we can better characterize patterns of hearing loss associated with cognitive decline and dementia, while also examining cognitive state transitions to assess potential bidirectionality.

Traditional longitudinal models are limited in capturing the dynamic, multi-state nature of hearing and cognition. To address this, our study applies a first-order multi-state Markov chain model to analyze transitions between hearing states over time while incorporating cognitive and dementia-related variables.

Hypothesis: Changes in hearing over time—represented as transitions between states—are causally linked to dementia risk and related exposures, with a potentially bidirectional relationship between hearing and cognition.

Introduction

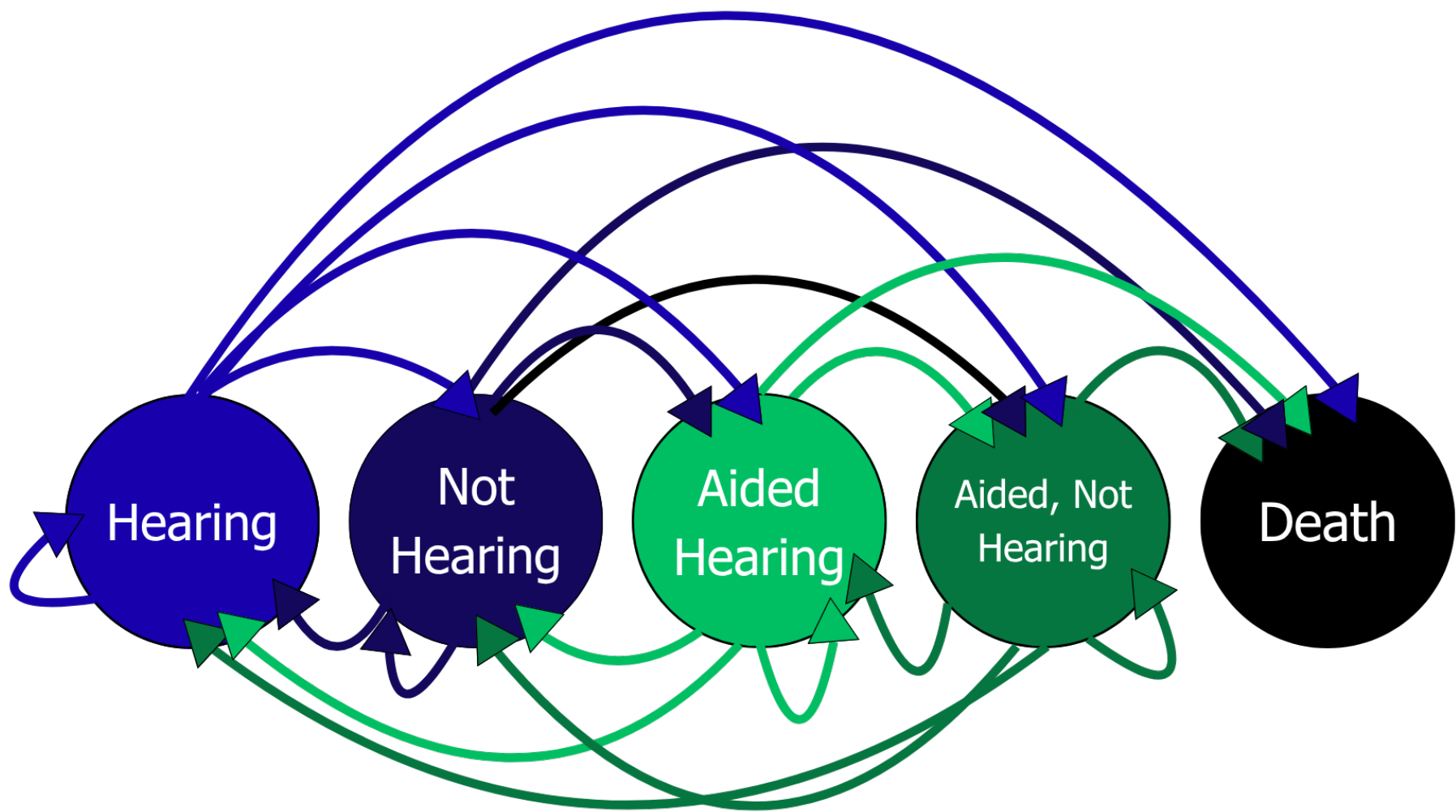


Figure 1: First-order Markov chain model for hearing states and their transitions used in this study

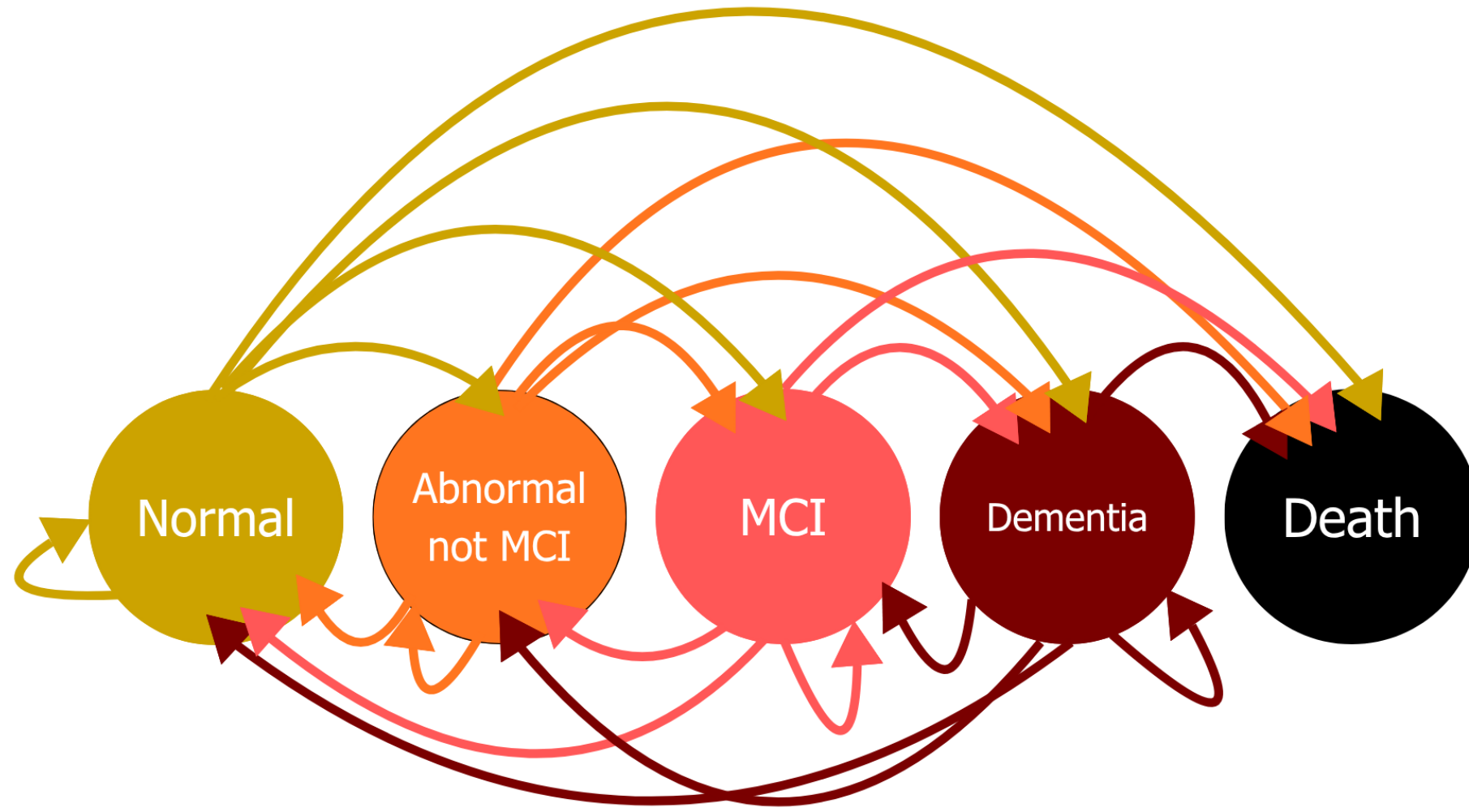


Figure 2: First-order Markov chain model for cognitive states and their transitions used in this study

Methods

Data Source:

- NACC Uniform Data Set (UDS; 2015–2024) annual assessments
- Date range reflects focus on UDS v3 measures, including hearing aid use and expanded health data

Study Sample:

- Cognitively normal participants at the first visit
- Excluded those with Down syndrome
- Included only individuals with ≥2 annual visits

Hearing states:

Hearing and hearing aid use were surveyed each visit, including the effectiveness of hearing aids. Hearing status was supplemented by variables indicating the inability to complete the neurocognitive battery due to hearing impairment. This resulted in the 5 states shown in figures 1 and 3.

- For cognitive models, hearing was split into two indicator variables, functional hearing (yes/no) and hearing aid use (yes/no) that were not mutually exclusive.

Cognitive States:

Cognitive status was assessed at each annual visit with cognitive assessment battery. Abnormal cognition was included as a state for participants that did not meet diagnostic criteria for mild cognitive impairment (MCI) or dementia, but were not classified as having normal cognition.

- For the hearing Markov model, normal cognition was made a binary variable (normal vs. abnormal). For this model, abnormal includes dementia, MCI, or other significant, clinical changes in cognitive impairment.

Death in both models is included as a fourth absorbing state if participants had passed within a year of the last annual exam.

Statistical Analyses:

Chi-square and **t-tests** for baseline comparisons and covariate associations

First-Order Markov Chain Model First characterized one-step state-transition probabilities over time without predictors Added predictors included:

- Age
- Biological sex
- Cognitive status for hearing model
- Hearing status for cognitive model

Generated a model for each transition state to calculate likelihood of state transition using PROC NL MIXED in SAS 9.4®

Table 1: Baseline Demographics for Included NACC Sample	
Characteristics	Overall Sample
N	2661
Average baseline age (stdev)	69.48 (10.83)
Female sex	1713 (64.37%)
Race	
White	1992 (74.86%)
Black or African American	524 (19.69%)
Other	132 (4.96%)
Unknown	13 (0.49%)
Hispanic ethnicity	205 (7.70%)
Functional baseline hearing	2314 (86.96%)
Hearing aid used at baseline	318 (12.05%)

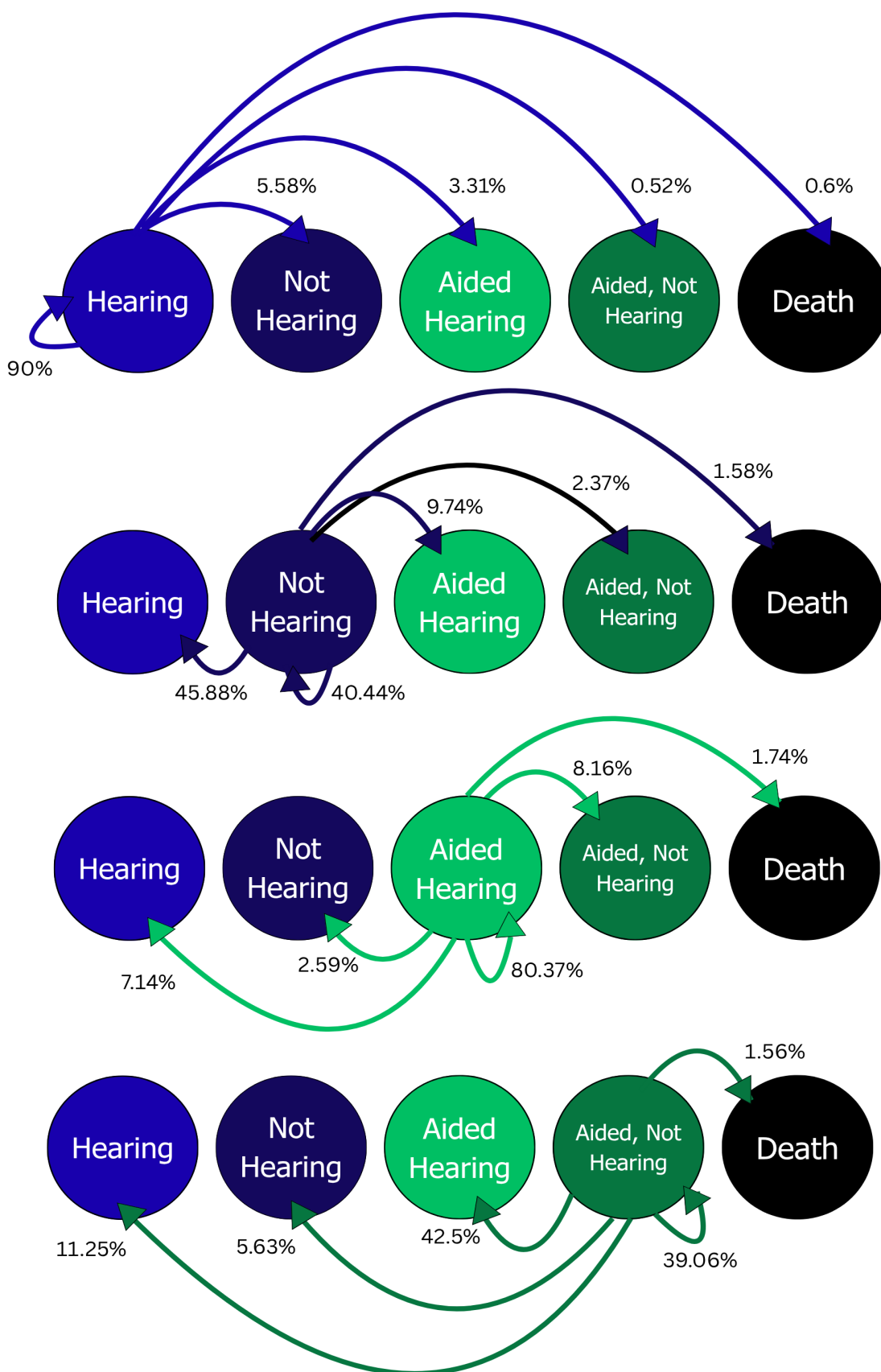


Figure 3: Unadjusted Hearing Transition Probabilities

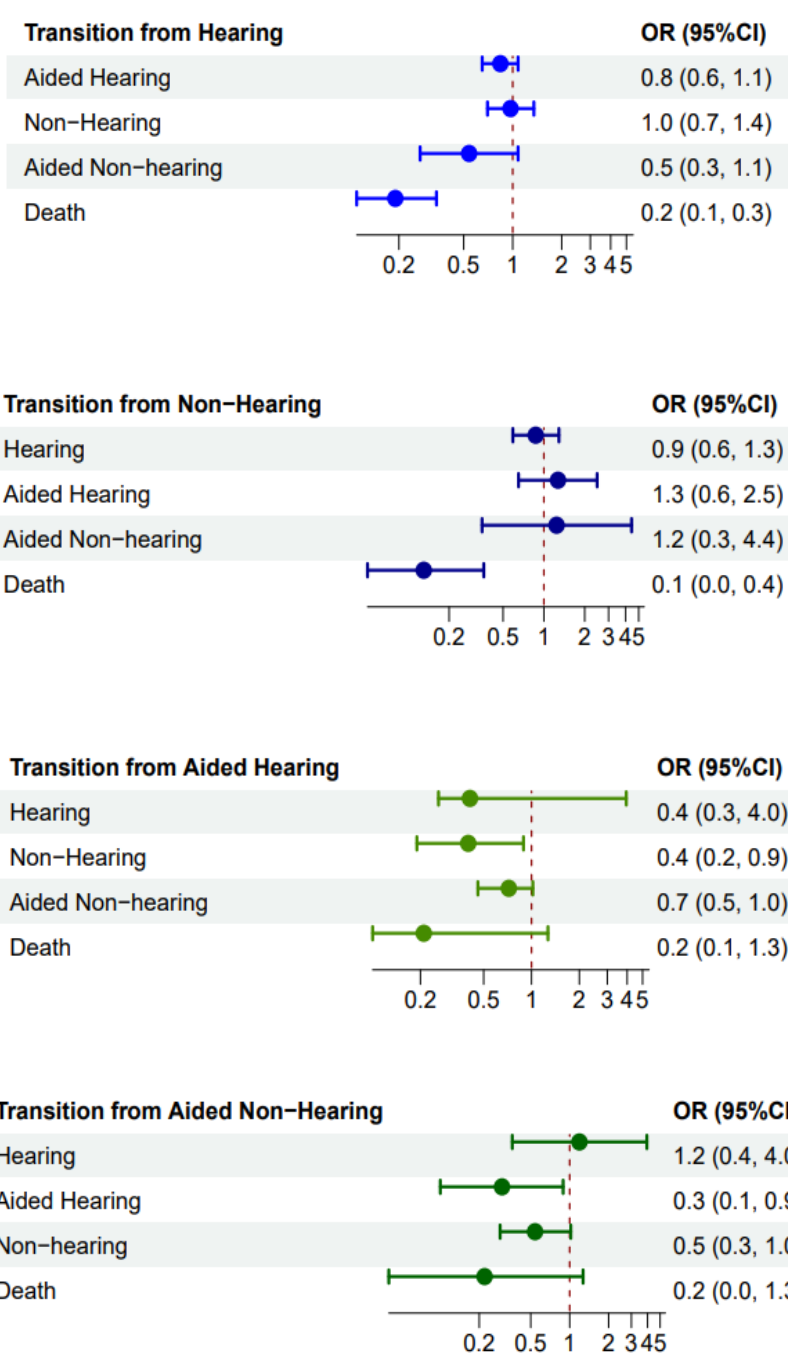


Figure 4: Adjusted odds of hearing state transition for normal cognition vs abnormal cognition

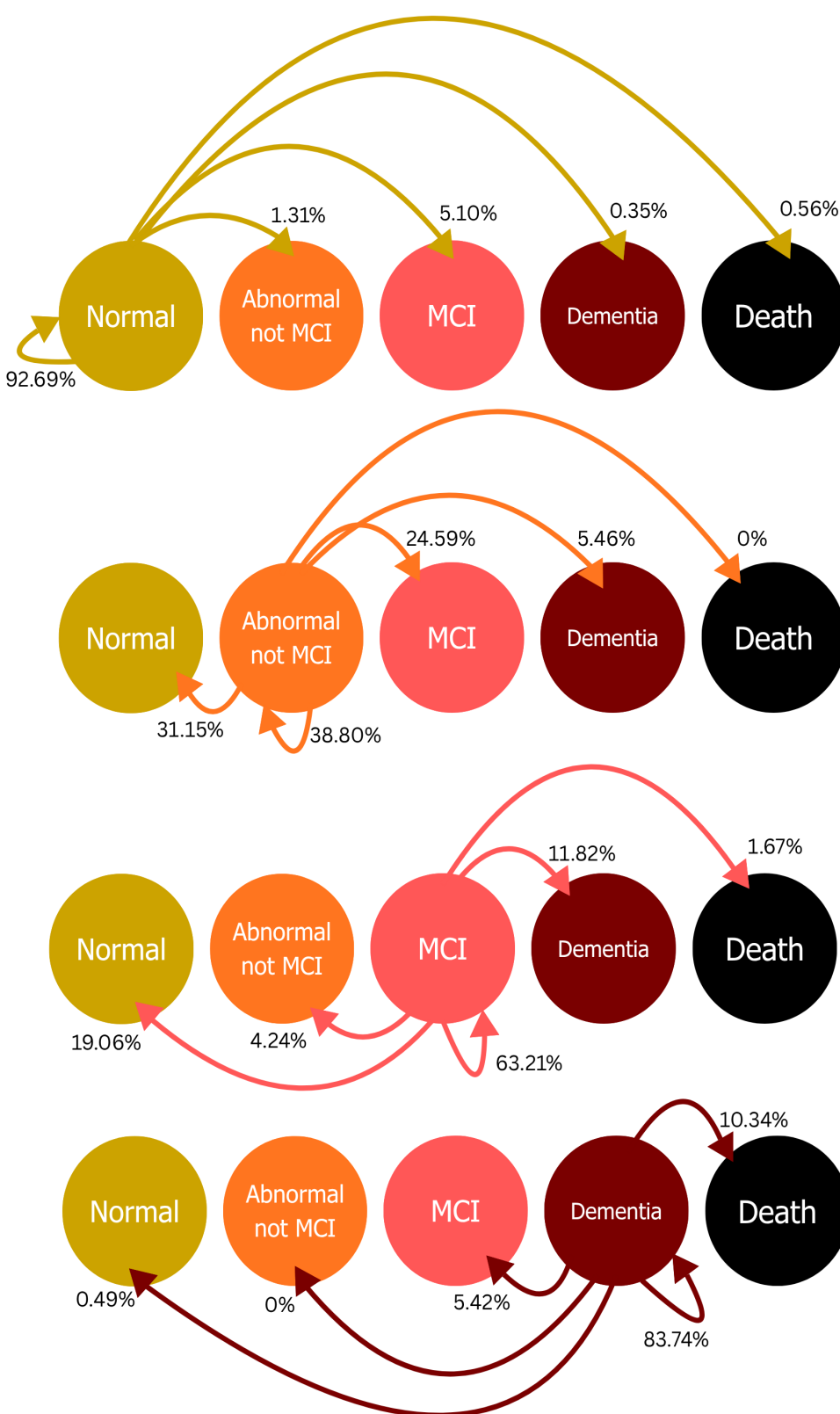


Figure 5: Unadjusted Cognitive Transition Probabilities

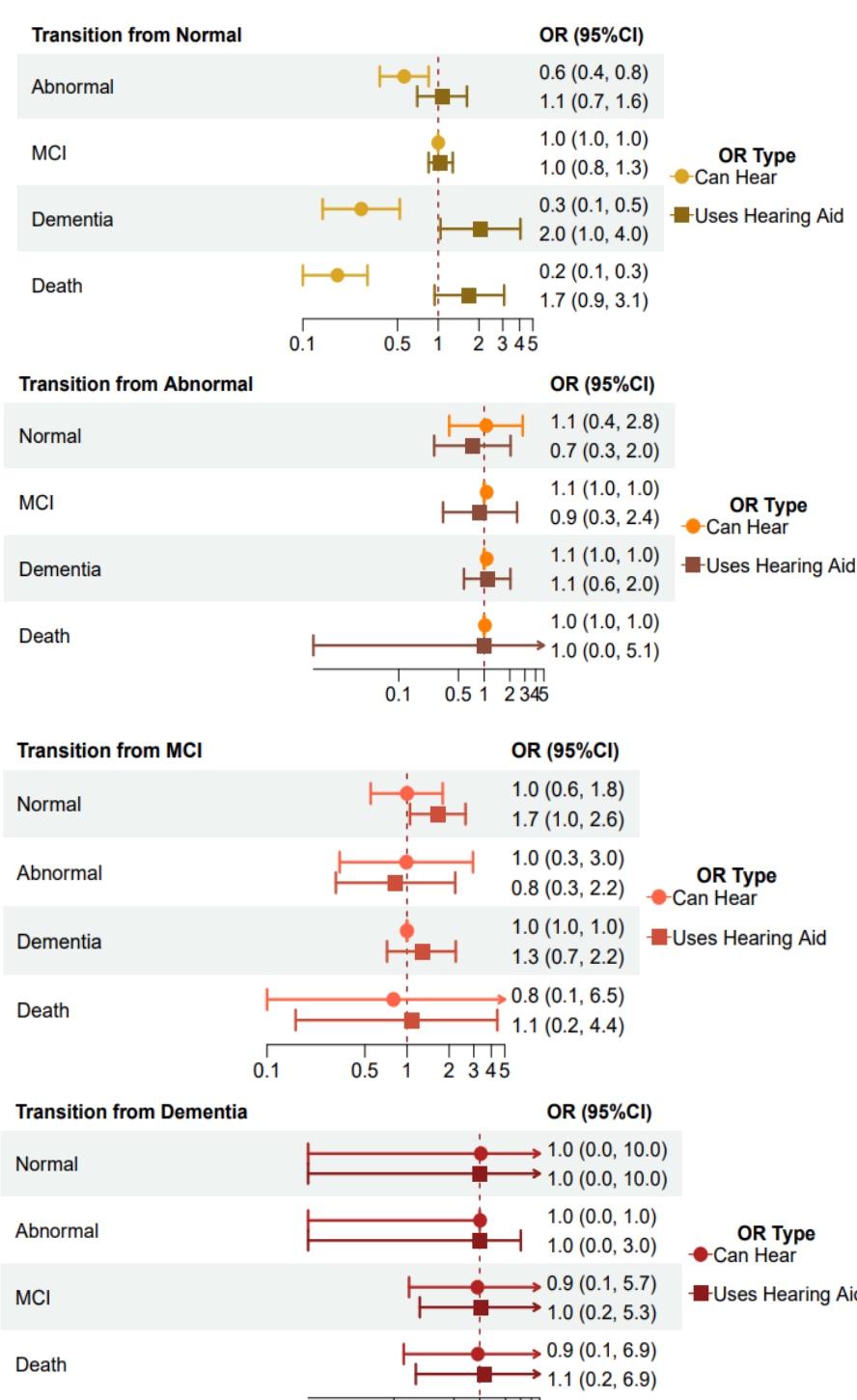


Figure 6: Adjusted odds of cognitive transition for hearing ability and hearing aid use

Discussion

Looking at both Markov models, **hearing with aid is associated with cognition in both models**. In hearing models, *Figure 4*, Normal cognition was associated with lower odds of transitioning from aided non-hearing with aid to aided hearing (OR=0.30, 95% CI [0.10, 0.89]) and from aided hearing to hearing (OR=0.41, [0.26, 0.65]). Cognition was also associated with hearing with aid to non-hearing (OR=0.40, [0.19, 0.82]).

Similarly, in cognitive models, *Figure 6*, hearing ability was associated with reduced odds of transitioning from normal cognition to dementia (OR=0.27, [0.14, 0.52]). **Hearing aid use was associated with higher odds of transitioning from normal cognition to dementia** (OR=2.05, 95% [1.04, 4.05]).

This research continues to highlight the needs for:

- Hearing screening alongside cognitive assessments
- Further defining hearing loss with quantitative measures, and differentiating those with successful hearing treatment from those who may have underlying conditions

My dissertation work will continue to explore longitudinal methods to study how hearing over time affects cognition and dementia.

1.Deal, J. A., & Reed, N. S. (2023). Hearing health and dementia. The Lancet Public Health, 8(10), e751.
2.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. https://doi.org/10.1001/jamaoto.2017.2513
3.Goman AM, Lin FR. Prevalence of Hearing Loss by Severity in the United States. Am J Public Health. 2016;106(10):1820–1822. doi:10.2105/AJPH.2016.303299