Hearing Loss and Dementia: Public Health Implications for Older Adults

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Prevalence of Hearing Loss by Age, United States, 2001-2008

Hearing loss defined as a better-ear PTA of 0.5-4kHz tones > 25 dB

80 million
2 out of 3 adults 70+

Lin et al., Arch Int Med. 2011
Hearing Loss & Function

“How can I live better?”

Risk Factors → Hearing Loss

?
Hearing Loss & Function

Risk Factors → Hearing Loss → Functional Outcomes

“How can I live better?”
Healthy Aging

- Cognitive Vitality & Avoiding Dementia
- Maintaining Physical Mobility & Activity
- Keeping Socially Engaged & Active
- Health Economic Outcomes/Mortality
- Hearing Loss
Healthy Aging

- Cognitive Vitality & Avoiding Dementia
- Keeping Socially Engaged & Active
- Avoiding Injury
- Maintaining Physical Mobility & Activity
- Health Economic Outcomes/Mortality
- Hearing Loss
Hearing Loss & Cognition

Hearing Loss → Dementia & Cognitive Decline
Objectives

• Introduce important cognitive outcomes in geriatrics/gerontology dementia

• Present epidemiologic evidence for a relationship between hearing impairment and cognitive decline and dementia
What is cognitive function?

- Collection of mental processes controlled by the brain
- Includes attention, memory, language production and understanding, learning, reasoning, problem-solving and decision-making
Dementia

- Cognitive or behavioral (neuropsychiatric) symptoms that:
  1. Interfere with the ability to function at work or at usual activities; and
  2. Represent a decline from previous levels of functioning and performing; and
  3. Are not explained by delirium or major psychiatric disorder

Dementia

• ≥ 2 domains of cognitive function
  – e.g., memory, language, executive function

• Significant interference in the ability to function at work or in usual daily activities
  – Differentiates dementia from MCI

The Continuum of Alzheimer’s disease

Adapted from Sperling et al., Alzheimer’s and Dementia (2011) 7:280-292.
Alzheimer’s disease

• Insidious onset
• Clear-cut worsening of cognition
• Initial/most prominent cognitive complaints:
  – Memory & learning (amnestic)
  – Non-amnestic (language, visuospatial, executive function)
• No evidence of other causes (e.g., cerebrovascular disease)

## Figure 5

### Projected Number of People Age 65 and Older (Total and by Age Group) in the U.S. Population With Alzheimer’s Disease, 2010 to 2050

<table>
<thead>
<tr>
<th>Millions of people with Alzheimer’s</th>
<th>Ages 65-74</th>
<th>Ages 75-84</th>
<th>Ages 85+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>2010</td>
<td>2020</td>
<td>2030</td>
</tr>
<tr>
<td>2010</td>
<td>4.7</td>
<td>5.4</td>
<td>5.8</td>
</tr>
<tr>
<td>2016</td>
<td>13.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Created from data from Hebert et al. (17, 18)


Hebert & al. Neurology May 7, 2013 vol. 80 no. 19 1778-1783
Dementia Incidence Declining?

Temporal Trends in the Framingham Heart Study

<table>
<thead>
<tr>
<th>Subtype</th>
<th>No. of Cases</th>
<th>Total No. of Observation Periods</th>
<th>Epoch 2 (5-Yr Hazard Ratio (95% CI))</th>
<th>Epoch 3 (5-Yr Hazard Ratio (95% CI))</th>
<th>Epoch 4 (5-Yr Hazard Ratio (95% CI))</th>
<th>P Value for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall dementia</td>
<td>371</td>
<td>9015</td>
<td>0.78 (0.59–1.04)</td>
<td>0.62 (0.47–0.83)</td>
<td>0.56 (0.41–0.77)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Alzheimer’s disease</td>
<td>264</td>
<td>9015</td>
<td>1.00 (0.70–1.43)</td>
<td>0.88 (0.62–1.25)</td>
<td>0.70 (0.48–1.03)</td>
<td>0.052</td>
</tr>
<tr>
<td>Vascular dementia</td>
<td>84</td>
<td>9014</td>
<td>0.89 (0.51–1.56)</td>
<td>0.46 (0.25–0.86)</td>
<td>0.45 (0.23–0.87)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Compared to late 1970’s – early 80’s

late 1980’s – early 90’s
late 90’s – early 2000’s
late 2000’s – early 2010’s
Fig. 2. The growth in numbers of people with dementia in high-income (HIC) and low- and middle-income countries (LMIC).

M. Prince et al. / Alzheimer's & Dementia 9 (2013) 63–75
The Cost of Dementia

Conclusion: Health care expenditures among persons with dementia were substantially larger than those for other diseases, and many of the expenses were uncovered (uninsured). This places a large financial burden on families, and these burdens are particularly pronounced among the demographic groups that are least prepared for financial risk.
The Cost of Dementia
## Treatments for Alzheimer’s disease

<table>
<thead>
<tr>
<th>Drug name</th>
<th>Brand name</th>
<th>Approved For</th>
<th>FDA Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. donepezil</td>
<td>Aricept</td>
<td>All stages</td>
<td>1996</td>
</tr>
<tr>
<td>2. galantamine</td>
<td>Razadyne</td>
<td>Mild to moderate</td>
<td>2001</td>
</tr>
<tr>
<td>3. memantine</td>
<td>Namenda</td>
<td>Moderate to severe</td>
<td>2003</td>
</tr>
<tr>
<td>4. rivastigmine</td>
<td>Exelon</td>
<td>All stages</td>
<td>2000</td>
</tr>
<tr>
<td>5. donepezil and memantine</td>
<td>Namzaric</td>
<td>Moderate to severe</td>
<td>2014</td>
</tr>
</tbody>
</table>

http://www.alz.org/research/science/alzheimers_disease_treatments.asp
# Treatments for Alzheimer’s disease

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<td>Moderate to severe</td>
<td>2014</td>
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</table>

*Slow progression of symptoms, but only for a limited time*

http://www.alz.org/research/science/alzheimers_disease_treatments.asp
Prevention!!!
Identification of modifiable risk factors urgently needed

Slow progression of symptoms, but only for a limited time

http://www.alz.org/research/science/alzheimers_disease_treatments.asp
“Currently, firm conclusions cannot be drawn about the association of any modifiable risk factor with cognitive decline”
The Continuum of Alzheimer’s disease

Adapted from Sperling et al., Alzheimer’s and Dementia (2011) 7:280-292.
The Continuum of Alzheimer’s disease

Timing of intervention

Mild Cognitive Impairment (MCI)

Aging

Dementia

AGE (YEARS)

VS.

Does the effect of a factor differ by point on the continuum?

Adapted from Sperling et al., Alzheimer’s and Dementia (2011) 7:280-292.
Clinical Outcome

Biologic Onset of Disease

Preclinical Phase

Normal

Symptoms First Appear

No Disease

Disease Diagnosed

BEFORE DISEASE STARTS

Therapy Given

DISEASE PRESENT

Clinical Phase

Clinical Outcome

Gordis.Epidemiology.5th ed.
The Continuum of Alzheimer’s disease

Adapted from Sperling et al., Alzheimer’s and Dementia (2011) 7:280-292.

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Prevention!!!
Identification of modifiable risk factors urgently needed

Adapted from Sperling et al., Alzheimer’s and Dementia (2011) 7:280-292.
Hearing Loss & Cognition

Hearing Loss

Cognitive Load

Dementia & Cognitive Function

Common pathological process
“Sunday”

Peripheral transduction

Central processing
“Sunday”

Peripheral transduction

Hearing Loss & Cochlear impairment

Decreased hearing sensitivity & poor frequency resolution

“Effortful listening”
Hearing Loss & Cognitive Load

Kahneman model of shared attention and resource capacity (D. Kahneman, Attention & Effort, 1973)

Cognitive Resource Capacity

Auditory Perceptual Processing Requirements

Available Cognitive Resources For Performance of Tasks

Age-Related Decline
Hearing Loss & the Brain

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


Grossman et al, Brain Lang, 2002
Hearing Loss & Cognition

Hearing Loss → Cognitive Load → Brain structure/function → Dementia & Cognitive Function → Common pathological process
Double Hit Theoretical Model

Hearing Loss & Brain Structure/Function

- Cerebrovascular Disease
- Alzheimer’s Neuropathology
- Hearing Impairment

F. Lin & M. Albert, Aging & Mental Health, 2014
• **Hypothesis**: Hearing loss is associated with accelerated atrophy in the superior, middle, and inferior temporal gyri

• 126 participants (56-86 yrs) in the neuroimaging substudy of the BLSA
  • Mean follow-up duration of 6.4 years
  • 1.5T MRI performed annually

*Lin et al. Neuroimage 2014*
Hearing Loss & Accelerated Brain Volume Decline

Voxel-Based Analyses

Difference in mean gray matter volume change in those with HL vs. NH

Faster decline in brain volume in HL vs. NH

Lin et al. Neuroimage 2014
### Estimated Annual Rates of Change in Brain Volume (cm³/year), Baltimore Longitudinal Study on Aging (BLSA)

<table>
<thead>
<tr>
<th></th>
<th>Normal Hearing mean (SE)</th>
<th>Hearing Loss, mean (SE)</th>
<th>Difference mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N=75</strong></td>
<td><strong>N=51</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Global measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole brain</td>
<td>-7.21 (0.27)**</td>
<td>-8.33 (0.36)**</td>
<td>-1.13 (0.45) + p = .015</td>
</tr>
<tr>
<td>vCSF</td>
<td>1.30 (0.10)**</td>
<td>1.28 (0.14)**</td>
<td>-0.020 (0.18)</td>
</tr>
<tr>
<td>White matter</td>
<td>-4.14 (0.31)**</td>
<td>-4.99 (0.39)**</td>
<td>-0.85 (0.39) + p = .031</td>
</tr>
<tr>
<td>Gray matter</td>
<td>-2.63 (0.22)**</td>
<td>-3.38 (0.28)**</td>
<td>-0.76 (0.36) + p = .036</td>
</tr>
<tr>
<td><strong>Lobar measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>-0.96 (0.11)**</td>
<td>-1.11 (0.14)**</td>
<td>-0.16 (0.14)</td>
</tr>
<tr>
<td>Temporal</td>
<td>-0.46 (0.096)**</td>
<td>-0.71 (0.12)**</td>
<td>-0.25 (0.12) + p = .036</td>
</tr>
<tr>
<td>Parietal</td>
<td>-0.71 (0.051)**</td>
<td>-0.74 (0.066)**</td>
<td>-0.044 (0.081)</td>
</tr>
<tr>
<td>Occipital</td>
<td>-0.54 (0.057)**</td>
<td>-0.50 (0.073)**</td>
<td>0.047 (0.071)</td>
</tr>
<tr>
<td><strong>Regional Volumes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior temporal gyrus</td>
<td>-0.20 (0.023)**</td>
<td>-0.31 (0.030)**</td>
<td>-0.11 (0.038) + p = .0046</td>
</tr>
<tr>
<td>Middle temporal gyrus</td>
<td>-0.15 (0.033)**</td>
<td>-0.30 (0.042)**</td>
<td>-0.15 (0.054) + p = .0065</td>
</tr>
<tr>
<td>Inferior temporal gyrus</td>
<td>-0.048 (0.015)**</td>
<td>-0.12 (0.020)**</td>
<td>-0.067 (0.025) + p = .0093</td>
</tr>
<tr>
<td>Hippocampus</td>
<td>-0.019 (0.0051)**</td>
<td>-0.031 (0.0065)**</td>
<td>0.012 (0.0002)</td>
</tr>
</tbody>
</table>

+ < .05; * < .01; ** <.001

N=126 participants aged 56-86 years
Annual MRI for up to 10 yrs
Mean follow-up = 6.4 years

Sound & speech
But also memory, sensory integration

Lin et al., Neuroimage 2013
Hearing Loss & Cognition

Hearing Loss

Cognitive Load

Brain structure/function

Social Isolation

Dementia & Cognitive Function

Common pathological process
Social Isolation

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 & Cacioppo, Genome Biology, 2007
Cole & Cacioppo, PNAS, 2011
Hearing Loss & Healthy Aging
Cross-sectional Datasets for Epidemiologic Analyses

- **NHANES**: National Health and Nutritional Examination Survey
  - Cross-sectional, representative sample of U.S. population
Hearing Loss & Healthy Aging
Longitudinal Datasets for Epidemiologic Analyses

- **ARIC**: *Atherosclerosis Risk in Communities*
  - Prospective, population-based study of 15,792 men and women from 4 US communities aged 45-64 years at baseline (1987-89)

- **BLSA**: *Baltimore Longitudinal Study on Aging*
  - Ongoing prospective study of older adults since 1958

- **Health ABC**: *Health, Aging, & Body Composition*
  - Prospective, population-based study of ~3000 adults 70 years and older
Cognitive Assessment

• Global cognitive function
  – Mini-Mental State Exam (Folstein 1975)

• Cognitive domains
  – Address different cognitive abilities
  – e.g.,
    • Memory
    • Executive Function
      – Cognitive abilities that control & regulate other abilities & behaviors
      – Goal-directed behavior, planning, initiating, inhibiting
Cognitive Assessment

• Why study cognitive domains?
  – Hierarchy of decline across domains
    • Speed 30’s
    • Vocabulary intact into 70’s
  – Domain-specific decline associated with:
    • Transition to dementia
    • Disability
    • Mortality
The Mini-Mental State Exam

Patient ___________________ Examinee ___________________ Date ___________________

Maximum Score

Orientation
5. ( ) What is the (year) (season) (date) (day) (month)?
5. ( ) Where are we (state) (country) (town) (hospital) (floor)?

Registration
3. ( ) Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials ___________

Attention and Calculation
5. ( ) Serial 7’s. 1 point for each correct answer. Stop after 5 answers. Alternatively spell “world” backward.

Recall
3. ( ) Ask for the 3 objects repeated above. Give 1 point for each correct answer.

Language
2. ( ) Name a pencil and watch.
1. ( ) Repeat the following “No ifs, ands, or buts”
3. ( ) Follow a 3-stage command: “Take a paper in your hand, fold it in half, and put it on the floor.”
1. ( ) Read and obey the following: CLOSE YOUR EYES
1. ( ) Write a sentence.
1. ( ) Copy the design shown.

Total Score

ASSESS level of consciousness along a continuum __________ Alert Drowsy Stupor Coma
Executive Function:
Digit Symbol Substitution Test (DSST)
Executive Function: Stroop Mixed

Look at the list below and say the **COLOR** not the word.

<table>
<thead>
<tr>
<th>YELLOW</th>
<th>BLUE</th>
<th>ORANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLACK</td>
<td>RED</td>
<td>GREEN</td>
</tr>
<tr>
<td>PURPLE</td>
<td>YELLOW</td>
<td>RED</td>
</tr>
<tr>
<td>ORANGE</td>
<td>GREEN</td>
<td>BLACK</td>
</tr>
<tr>
<td>BLUE</td>
<td>RED</td>
<td>PURPLE</td>
</tr>
<tr>
<td>GREEN</td>
<td>BLUE</td>
<td>ORANGE</td>
</tr>
</tbody>
</table>

**Left – Right Conflict**

Your right brain tries to say the color but your left brain insists on reading the word.

Executive Function: Trail Making Tests

Part A

Part B
Tests do not depend on hearing
## Hearing Loss and Cognition
### Cross-Sectional Studies

### NHANES

<table>
<thead>
<tr>
<th>Test</th>
<th>β^a (95% CI)</th>
<th>P</th>
<th>β^b (95% CI)</th>
<th>P</th>
<th>Δ Age (years) equivalent to 25 dB of hearing loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol Substitution Test</td>
<td>-0.55</td>
<td>&lt;.01</td>
<td>-3.86</td>
<td>.02</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>(-0.92 - -0.18)</td>
<td></td>
<td>(-7.15 - -0.56)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**N = 605 adults 60-69 years**


### BLSA

<table>
<thead>
<tr>
<th>Test</th>
<th>β^a (95% CI)</th>
<th>P</th>
<th>β^b (95% CI)</th>
<th>P</th>
<th>Δ Age (years) equivalent to 25 dB of hearing loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroop Mixed</td>
<td>-0.33</td>
<td>&lt;.001</td>
<td>-2.27</td>
<td>.02</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>(-0.48 - -0.18)</td>
<td></td>
<td>(-4.14 - -0.40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trail Making B</td>
<td>-0.00011</td>
<td>.001</td>
<td>-0.00074</td>
<td>.05</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>(-0.00018 - -0.000044)</td>
<td></td>
<td>(-0.0015 - 2.74x10^-6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**N = 347 adults >60 years**

Lin et al., Neuropsych., 2011

Models adjusted for age, sex, race, education, diabetes, smoking, hypertension
Hearing Loss & Cognitive Decline

Adjusted 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 hearing loss vs. normal hearing

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

Lin et al. JAMA Int Med. 2013
Hearing Loss & Memory Decline
ARIC, 1990-2013

* Adjusted for age, age², sex, education, smoking status, diabetes, hypertension, and Wide Range Achievement Test (WRAT)
Rates of 20-Year Change* in MEMORY, ARIC

<table>
<thead>
<tr>
<th>Hearing status:</th>
<th>Estimate 95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate/severe</td>
<td>-1.66 -1.35 -1.05</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mild</td>
<td>-1.24 -1.02 -0.80</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>None</td>
<td>-1.13 -0.88 -0.64</td>
<td>&lt;0.0001</td>
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Difference Comparing:

<table>
<thead>
<tr>
<th></th>
<th>Estimate 95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild to None</td>
<td>-0.47 -0.14 0.20</td>
<td>0.411</td>
</tr>
<tr>
<td>Moderate/severe to None</td>
<td>-0.86 -0.47 -0.08</td>
<td>0.018</td>
</tr>
</tbody>
</table>

* Adjusted for age, age², sex, education, smoking status, diabetes, hypertension, and Wide Range Achievement Test (WRAT)
MEMORY

SPEED & ATTENTION

LANGUAGE

GLOBAL FUNCTION

Hearing Impairment
- None, ≤ 25 dB
- Mild, 26–40 dB
- Moderate or severe, >40 dB

Memory Language Speed & Attention Global Function
Among participants with hearing loss, do rates of cognitive decline differ by hearing aid use?

* Adjusted for age, age^2, sex, education, smoking status, diabetes, hypertension, and Wide Range Achievement Test (WRAT)
**Memory**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Estimate</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No hearing aid, N=42</td>
<td>-2.28</td>
<td>-1.84</td>
<td>-1.39</td>
</tr>
<tr>
<td>Hearing aid, N=43</td>
<td>-1.25</td>
<td>-0.89</td>
<td>-0.52</td>
</tr>
<tr>
<td>Difference</td>
<td>-1.53</td>
<td>-0.95</td>
<td>-0.38</td>
</tr>
</tbody>
</table>

**Global Composite**

<table>
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<th>Condition</th>
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<th>95% CI</th>
<th>P-value</th>
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<tr>
<td>No hearing aid, N=42</td>
<td>-1.70</td>
<td>-1.45</td>
<td>-1.20</td>
</tr>
<tr>
<td>Hearing aid, N=43</td>
<td>-1.21</td>
<td>-0.97</td>
<td>-0.74</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.83</td>
<td>-0.48</td>
<td>-0.14</td>
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</table>

*Among participants with moderate/severe hearing loss*
Hearing Loss & Incident Dementia

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

<table>
<thead>
<tr>
<th>Level</th>
<th>HR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>1.89</td>
<td>1.00 – 3.58</td>
<td>.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>3.00</td>
<td>1.43 – 6.30</td>
<td>.004</td>
</tr>
<tr>
<td>Severe</td>
<td>4.94</td>
<td>1.09 – 22.4</td>
<td>.04</td>
</tr>
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</table>

*Risk of incident all-cause dementia (compared to normal hearing)*

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

Lin et al., Arch Neuro., 2011
• If we treat hearing impairment, do we delay or prevent functional decline in older adults?
ACHIEVE Randomized Trial

- Aging, Cognition, and Hearing Evaluation in Elders

- ACHIEVE-Feasibility
  - 20 participants
  - Hearing intervention

- ACHIEVE-Pilot
  - 40 participants
  - Randomized: Hearing vs. Successful Aging
  - 6-mo follow-up

(Washington County, MD)
Hearing Intervention

- Goal: eliminate or minimize activity limitations & participation restrictions from HL
- Individual needs assessment & goal-setting, development of self-management abilities
- 4 sessions (~1 hr each, over 2-3 mos)
- Hearing aids & other technologies

Theresa Chisolm, PhD
Michelle Arnold AuD, PhD, CCC-A
Victoria Sanchez AuD, PhD, CCC-A
Courtney Matthews
Successful Aging Intervention

- Based on the 10 Keys™ to Healthy Aging program (Center for Aging and Population Health Prevention Research Center)

- 4 sessions (~1 hr each, over 2-3 mos)

- Aging Successfully With Pain RCT

Nancy W Glynn, PhD

• Elizabeth Rogers
ACHIEVE-P
Eligibility, Randomization and Follow-up

Screened:
- 152
  - 75 Ineligible
  - 21 Declined
  - 15 Not enrolled*

Randomized:
- 40
  - Hearing: 20
  - Successful Aging: 20

Completed 6-mo follow-up:
- Hearing: 20
- Successful Aging: 19

- 1 Death**

* Eligible but not enrolled because recruitment targets had been reached
** Unrelated to study intervention
## ACHIEVE-P

### 6-Month Change in Standardized Proximal Outcomes, N=40

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Hearing Intervention Mean (SD), N=20</th>
<th>Successful Aging Intervention Mean (SD), N=20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived handicap due to HI*†</td>
<td>-1.40 (0.96)</td>
<td>0.02 (0.68)</td>
</tr>
<tr>
<td>Loneliness*</td>
<td>-0.19 (0.87)</td>
<td>0.22 (0.94)</td>
</tr>
<tr>
<td>Social Network**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of people‡</td>
<td>0.17 (0.65)</td>
<td>-0.42 (0.66)</td>
</tr>
<tr>
<td>Diversity</td>
<td>0.15 (1.25)</td>
<td>-0.12 (0.70)</td>
</tr>
<tr>
<td>Social Function**</td>
<td>0.00 (0.65)</td>
<td>-0.26 (0.91)</td>
</tr>
<tr>
<td>Mental Function**</td>
<td>0.26 (0.80)</td>
<td>-0.14 (0.60)</td>
</tr>
<tr>
<td>Physical Function**</td>
<td>0.11 (0.76)</td>
<td>-0.07 (0.40)</td>
</tr>
</tbody>
</table>

* Lower scores are better; **Higher scores are better
†p<0.0001; ‡p<0.01
### ACHIEVE-P
6-Month Change in Standardized Cognitive Domain Score, N=40

<table>
<thead>
<tr>
<th>Cognitive Domain</th>
<th>Hearing Intervention</th>
<th>Successful Aging Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD), n=20</td>
<td>Mean (SD), n=20</td>
</tr>
<tr>
<td>Memory</td>
<td>0.48 (0.69)</td>
<td>0.19 (0.66)</td>
</tr>
<tr>
<td>Language</td>
<td>0.05 (0.38)</td>
<td>0.00 (0.42)</td>
</tr>
<tr>
<td>Executive Function</td>
<td>0.03 (0.42)</td>
<td>0.17 (0.47)</td>
</tr>
<tr>
<td>Global Function</td>
<td>0.16 (0.42)</td>
<td>0.14 (0.39)</td>
</tr>
</tbody>
</table>
Full ACHIEVE Randomized Trial

- 750 participants: 70-84 year-old cognitively-normal older adults with hearing loss
- 1:1 randomization hearing vs. successful aging
- Follow-up at 6 mos & then annually for 3 years
- Primary outcome: change in global function
  - Powered to detect a minimum of a 0.30 SD difference
- Proximal outcomes: speech/audibility understanding, hearing aid use
- Secondary outcomes: domain-specific cognitive function, social fxn, physical fxn, physical activity
Access HEARS: Hearing care Equality through Accessible Research & Solutions

HEARS Intervention
1) Hearing Loss Screening
2) Device Orientation:
   - Self-fit amplification device
   - Individual programming
3) Counseling:
   - Expectation management
   - Communication Strategies

Pilot Studies in Multiple Populations

Licensing & Dissemination
- Non-profits
- Local government

2016-2019

Pilot Studies
- Multiple Communities

2014-2016

Intervention Development

2013

Outcomes in participant & communication partner

Social Engagement Communication Activities
HRQL

Carrie Nieman

Sara Mamo

Janet Choi

Older Adults in Assisted Living Facilities or with Cognitive Impairment

Korean-American Older Adults – Korean Martyrs Catholic Church
Memory Clinic HEARS

Results (N=20) of Neuropsychiatric Inventory Scores Post Intervention
• Frank R. Lin, MD, PhD
• Jennifer Deal, PhD
• Sara Mamo, AuD PhD
• Marilyn Albert, PhD
• Josef Coresh, MD PhD
• Luigi Ferrucci, MD PhD
• Tamara Harris, PhD
• Elizabeth Helzner, PhD
• David Knopman, MD
• Karen Bandeen-Roche, PhD
• Thomas H. Mosley, PhD
• Sheila Pratt, PhD
• Susan Resnick, PhD
• Suzanne Satterfield, MD DrPH
• A. Richey Sharrett, MD DrPH
• Eleanor Simonsick, PhD
• Lisa M. Wruck, PhD
• Kristine Yaffe, MD

• Eleanor Schwartz Charitable Foundation
• National Heart, Lung, and Blood Institute (NHLBI) contracts
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  HHSN268201100007C,
  HHSN268201100008C,
  HHSN268201100009C,
  HHSN268201100010C,
  HHSN268201100011C,
  HHSN268201100012C.
• NIDCD K23DC011279
• National Institute on Aging (NIA) Contracts N01-AG-6-2101; N01-AG-6-2103; N01-AG-6-2106; NIA grant R01-AG028050, and NINR grant R01-NR012459. This research was supported in part by the Intramural Research Program of the NIH, National Institute on Aging
Thank you!
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