Hearing Loss in Older Adults: A Public Health Perspective

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Disclosures

- Research grants: NIH, Eleanor Schwartz Charitable Foundation, American College of Surgeons, Triological Society

- Scientific Advisory Board for Pfizer and Autifony Therapeutics

- Consultant for Cochlear Ltd & Gerson Lehrman Group

- Speaker honoraria from Amplifon & Med El
Prevalence of Hearing Loss in the United States, 2001-2008

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

Lin et al., Arch Int Med. 2011
Hearing Loss & Hearing Aid Use
Prevalence in the U.S., 1999-2006

Chien W et al, Arch Int Med, 2012
Age-Related Hearing Loss (ARHL)

Basic Questions

• What are the consequences of ARHL for older adults?

• What is the impact of treating ARHL on older adults?

• How can ARHL be effectively addressed in the community?
John Smith, 72 y.o.
Age-Related Hearing Loss (ARHL)

*Basic Questions*

- What are the consequences of ARHL for older adults?
- What is the impact of treating ARHL on older adults?
- How can ARHL be effectively addressed in the community?
Healthy Aging
Hearing Loss & Healthy Aging

Common Cause or Modifiable Risk Factor

Hearing Loss → ? → Cognitive & Physical Functioning

Common pathological process
Hearing Loss & Cochlear impairment

Decreased sensitivity & distortion in sound encoding

“Effortful listening”
Hearing Loss & Healthy Aging

*Common Cause* or *Modifiable Risk Factor*

- **Cognitive Load**
- **Hearing Loss**
- **Cognitive & Physical Functioning**
- **Common pathological process**
Hearing Loss & Cognitive Load

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

Cognitive Resource Capacity

<table>
<thead>
<tr>
<th>Auditory Perceptual Processing Requirements</th>
<th>Available Cognitive Resources For Performance of Tasks</th>
<th>Age-Related Decline</th>
</tr>
</thead>
</table>

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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


Grossman et al, Brain Lang, 2002
Hearing Loss & Healthy Aging

*Common Cause* or *Modifiable Risk Factor*

- Cognitive Load
- Brain structure/function
- Cognitive & Physical Functioning
- Hearing Loss

Common pathological process
Double Hit Theoretical Model

Hearing Loss & Brain Structure/Function

Microvascular Disease

Alzheimer’s Neuropathology

Structure/Function

Hearing Impairment

F. Lin & M. Albert, Aging & Mental Health, 2014
Hearing Loss & Healthy Aging

Common Cause or Modifiable Risk Factor

Cognitive Load

Hearing Loss

Brain structure/function

Social Isolation

Cognitive & Physical Functioning

Common pathological process
Social Isolation

Cognitive & Physical Functioning

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
Hearing Loss & Healthy Aging

Common Cause or Modifiable Risk Factor

Cognitive Load

Brain structure/function

Social Isolation

Cognitive & Physical Functioning

Common pathological process
Healthy Aging

- Avoiding Injury
- Maintaining Physical Mobility & Activity
- Keeping Socially Engaged & Active
- Health Resource Utilization
- Cognitive Vitality & Avoiding Dementia
- Hearing Loss
Projected Worldwide Prevalence of Dementia 2010-2050

Low and middle income countries

High income countries

Year

2010 2020 2030 2040 2050
Hearing Loss & Cognition

Background

– Memory
  • Free and cued selective reminding test (FCSRT)

– Executive Function
  • Trail Making B
  • Stroop Mixed
  • Digit symbol substitution

– Psychomotor/processing speed

– Verbal function & language

These tests are not dependent on hearing.
Hearing Loss & Cognition

Executive Function: Trail Making B

Trail Making B
Hearing Loss & Cognition

Executive Function: Stroop Mixed

Stroop Mixed

GREEN

RED

RED

YELLOW

RED

BLUE

GREEN

BLUE

BLUE

GREEN

BLUE

YELLOW

GREEN

BLACK
Executive Function: Digit Symbol Substitution Test (DSS)
### NHANES

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

<table>
<thead>
<tr>
<th>Test</th>
<th>( \beta^a )</th>
<th>( P )</th>
<th>( \beta^b )</th>
<th>( P )</th>
<th>( \Delta \text{Age (years)} ) equivalent to 25 dB of hearing loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol Substitution Test</td>
<td>-0.55 ((-0.92 - -0.18))</td>
<td>&lt;.01</td>
<td>-3.86 ((-7.15 - -0.56))</td>
<td>.02</td>
<td>7.0</td>
</tr>
</tbody>
</table>

### BLSA

**N = 347 adults >60 years**

<table>
<thead>
<tr>
<th>Test</th>
<th>( \beta^a ) ((-\text{value}))</th>
<th>( P )</th>
<th>( \beta^b ) ((-\text{value}))</th>
<th>( P )</th>
<th>( \Delta \text{Age (years)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroop Mixed</td>
<td>-0.33 ((-0.48 - -0.18))</td>
<td>&lt;.001</td>
<td>-2.27 ((-4.14 - -0.40))</td>
<td>.02</td>
<td>6.8</td>
</tr>
<tr>
<td>Trail Making B</td>
<td>-0.00011 ((-0.00018 - -0.000044))</td>
<td>.001</td>
<td>-0.00074 ((-0.0015 - 2.74 \times 10^{-5}))</td>
<td>.05</td>
<td>6.7</td>
</tr>
</tbody>
</table>

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

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

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

Lin et al. JAMA Int Med. 2013

42% faster rate of cognitive decline in DSS scores in HL vs. NH
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)\(^a\)

<table>
<thead>
<tr>
<th>Severity</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>0.05</td>
</tr>
<tr>
<td>Moderate</td>
<td>3.00</td>
<td>1.43 – 6.30</td>
<td>0.004</td>
</tr>
<tr>
<td>Severe</td>
<td>4.94</td>
<td>1.09 – 22.4</td>
<td>0.04</td>
</tr>
</tbody>
</table>

\(^a\) Adjusted for age, sex, race, education, DM, smoking, & hypertension

Lin et al., Arch Neuro., 2011
Hearing Loss & Accelerated Brain Volume Decline

**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
Voxel-Based Analyses

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

Lin et al., Neuroimage 2014
Double Hit Theoretical Model

Hearing Loss & Brain Structure/Function

Microvascular Disease

Alzheimer’s Neuropathology

Structure/Function

Hearing Impairment

F. Lin & M. Albert, Aging & Mental Health, 2014
Avoiding injury
- Increased falls (Viljanen et al., JGMS 2009; Lin et al., Arch Int Med 2012)

Physical mobility/functioning
- Reduced walking speed (Viljanen et al., JAGS 2009; Li et al., Gait & Posture 2012)
- Accelerated decline in physical functioning (Chen et al., JAGS, 2015)
- Driving ability (Hickson et al., JAGS 2009; Picard et al. 2008)

Health resource utilization/mortality
- Increased odds of hospitalization (Genther et al., JAMA, 2013; JGMS 2015)
- Increased mortality (Karpa et al., Ann Epi 2010; Fisher et al. 2013; Genther et al., JGMS 2014)
Hearing Loss & Healthy Aging

Common Cause or Modifiable Risk Factor

Cognitive Load

Brain structure/function

Cognitive & Physical Functioning

Hearing Loss

Social Isolation

Common pathological process
Age-Related Hearing Loss (ARHL)

Basic Questions

• What are the consequences of ARHL for older adults?

• What is the impact of treating ARHL on older adults?

• How can ARHL be effectively addressed in the community?
The question of whether treating hearing loss could delay cognitive/physical decline or dementia remains unknown.

There has never been a randomized clinical trial of treating hearing loss to explore effects on reducing the risk of cognitive decline/dementia.
Hearing loss intervention could:

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

Role of HL as a potentially modifiable, late-life risk factor for cognitive decline & dementia
Conceptual Model for the **Aging, Cognition, and Hearing Evaluation in Elders (ACHIEVE Healthy Aging) RCT**

*In collaboration with Marilyn Albert, Joe Coresh, Richey Sharrett, ARIC Study Team (T. Mosley, D. Knopman, C. Jack), and U. South Florida (T. Chisolm, A. Eddins)*

### Intervention

- Best-Practices Hearing Rehabilitative Treatment Vs. Successful Aging Control

### Proximal/Mediating Outcomes

- Audibility of speech & environmental sounds
- Enhanced Verbal Communication & Social Engagement

### Primary Outcome

- Cognitive Functioning

### Secondary Outcomes

- HRQL
- Social/Leisure Activities
- Daily Functioning
- Mobility
- Brain structure (MRI)
Atherosclerosis Risk in Communities (ARIC)

ARIC Cohort: 1987-present; n=15,792

Supported by National Institutes of Health
NHLBI with ancillary studies by NCI, NEI, NIA, NIAAA, NIDCD, NIDDK, NIEHS, NINDS, NCRR & NIH Roadmap
ACHIEVE Trial Design

Timeline & Overview of RCT

- **Timeline:**
  - 2014-2016 RCT planning process (R34AG046548)
    - Pilot study, development of protocol/operations manual, etc.
  - 2016 Trial grant submission
  - 2017-18 Recruitment at ARIC field sites
  - 2018-21 Follow-up

- **Participants:** ~766 70-84 y.o., healthy, cognitively normal community-dwelling adults with untreated mild-moderate HL recruited

- **Intervention:** Randomization to best-practices hearing rehabilitative treatment vs. successful aging intervention control

- **Outcome:** Study powered to detect 0.25 effect-size difference in rates of cognitive decline between the two groups at 3 years post-randomization
Age-Related Hearing Loss (ARHL)  
*Basic Questions*

- What are the consequences of ARHL for older adults?
- What is the impact of treating ARHL on older adults?
- How can ARHL be effectively addressed in the community?
Hearing Loss & Hearing Aid Use
Prevalence in the U.S., 1999-2006
Prevalence of Hearing Aid Use

- **United States** *(Arch Int Med, 2012)*
  - 26.7M adults ≥ 50 years with hearing loss
  - 3.8M use hearing aids
  - Overall rate of HA use: 14.2%

- **England and Wales** *(NICE Report, 2000)*
  - 8.1M with hearing loss
  - 1.4M use hearing aids
  - Overall rate of HA use: 17.3%
Barriers to Hearing Health Care (HHC)

Cost/Affordability

Access to Services & Technology
Current (only) gold-standard model of HHC:

- Repeat clinic-based visits with audiologist/dispenser for evaluation, counseling, sensory management, fitting
- FDA/state regulations restrict direct access to hearing aids
Barriers to Hearing Health Care (HHC)

Cost/Affordability

Awareness & Understanding

Access to Services & Technology
• Awareness of impact/public health importance

Hearing Loss

Intervention

Cognitive Load

Changes in brain structure

Reduced Social Engagement

Cognitive & Physical Functioning

• Understanding of treatment options

Barriers to Hearing Health Care (HHC)

- Cost/Affordability
- Awareness & Understanding
- Access to Services & Technology
- Technology Design & Utility
Technology Design & Utility

Hearing when it really matters...

FM Receiver with loop

Streamer

Proprietary 2.4GHz or 900MHz

Remote Mic
Barriers to Hearing Health Care (HHC)

- Cost/Affordability
- Awareness & Understanding
- Access to Services & Technology
- Technology Design & Utility
How can ARHL be effectively addressed in the community?

**Future Trends**

- Understanding & approaching hearing loss in the context of healthy aging/public health
  - White House Conference on Aging & President’s Council of Advisors on Science & Technology – Report released Oct 2015
PCAST is an advisory group of the nation’s leading scientists and engineers who directly advise the President and the Executive Office of the President. PCAST makes policy recommendations in the many areas where understanding of science, technology, and innovation is key to strengthening our economy and forming policy that works for the American people.
• **#1** - FDA should designate as a distinct category (“basic” hearing aids) non-surgical, air conduction hearing aids intended to address bilateral, gradual onset, mild-to-moderate age-related hearing & approve this class of hearing aids for over-the-counter (OTC) sale, without the requirement for consultation with a credentialed dispenser.

• **#2** - FDA should withdraw its draft guidance of November 7, 2013 on Personal Sound Amplification Products (PSAPs). PSAPs should be broadly defined as devices for discretionary consumer use that are intended to augment, improve, or extend the sense of hearing in individuals.
How can ARHL be effectively addressed in the community?

**Future Trends**

- Understanding & approaching hearing loss in the context of healthy aging/public health
  - White House Conference on Aging & President’s Council of Advisors on Science & Technology – Report released Oct 2015
  - Institute of Medicine Consensus Study – Report due 2016
How can ARHL be effectively addressed in the community?

Future Trends

• Understanding & approaching hearing loss in the context of healthy aging
  → White House PCAST – Oct 2015 report
  → Institute of Medicine – Report due 2016

• Innovations in hearing health care/technology
  • Accessible services & affordable technology
Innovations in Hearing Health Care
Affordable & Accessible Options are Needed

- **Technology** – Personal sound amplifiers (PSAP)
  - Over-the-counter “hearing aids” with in-situ testing & verification
  - Cost < $100-300
Convergence of medical devices (hearing aids) & consumer electronics ("PSAPs", "hearables")
Electroacoustic/Real Ear Analysis of PSAPs
Innovations in Hearing Health Care
Affordable & Accessible “Stepping Stones” are Needed for Hearing Health Care

• **Technology** – Personal sound amplifiers (PSAP)
  – Over-the-counter “hearing aids” with in-situ testing & verification
  – Cost < $100-300

• **Services** - Community health care workers
  – Community-based hearing screening
  – Counseling, education, & provision of sound amplifiers & other assistive technologies
  – Referral as needed
**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**
- Carrie Nieman
- Sara Mamo
- Janet Choi

**Outcomes in participant & communication partner**
Social Engagement
Communication Activities
HRQL

**Licensing & Dissemination**
- Non-profits
- Local government

2016-2019

**Pilot Studies**
- Multiple Communities
2014-2016

**Intervention Development**
2013

Older Adults in Assisted Living Facilities or with Cognitive Impairment
Korean-American Older Adults – Korean Martyrs Catholic Church

Access HEARS

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Normal Hearing

How are you?

Some Hearing Loss

How are you?

A lot of Hearing Loss

How are you?
Communication Tip #2: Repeat then Reword

If someone did not understand you, repeat it once. If that does not work, reword it.

What did you think of the meal?
What did you think of the meal?
Tell me about the food.

Repetition only works once.
Place the Battery, Turn on CS-50

Checklist

☐ Connect battery to earpiece
☐ Indicate when CS-50 is ON
<table>
<thead>
<tr>
<th>Week 1</th>
<th>Notes, questions, concerns:</th>
<th>This week there was trouble adjusting the volume. Different TV stations had different levels of volumes. People came into her room with different ways of expressing themselves. She would holler that the device was too loud.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>Notes, questions, concerns:</td>
<td>The &quot;hush&quot; stopped right away. Her asking to repeat a statement has almost disappeared. The speed of conversation has quickly picked up. She helped me to adjust the hearing device to make things more comfortable.</td>
</tr>
<tr>
<td>Week 3</td>
<td>Notes, questions, concerns:</td>
<td>She began telling her historical stories more accurately. She asked me questions in smoother sentences. Her patience was extended. There were less &quot;hurry-ups.&quot;</td>
</tr>
<tr>
<td>Week 4</td>
<td>Notes, questions, concerns:</td>
<td>She seemed to be less interested in having her way and imposing restrictions on the second party when she did not get her way.</td>
</tr>
<tr>
<td>Week 5</td>
<td>Notes, questions, concerns:</td>
<td>Her willingness to make decisions is stronger. Such decisions have made more sense. Note: The dimming is still there, but it seems to take more of a back seat in her life.</td>
</tr>
</tbody>
</table>
Additional Models of Hearing Health Care are Needed

Audiologist as the Leader of a Team

- **PSAP or OTC Hearing Aid**
  - Duration: 1-2 hours
  - Cost: $1-2

- **Community Health Worker**
  - Duration: 1/2 day
  - Cost: $$

- **Hearing Aid Dispenser**
  - Duration: 1-2 months
  - Cost: $$$

- **Gold Standard Audiology Care**
  - Duration: 3-6 months
  - Cost: $$$$$

Sara Mamo
Nick Reed
How can ARHL be effectively addressed in the community?

Future Trends

• Understanding & approaching hearing loss in the context of healthy aging
  → Jan 2014 Institute of Medicine Workshop in the U.S.

• Innovations in hearing health care/technology
  • Accessible services & affordable technology
  • Open wireless standards
Open Wireless Standards

- Fundamental limitation of all hearing aids?

- How to increase signal-to-noise ratio?

- Options:
  - Post-microphone
    - Algorithmic processing of sound
  - Pre-microphone
    - Hearing loop systems
    - Proprietary wireless systems (2.4Ghz, 900Mhz)
Hearing when it really matters...
Convergence of medical devices with consumer electronics
How can ARHL be effectively addressed in the community?

**Future Trends**

- Understanding & approaching hearing loss in the context of healthy aging
  - Institute of Medicine Workshop – Report due 2016
  - White House PCAST – Report due Fall 2015

- Innovations in hearing health care/technology
  - Accessible services & affordable technology
  - Open wireless standards

- Third-party reimbursement of hearing health care
  - Unbundling of hearing health care
  - Coverage for audiologic rehabilitative services (not devices)
“Are you telling me that I’m going to develop dementia?”

- Hypertension $\rightarrow$ Heart attack & stroke
  - Intervention: Medication, Lifestyle modification

- Hearing loss $\rightarrow$ Cognitive decline, dementia, poorer physical functioning
  - Intervention: Comprehensive hearing tx?

Consequences of hearing loss for older adults:

- Intervention: Comprehensive hearing tx?

Impact of treating hearing loss on older adults?

- How can hearing loss be effectively addressed in the community?
Acknowledgments

- Johns Hopkins
  - Carrie Nieman
  - Sara Mamo
  - Nick Reed
  - Joe Coresh
  - Richey Sharrett
  - Josh Betz
  - Esther Oh
- NIA
  - Luigi Ferrucci
  - Susan Resnick
  - Yang An
  - Eleanor Simonsick
- Nicole Marrone
  - Terry Chiselm

- K23DC011279
- R34AG046548
- R01HL096812
- R21DC015062
- P30AG048773
- Triological Society & American College of Surgeons Clinician Scientist Award
- Eleanor Schwartz Charitable Foundation
- NIA Intramural Research Program