Hearing Loss in Older Adults: A Public Health Perspective

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

• Consultant for Cochlear Ltd

• Scientific Advisory Board for Pfizer and Autifony Therapeutics

• Speaker honoraria from Amplifon & Med El

• Board of Trustees, Hearing Loss Association of America
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 & Lin, 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?
Healthy Aging

Cognitive Vitality & Avoiding Dementia
Avoiding Injury
Maintaining Physical Mobility & Activity
Keeping Socially Engaged & Active
Health Resource Utilization

Hearing Loss

Hearing Loss & Healthy Aging

Common Cause or Modifiable Risk Factor

Hearing Loss → ? → Cognitive & Physical Functioning

Common pathological process
“Sunday”

Hearing Loss & Cochlear impairment

Increased hearing sensitivity & poor frequency resolution

“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

Auditory Perceptual Processing Requirements

Available Cognitive Resources For Performance of Tasks

Age-Related Decline

Hearing Loss & Healthy Aging

*Common Cause* or *Modifiable Risk Factor*

Hearing Loss → Cognitive Load → Brain structure/function

Cognitive & Physical Functioning

Common pathological process
Double Hit Theoretical Model
Hearing Loss & Brain Structure/Function

Microvascular Disease
Alzheimer’s Neuropathology
Hearing Impairment

F. Lin & M. Albert, Aging & Mental Health, 2014

Hearing Loss & Healthy Aging
Common Cause or Modifiable Risk Factor

Cognitive Load
Brain structure/function
Cognitive & Physical Functioning
Social Isolation
Common pathological process
Hearing Loss & Healthy Aging

Common Cause or Modifiable Risk Factor

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
Datasets for Epidemiologic Analyses

- **NHANES**: National Health and Nutritional Examination Surveys
  - Cross-sectional, representative sample of U.S. population

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

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

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**Healthy Aging**

- Cognition Vitality & Avoiding Dementia
- Avoiding Injury
- Maintaining Physical Mobility & Activity
- Keeping Socially Engaged & Active
- Health Resource Utilization
- Hearing Loss
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
Hearing Loss & Cognition
Executive Function: Digit Symbol Substitution Test (DSS)

DSS: Digit Symbol Substitution Test

N = 605 adults 60-69 years

NHANES N = 605 adults 60-69 years

<table>
<thead>
<tr>
<th>Test</th>
<th>Age (per year) $\beta^a$ (95% CI)</th>
<th>$P$</th>
<th>Hearing loss (per 25 dB) $\beta^b$ (95% CI)</th>
<th>$P$</th>
<th>$\Delta$ Age (years) equivalent to 25 dB of hearing loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol Substitution Test</td>
<td>-0.55  (&lt;.01)</td>
<td></td>
<td>-3.86  (.02)</td>
<td></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>

BLSA N = 347 adults >60 years

<table>
<thead>
<tr>
<th>Test</th>
<th>$\beta^a$ (95% CI)</th>
<th>$P$</th>
<th>$\beta^b$ (95% CI)</th>
<th>$P$</th>
<th>$\Delta$</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>
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<tr>
<td>Trail Making B</td>
<td>-0.00011 (0.00018)</td>
<td>.001</td>
<td>-0.00074 (0.00064)</td>
<td>.05</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>(-0.00018 - -0.00004)</td>
<td></td>
<td>(-0.0015 - -0.00004)</td>
<td></td>
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</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

41% faster rate of cognitive decline in 3MS scores in HL vs. NH

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
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>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>0.05</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>
</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
**Healthy Aging**

Cognitive Vitality & Avoiding Dementia

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, in press)
- Driving ability (Hickson et al. JAGS 2009; Picard et al 2008)

Health resource utilization/mortality
- Increased odds of hospitalization (Genther et al, JAMA, 2013)
- 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

Hearing Loss

Brain structure/function

Social Isolation

Cognitive & Physical Functioning

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.
Best Practices Hearing Rehabilitative Treatment

**Conceptual Model for HL-Cognition 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**
- **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)

**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?

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Hearing Loss & Hearing Aid Use

Prevalence in the U.S., 1999-2006

Arch Int Med, 2012
**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

Total Cost = $3050-5050
Hearing Loss

Cognitive Load

Changes in brain structure

Reduced Social Engagement

Cognitive & Physical Functioning

Awareness & Understanding

• Awareness of impact/public health importance


Barriers to Hearing Health Care (HHC)

Cost/Affordability

Awareness & Understanding

Access to Services & Technology

Technology Design & Utility
Hearing when it really matters...

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
  - Institute of Medicine Workshop in the U.S. addressing 3 basic questions on HL & healthy aging

**IOM Workshop on Hearing Loss & Healthy Aging**

*January 13-14, 2014 Washington, D.C.*

- Two-day workshop addressing:
  - Implications of HL for healthy aging/public health & needed areas of research
  - Developing innovative models of care & technologies to address HL
  - Short & long-term collaborative strategies to approach HL as a public health priority in the U.S.

[Website](http://www.iom.edu/hearingloss-aging)
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

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
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
AccessHEARS: Hearing health care Equality through Accessible Research & Solutions

Individuals 60+ years & communication partners

Two-hour ARHL Intervention:
1) Hearing Loss Education
   - Hearing loss basics
2) Device Orientation:
   - Self-fit amplification device
   - Individual programming
3) Counseling:
   - Expectation management
   - Communication Strategies

Randomized to Immediate vs. 3 mos delayed tx

Outcomes in participant & communication partner

Social Engagement
Communication Activities
HRQL

Implementation & Dissemination Studies
CMS AARP
Randomized Controlled Trial
2014
Pilot Intervention Study
2015-2016
Multi-site
2017-2019

Training Workbook

Baltimore HEARS

2014-2019
Principles of Instruction

1. Engage in solving meaningful problems
2. Activate relevant previous experience
3. Demonstration
4. Use new skill to solve problems
5. Integrate new skill into daily life
How We Hear

There are 3 main steps in how we hear.

- Sound enters ear
- Signal goes to brain
- Brain interprets signal

Checklist
- Explain the 3 steps of hearing

Normal Hearing

Some Hearing Loss

A lot of Hearing Loss
Communication Tips and Tricks

1. Attention First
2. Get Face to Face
3. Speak Slowly
4. Big Ideas and Key Words
5. Repeat then Reword
6. Summarize

Tip #1: Attention First

The conversation can’t start until you are in the same room and both of you are aware you want to share something.

Example
Talking across a room
Turn ON the Pocket Talker

Checklist
- Turn ON Pocket Talker
- Note red ON light

Place the Battery, Turn on CS-50

Checklist
- Connect battery to earpiece
- Indicate when CS-50 is ON
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
- 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)
• Hypertension → Heart attack & stroke
  – Intervention: Medication, Lifestyle modification

• Hearing loss → Cognitive decline, dementia, poorer physical functioning
  – Intervention: Comprehensive hearing tx?

“Are you telling me that I’m going to develop dementia?”

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