Hearing Loss & Aging – A Public Health Perspective

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Hearing Loss & Public Health

Rationale

Eras of Public Health

1st – Infectious diseases (early 20th cent.)
2nd – Chronic diseases (mid 20th cent. – now)
3rd – Aging processes (21st cent. & on)

Population Ages 60+ by Region 1980 – 2050


Fries JF, 1982; Deaton A, 2013
What health & policy strategies are needed for optimal/healthy aging?

- Prevention/delay of disease → Compression of morbidity
- Effective treatment of disease → Managing multimorbidity
- Lifestyle factors → Diet, physical activity, social engagement, etc.
- Biological processes underlying aging → future drugs?
- **Optimizing sensory function?**
Our ability to hear & engage with the people & environment around us is fundamental to our health & well-being.

Prevalence of Hearing Loss by Age Decade

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

Lin et al., Arch Int Med. 2011

Hearing Loss & Aging

Basic Questions from the Perspective of Public Health

• What are the consequences of HL for older adults?

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

• How can HL be effectively addressed in society?
Healthy Aging

- Cognitive Vitality & Avoiding Dementia
- Avoiding Injury
- Maintaining Physical Mobility & Activity
- Keeping Socially Engaged & Active
- Positive Mood & Mental Health
- Hearing Loss

System:
- Name: 2/27/19
Projected Number of People 65+ with Alzheimer’s Disease by Age Group, U.S. 2010-2050

Hearing Loss & Cognition

*Common Cause* or *Modifiable Risk Factor*

- Cognitive Load
- Hearing Loss
- Cognitive Impairment & Dementia
- 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 & 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 & Cognition

Common Cause or Modifiable Risk Factor

- Cognitive Load
- Hearing Loss
- Brain structure/function
- Cognitive Impairment & Dementia
- Common pathological process

Multiple Hit Theoretical Model of Risk Factors for Brain Aging/Injury

Hearing Loss & Brain Structure/Function

- Microvascular Disease
- Alzheimer’s Neuropathology
- Hearing Impairment

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

*Common Cause* or *Modifiable Risk Factor*

Cognitive Load

Hearing Loss

Brain structure/function

Cognitive Impairment & Dementia

Social Isolation

Common pathological process

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

Cole & Cacioppo, Genome Biology, 2007
Cole & Cacioppo, PNAS, 2011

**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
Hearing Loss & Cognition

Common Cause or Modifiable Risk Factor

- Cognitive Load
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- Cognitive Impairment & Dementia
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Studying Hearing Loss & Cognition

Role of Epidemiology (rather than clinical research)

- **NHANES**: National Health and Nutritional Examination Surveys
  - Cross-sectional, representative sample of U.S. population (~3000-4000)

- **BLSA**: Baltimore Longitudinal Study of Aging at the NIH
  - Ongoing prospective study of >1000 older adults since 1958

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

- **ARIC**: Atherosclerosis Risk in Communities Study
  - Prospective, population-based study of ~16,000 adults followed since 1977
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.

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**Hearing Loss & Cognition**

*Executive Function: Trail Making B*

Trail Making B

A 6
B 3
C 7
D 4
E 5
F 8
G 1
H 2

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

Executive Function: Stroop Mixed

<table>
<thead>
<tr>
<th>GREEN</th>
<th>RED</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>YELLOW</td>
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<tr>
<td>RED</td>
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Hearing Loss & Cognition

Executive Function: Digit Symbol Substitution Test (DSS)

DSS: Digit Symbol Substitution Test
Hearing Loss and Cognition

**Cross-Sectional Studies**

### NHANES
N = 605 adults 60-69 years

<table>
<thead>
<tr>
<th>Model</th>
<th>B (95% CI)</th>
<th>P</th>
<th>Hearing loss (per 25 dB)</th>
<th>β (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 (-0.92 to -0.18)</td>
<td>&lt;0.01</td>
<td>-3.86 (-7.15 to -0.56)</td>
<td>0.02</td>
<td>7.0</td>
<td></td>
</tr>
</tbody>
</table>

Models adjusted for age, sex, race, education, diabetes, smoking, hypertension

### BLSA
N = 347 adults >60 years
Lin et al., Neuropsych., 2011

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<th>B (95% CI)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Stroop Mixed</td>
<td>-0.33 (-0.48 to -0.18)</td>
<td>&lt;0.001</td>
<td>-2.27 (-4.14 to -0.40)</td>
<td>0.02</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>Trail Making B</td>
<td>-0.00011 (-0.00018 to -0.000044)</td>
<td>0.001</td>
<td>-0.0074 (-0.0015 to 2.74 x 10^-5)</td>
<td>0.015</td>
<td>6.7</td>
<td></td>
</tr>
</tbody>
</table>

Hearing Loss & Cognitive Decline

**HealthABC**
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 DSS 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 Baltimore Longitudinal Study of Aging

Risk of incident all-cause dementia (compared to normal hearing)\(^a\)

<table>
<thead>
<tr>
<th></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 & Incident Dementia

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

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

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

J. Gallacher et al., Neurology, 2012
Hearing loss in mid & late life identified as the single modifiable risk factor for dementia with the greatest population attributable fraction of risk.
Hearing Loss & Aging
Basic Questions from the Perspective of Public Health

• What are the consequences of HL for older adults?
• What is the impact of treating HL on older adults?
• How can HL be effectively addressed in society?

The question of whether treating hearing loss could delay cognitive decline or dementia remains unknown

There has never been a randomized controlled trial of treating hearing loss to explore effects on reducing the risk of cognitive decline/dementia
Hearing Loss & Dementia

Hearing Loss as a Modifiable Risk Factor

- 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 risk factor in late-life for cognitive decline & dementia

Aging & Cognitive Health Evaluation in Elders
Randomized Trial (N = 850)
In Partnership with Joe Coresh & ARIC-NCS

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

- Dementia
- Social/Leisure Activities
- Physical Functioning
- Mobility
- Falls & Hospitalizations
- MRI brain
ACHIEVE Trial Design
Study Sites & Inclusion Criteria

Main study inclusion criteria:
- 70-84 y.o. community-dwelling adults
- Mild-moderate hearing loss
- No cognitive impairment
- No self-reported disability in >1 ADL
- No self-reported hearing aid use in the past year

ACHIEVE Trial Design
Interventions

Hearing Loss Intervention – Univ S. Florida
- Could help promote better social engagement & reduce load of hearing loss on the brain
- 4 sessions with a study audiologist to receive hearing loss education & hearing devices
- Semiannual visits thereafter for 3 years to receive booster sessions & track cognitive/physical health

Successful Aging Education Intervention – U. Pitt
- Established program that helps promote better understanding of key health topics (nutrition, high blood pressure) important for healthy aging
- 4 sessions with a health educator to cover the 10 Keys™ program
- Semiannual visits thereafter for 3 years to receive booster sessions & track cognitive/physical health
ACHIEVE Trial Design

Outcomes & Analysis

• Baseline & semiannual visits for intervention delivery & outcome assessments
• Primary outcome – Global & domain-specific cognitive function
  • Comprehensive neurocog battery including tests of memory, executive function, etc.
  • Verification of speech understanding/audibility is confirmed before cognitive testing at all time points (with additional steps taken as needed) to ensure testing is not confounded by poor speech understanding
• Secondary outcomes
  • Adjudicated dementia/MCI diagnoses, depression, communicative & social function, physical functioning, accelerometry, falls, hospitalizations, HRQL, hearing aid data logging, brain MRI
• Analysis
  • Multiple imputation ANCOVA model of change from baseline to year 3 with adjustment for baseline cognitive factor score, baseline hearing loss, race*center, ARIC status, age, & education

ACHIEVE Trial

Timeline

• 2011-2013
  • Epidemiological studies establishing association of hearing loss & dementia
• 2014-2016
  • Trial planning grant (NIH R34AG046548)
  • Pilot study, development of protocol/operations manual, submission of grant for full-scale trial
• 2017
  • ACHIEVE grant funded by the NIA (R01AG055426)
• 2018-19 Recruitment at field sites
• 2019-22 Follow-up
Hearing Loss & Aging
Basic Questions from the Perspective of Public Health

• What are the consequences of HL for older adults?

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

• How can HL be effectively addressed in society?

What’s the goal when seeing a patient with hearing loss?

Making sure the patient understands how a hearing aid can help them?

Ensuring hearing aid is properly programmed and fit?

Ensuring that the individual can communicate effectively in all settings
Ensuring Effective Communication

- Teaching communication strategies
- Helping the patient choose the right technologies

Communication Strategies

Communication Tip #1: Get Face to Face
Facial expressions and gestures help fill in the gaps. Turn off background noise.

Communication Tip #2: Repeat then Reword
If someone did not understand you, repeat it once. If that does not work, reword it.

Communication Tip #3: Summarize
Be specific about what you do and do not hear. Summarize what you heard.

Do not say ‘huh?’ or ‘what?’

Say ‘I heard you say something about ___ but I missed ___.’
Choosing the Right Technologies

• Hearing aids – importance of remote mics/streamers
• Cochlear implants – speech discrimination <60% deserves referral
• Assistive listening devices
  • Telephone use – Skype/Facetime; Captioned phones
  • Portable body-worn amplifier

Internet-Protocol Captioned Telephone Service Telephone Use

• Captioned telephones help people with hearing loss to hear & read what their callers say
• A captioning phone sends the caller’s voice to a captioning service center via the internet where words are quickly converted to text by a captioning agent using voice recognition technology
• The cost of the captioning service is covered fully for qualified individuals by a fund established under the Americans with Disabilities Act – some providers also make their equipment available at no cost to qualified individuals
• To qualify, a hearing care or healthcare professional must certify the individual has a hearing loss that requires captions to use the phone effectively
Portable Amplifiers

Super Ear SE9000

Comfort Duett
Choosing the Right Technologies

- Hearing aids – importance of remote mics/streamers
- Cochlear implants – speech discrimination <60% deserves referral
- Assistive listening devices
  - Telephone use – captioned phones
  - Portable body-worn amplifier
- Over-the-Counter Hearing Aids

Over-the-Counter Hearing Aids

- Current FDA/State regulations limit hearing aid sales only through a licensed professional
- Based on recommendations from the White House President’s Council of Advisors on Science and Technology (2015) and the National Academies (2016), OTC Hearing Aid Bill passed into law in August 2017
- By August 2020, the FDA will issue regulations and performance standards for OTC hearing aids to ensure safety/effectiveness
- Regulations will allow any manufacturer meeting regulations/standard to direct sell HAs OTC to consumers
Convergence of medical devices (hearing aids) & consumer electronics (“hearables”)

Ensuring our Patients Can Communicate Effectively

Summary

- Communication strategies
- Helping patients choose the right technologies
  - Hearing aids
  - Cochlear implants
  - Assistive listening devices (captioned phones, portable amplifiers)
  - Over-the-Counter Hearing Aids (2020 or sooner)
Hypertension → Heart attack & stroke
   Intervention: Medication, Lifestyle modification

Hearing loss → Cognitive decline, dementia
   Intervention: Hearing loss interventions/treatments??

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

Thank You

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www.jhsph.edu/cochlear-center