The Spectrum of Hearing Impairment
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Hearing Loss and Healthy Aging:
An IOM-NRC Workshop

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UNIVERSITY OF SOUTH FLORIDA
Spectrum of Hearing Impairment in Older Adults

“Blindness separates us from things but deafness separates us from people.” Helen Keller
Age-Related Hearing Loss

- Presbycusis, is the slow loss of hearing that occurs as people get older.

Age-Related Hearing Loss

- Elevated thresholds (can’t hear soft sounds)
- Reduces speech understanding in noisy and reverberant (echoing) environments
- Interferes with the perception of rapid changes in speech
Common Complaints

• “I can hear people talking but can’t understand what they are saying”

“If they spoke slower (or clearer), I could understand what they are saying”
Age-Related Hearing Loss

• Communication

• Frustration

• Associated with
  – Sadness and depression
  – Worry and anxiety
  – Paranoia
  – Emotional turmoil and insecurity
    • National Council on Aging (1999)

• Reduced QoL
Age-Related Hearing Loss

• An increased likelihood of depression:
  – Odds Ratio = 1.8 (95% Confidence Interval: 1.1-2.7)

• Decreased self-sufficiency in Activities of Daily Living:
  – Odds Ratio = 2.1 (95% Confidence Interval: 1.4-3.2)

  (Carabellese, Appollonio, Rozzini et al., 1993)
Hearing Loss & Incident Dementia

Lin et al., Arch Neuro., 2011

Hazard ratio of incident all-cause dementia (compared to normal hearing)\textsuperscript{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>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>

\textsuperscript{a} Adjusted for age, sex, race, education, DM, smoking, & hypertension
### Comparison of Symptoms

(Chartrand, 2001)

<table>
<thead>
<tr>
<th>Alzheimer’s Disease</th>
<th>Untreated Hearing Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Depression, anxiety, disorientation</td>
<td>• Depression, anxiety, feelings of isolation</td>
</tr>
<tr>
<td>• Reduced language comprehension</td>
<td>• Reduced communication ability</td>
</tr>
<tr>
<td>• Impaired memory</td>
<td>• Lessened cognitive input</td>
</tr>
<tr>
<td>• Inappropriate psychosocial responses</td>
<td>• Inappropriate psychosocial responses</td>
</tr>
<tr>
<td>• Loss of ability to recognize</td>
<td>• Lessened mental scores</td>
</tr>
<tr>
<td>• Denial, defensiveness, negativity</td>
<td>• Denial, heightened defensiveness, negativity</td>
</tr>
<tr>
<td>• Distrust, suspiciousness of others</td>
<td>• Distrust, paranoia re: others are talking about them</td>
</tr>
</tbody>
</table>
Age-Related Hearing Loss

• There is no cure for age-related hearing loss

• Treatments can improve everyday function

• Hearing loss can be effectively managed so that we can continue to live a full and active life.

Managing Hearing Loss for Healthy Aging

- **Identification**
- **Belief**: Hearing is important and Age-Related HL can be treated
Managing Hearing Loss for Healthy Aging

American Academy of Audiology’s Evidenced-Based Guidelines for the Audiologic Management of Adult Hearing Impairment


Subsequent Relevant Research
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

Hearing Impairment
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Rule-Out any Medically Treatable Hearing Loss
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan

- Technical Intervention
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan

- Technical Intervention
- Non-Technical Intervention
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment
- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan
- Technical Intervention
- Non-Technical Intervention

Outcomes Assessment
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment
- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan
- Technical Management
- Non-Technical Management

Outcomes Assessment
Hearing Impairment

*An example presbyacusis (sloping high-frequency hearing loss) synonymous with the ageing process.*
Hearing Impairment

The audiogram tells us how sensitive the individual’s hearing is to different sounds that range from low pitch to high pitch.
Hearing Impairment

- Degree of hearing loss from mild to profound
- Pure Tone Average (PTA)
- Calculated by averaging sensitivity thresholds at specific frequencies (Hz)

* An example presbyacusis (sloping high-frequency hearing loss) synonymous with the ageing process.
Hearing Impairment

- Degree of hearing loss from mild to profound

Pure Tone Average (PTA)
- Calculated by averaging sensitivity thresholds at specific frequencies (Hz)

Age-Related HL Not that Simple

* An example presbyacusis (sloping high-frequency hearing loss) synonymous with the ageing process.
Two Components of Hearing Loss

- Audibility
- Distortion
Two Components of Hearing Loss

**Audibility**
- Louder
- Louder
- Louder
- Louder
- Louder
- Louder
- Louder

**Distortion**

No matter how loud we make the sounds, there can still be problems with the clarity or the clearness.
Making sound louder is necessary, but not sufficient
External Factors

- Obscures speech sounds
- Distracts the listener
Special Type of Noise

• Visual Analogy

The following is a list of Farmer’s markets to be held in the surrounding areas.
The level of the direct speech signal falls by 6 dB for every doubling of distance.
Combined Negative Effects

- Make listening & communicating difficult for all
- Exacerbated by effects of:
  - Hearing Loss
  - Aging-related processing declines
Degree of Impairment

Speech Understanding in Noise

- Objective measure of Speech understanding in noise (e.g., QuickSIN, HINT, WIN)
- Signal-to-noise ratio needed to recognize 50% of the message
• Normal hearing person needs speech to be 2 dB > noise for 50% correct recognition
  – $\text{SNR-50} = +2 \text{ dB}$

• Person with hearing loss might need the speech to be 12 dB > than the noise for 50% correct recognition
  – $\text{SNR-50} = +12 \text{ dB}$
SNR-50 cannot be predicted by the audiogram!

Patient 1
67 y/o
SNR-50 = 15.2 dB

Patient 2
77 y/o
SNR-50 = 26.0 dB
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment
- Audiogram
- SNR-50
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan
- Technical Management
- Non-Technical Management

Outcomes Assessment
Activity Limitations and Participation Restrictions

• Detailed Case History
• Medical vs. Social-Emotional and Activities of Daily Living

• Psychometrically Valid Self-Report Measures

• Hearing Handicap Inventory for the Elderly (HHIE) (Ventry and Weinstein, 1982).
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment
- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan
- Technical Management
- Non-Technical Management

Outcomes Assessment
Individual Factors

- Cognition
- Expectations
- Motivation
- Willingness to take risks
- Assertiveness
- Manual Dexterity
- Visual Acuity
- Visual Acuity
- General Health
- Tinnitus
- Occupational Demands
- Presence of support systems
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment
- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Treatment Goals

Integrated Treatment Plan
- Technical Intervention
- Non-Technical Intervention

Outcomes Assessment
<table>
<thead>
<tr>
<th>Category</th>
<th>New</th>
<th>Return</th>
</tr>
</thead>
</table>

Specific needs:

- Being able to hear my son on the telephone
- Hearing Dr. Lin during dinner
- Understanding the talks at the IOM meeting

Client Oriented Scale of Improvement

<table>
<thead>
<tr>
<th>Degree of Change</th>
<th>Final Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worse</td>
<td>No Difference</td>
</tr>
<tr>
<td>CATEGORY</td>
<td>Hardly Ever</td>
</tr>
</tbody>
</table>

Categories:
1. Conversation with 1 or 2 in quiet
2. Conversation with 1 or 2 in noise
3. Conversation with group in quiet
4. Conversation with group in noise
5. Television/Radio at normal volume
6. Familiar speaker in phone
7. Unfamiliar speaker on phone
8. Hearing phone ring from another room
9. Hear front door bell or knock
10. Hear traffic
11. Increased social contact
12. Feel embarrassed or stupid
13. Feeling left out
14. Feeling upset or angry
15. Church or meeting
16. Other
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan

- Technical Interventions
- Non-Technical Interventions

Outcomes Assessment
Technical Interventions

- Hearing Aids
Frequency in Hertz

Conversational Speech

Sound level in dBHL
Frequency in Hertz

Unaided

Sound level in dBHL

Moderate Hearing Loss (30-60 dB)
Moderate Hearing Loss (30-60 dB)
Optimal Fitting of Hearing Aids

• Numerous evidence based decisions
  – Style
  – Features
  – Signal processing, etc

• Verification
  – Physical fit & comfort
  – Signal processing “Real ear testing”
Efficacy of Hearing Aid Intervention

• Randomized Controlled Trial
  – Mulrow et al., 1990

• Improvements
  – Emotional function
  – Social function
  – Communication function
  – Cognitive function

• Lessening of depression

• Sustained for up to 1 year of hearing aid use
HUI QoL measure as a function of hearing level in new referrals before and after (3m) hearing aid fitting MHAS  N= 589

Davis et al., 2007
HUI QoL measure as a function of hearing level in new referrals before and after (3m) hearing aid fitting MHAS  N= 589

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HUI QoL measure as a function of hearing level in new referrals before and after (3m) hearing aid fitting MHAS  N= 589

Davis et al., 2007
Technical Intervention

• Cochlear Implants

Lin et al. 2013
Cochlear Implants

- Medically and surgically appropriate candidate
- Selection of devices
  - Internal surgically implanted electrode arrays
  - External signal processors
- Surgery
- Mapping (adjusting the T- and C-levels) for optimal comfort and understanding

Improvements
- Speech perception
- QoL
  - e.g., Klop et al 2007 Laryngoscope
Even with the best hearing aids or cochlear implants, however...

- Challenges in listening and communicating
  - Hearing Loss
  - Cognitive Aging
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan

- Technical Interventions
- Non-Technical Interventions

Outcomes Assessment
Hearing Assistive Technologies

- Assistive Listening Devices (ALDs)
  - Used alone or combined with hearing aids and/or cochlear implants
  - To supplement performance in difficult listening conditions.
Sound is picked up and transmitted directly to the listener, thus overcoming deterioration due to noise, reverberation and distance.

Hardwired or Wireless (FM, Induction, Infrared, Bluetooth) Link between sound source and listener

Microphone or Electrical Connection → Transmitter → Receiver → Coupling to Ears/Hearing Aid/Implant

With permission C. Compton-Connelly, 2014
Hearing Assistive Technologies

• Alerting Devices
  – Visual or Tactile
Systematic Device Orientation & Instruction

• Device use and care
• Individually or in Groups
• At least one, but sometimes several sessions
• Only about 50% of medical information in general, and HAO information too! (Reese & Chisolm, 2004)
Managing Hearing Loss for Healthy Aging

Comprehensive Assessment

- Hearing Impairment
- Functional Hearing Related Difficulties
- Individual Factors

Integrated Treatment Plan

- Technical Interventions
- Non-Technical Interventions

Outcomes Assessment
Aural (Audiological) Rehabilitation

• Chisolm & Arnold (2012) – Evidence About the Effectiveness of Aural Rehabilitation Programs for Adults
### Table 1. Summary of Studies on Adult AR Groups That Met the Inclusion Criteria

<table>
<thead>
<tr>
<th>Reference</th>
<th>Design</th>
<th>Intervention</th>
<th>Outcome</th>
<th>Comments and Study Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawkins et al. (2005)</td>
<td>RCT</td>
<td>N = 31 total, 3 groups (HA, HA + AR, nothing)</td>
<td>Treatment AR group, 3 sessions</td>
<td>Rating: 00s</td>
</tr>
<tr>
<td>Anderson et al. (2005a)</td>
<td>RCT</td>
<td>N = 24 total, 2 groups (HA, HA + AR)</td>
<td>Treatment AR group, 8 hours</td>
<td>Rating: Group Aural Rehabilitation</td>
</tr>
<tr>
<td>Anderson et al. (2005b)</td>
<td>RCT</td>
<td>N = 20 total (10 each from 1996 study, contacted 5 yrs. later)</td>
<td>Treatment AR group, 8 hours</td>
<td>Rating: Group Aural Rehabilitation</td>
</tr>
<tr>
<td>Benyon et al. (2007)</td>
<td>RCT</td>
<td>N = 47 total, 26 HA + AR</td>
<td>Treatment AR for 4 years (# of hours unknown)</td>
<td>Rating:</td>
</tr>
<tr>
<td>Stickley et al. (2006)</td>
<td>Non-Intervention cohort design, N = 24</td>
<td>Treatment either group AR or HA</td>
<td>Rating:</td>
<td></td>
</tr>
<tr>
<td>Brewer (2001)</td>
<td>Non-Intervention cohort design, no control group, N = 35</td>
<td>Treatment group AR, 8-10 weeks (2 hours)</td>
<td>Rating:</td>
<td></td>
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<tr>
<td>Cihon et al. (2004)</td>
<td>RCT</td>
<td>N = 100, 53 HA only, 53 HA + AR</td>
<td>Treatment AR group, 8 hours</td>
<td>Rating:</td>
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<tr>
<td>Hallberg and Barennes (1994)</td>
<td>RCT</td>
<td>N = 38, 12 group AR, 26 no treatment</td>
<td>Treatment AR group, 6 weeks (12 hours)</td>
<td>Rating:</td>
</tr>
<tr>
<td>Norman et al. (1995)</td>
<td>Non-Intervention cohort design, N = 124</td>
<td>Treatment AR group, 6 weeks</td>
<td>Rating:</td>
<td></td>
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<tr>
<td>Neminger (2003)</td>
<td>Non-Intervention cohort design, N = 25</td>
<td>Treatment AR group, 6 weeks</td>
<td>Rating:</td>
<td></td>
</tr>
<tr>
<td>Shalinsky and Shalinsky (1995)</td>
<td>RCT</td>
<td>N = 40, 10 in each of 4 groups: HA, HA + AR, HA + cognitive learning style, HA + AR + cognitive learning style</td>
<td>Treatment AR group, 6 weeks</td>
<td>Rating:</td>
</tr>
<tr>
<td>Hawkins et al. (2005)</td>
<td>RCT</td>
<td>N = 105 total, 53 HA only, 53 HA + AR</td>
<td>Treatment AR group, 4 sessions</td>
<td>Rating: 00s</td>
</tr>
<tr>
<td>Anderson et al. (2005a)</td>
<td>RCT</td>
<td>N = 24 total, 2 groups (HA, HA + AR)</td>
<td>Treatment AR group, 8 hours</td>
<td>Rating:</td>
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</table>

**Outcome Measures:**
- **SF-36V, mental and physical components of quality of life**
- **Video observation, Hearing Coping Assessment (HCA)**
- **HCA and communication strategies subscale of CPHI (posttest only)**
- **Quantified Denver Scale of Communication Function, scales for AR change was in**

**Rating:**
- **Rating:**
- **Rating:**
- **Rating:**
- **Rating:**
- **Rating:**

**Comments and Study Details:**
- AR improved relaxation and posture, No difference in HAs or handicap
- HCA—no difference, On CPHI, AR subjects equal, watched faces more, Less pretending
- AR group had larger 5 sub-reduction in handicap, group change was in
- **Rating:**
- **Rating:**
- **Rating:**
- **Rating:**
- **Rating:**

**Evaluation:**
- **Evaluation:**
- **Evaluation:**
- **Evaluation:**
- **Evaluation:**
- **Evaluation:**

**Conclusion:**
- **Conclusion:**
- **Conclusion:**
- **Conclusion:**
- **Conclusion:**
- **Conclusion:**

**Methodology:**
- **Methodology:**
- **Methodology:**
- **Methodology:**
- **Methodology:**
- **Methodology:**

**Participants:**
- **Participants:**
- **Participants:**
- **Participants:**
- **Participants:**
- **Participants:**

**Setting:**
- **Setting:**
- **Setting:**
- **Setting:**
- **Setting:**
- **Setting:**
Weekly assignments

- Get to know
  - Communication strategies
  - Problem solving
  - Assistive listening devices
  - Information & advices to spouses
  - Applied relaxation
Weekly assignments

• Try out
  • Communication strategies
  • Problem solving
  • Assistive listening devices
  • Information & advices to spouses
  • Applied relaxation
Aural (Audiological) Rehabilitation

- Chisolm & Arnold (2012)
  - Evidence About the Effectiveness of Aural Rehabilitation Programs for Adults
**Table 1. Review**

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<tbody>
<tr>
<td>Boda and Oyer (1970)</td>
<td>Before/After with control group</td>
</tr>
<tr>
<td>Walden et al. (1981)</td>
<td>RCT</td>
</tr>
<tr>
<td>Kratos et al. (1992)</td>
<td>RCT with pre- and posttest outcome measures</td>
</tr>
<tr>
<td>Montgomery et al. (1984)</td>
<td>RCT with pre- and posttest outcome measures</td>
</tr>
<tr>
<td>Rubenstein and Boothroyd (1987)</td>
<td>Before/After with no control group</td>
</tr>
<tr>
<td>Kratos and Holm (1996)</td>
<td>Before/After with control group</td>
</tr>
</tbody>
</table>

**Measure**

- Auditory consonant recognition
- Visual consonant recognition
- A-V sentence recognition
- HHIE Speech recognition test at various SNRs (signal-to-noise ratios)
- A-V sentence test

**Improvement**

- All groups improved with training, AR + visual group improved more than the AR alone group
- Significant reduction in self-perceived hearing handicap and improvement in speech recognition in all subjects (control and experimental)
- Experimental group improved more on the audiovisual sentence task than
- No significant improvement

Note: AR = aural rehabilitation; A-V = auditory-visual; HHIE = Hearing Handicap Inventory for the Elderly; M-Rhyme Test = M-Rhyme Test (Resnick et al., 1975); RCT = randomized controlled trial; SPIN = Speech in Noise Test (Resnick et al., 1975); VA = Veterans Administration
Many Commercially Available Computer-Based Programs
LACE Training

- Comprehension of Degraded Speech
  - Speech-in-babble
  - Time-compressed speech
  - Competing speaker

- Enhancement of Cognitive Skills
  - Auditory working memory
  - Missing word identification using context

- Use of Communication Strategies
  - Helpful hints
Systematic Review: Computer Based Auditory Training Systems for Adults with Hearing Loss (Henshaw & Ferguson, 2013)

• “Our findings demonstrate that published evidence for the efficacy of individual computer-based auditory training for adults with hearing loss is not robust and therefore cannot be reliably used to guide intervention at this time.”

• Further research is needed for optimizing auditory training for adults with hearing loss
Summary of Evidence for Group AR and Auditory Training (Chisolm & Arnold)

• Post-fitting Group AR can improve outcome
  – Reduced perceived handicap
  – Improved speech-in-noise performance
  – Improved quality of life
• Group AR can ‘accelerate’ hearing aid benefit
• Communication partners benefit
• Even without device use, for milder HL, Group AR can provide information and strategies to enhance communication (1st step)
• Listening (auditory) training can be effective for “some” people, further research needed.
Final Thoughts: Hearing loss & healthy aging from a public health perspective

• Individuals recognize that they have the condition
• Society and individuals believe the condition is important & should be treated
• Making effective treatments readily accessible
Final Thoughts: Hearing loss & healthy aging from a public health perspective

- Age-related hearing loss is not understood to be an important public health issue
  - Studies of cognitive, functional, and social-emotional effects
  - Studies examining Health Beliefs & Attitudes and Hearing Loss
Final Thoughts:
Hearing loss & healthy aging from a public health perspective

• Evidence-based interventions are available
  – Continued need to improve, based on new understandings of cognitive aging
  – Studies examining potential for hearing intervention to influence cognitive, functional, and social-emotional status
Final Thoughts: Hearing loss & healthy aging from a public health perspective

• Lack of insurance coverage for hearing rehabilitative devices and services
  – Cost of devices (PSPs?)
  – Value through well-controlled studies of both technical and non-technical interventions

• Over-emphasis on devices rather than comprehensive, integrated hearing rehabilitation.
CHANGE THE LANDSCAPE
Spectrum of Hearing Impairment

“Blindness separates us from things but deafness separates us from people.” Helen Keller
Provide interventions that mitigate the negative effects

“Blindness separates us from things but deafness separates us from people.” Helen Keller
Live well with Hearing Loss as a part of Healthy Aging

“Blindness separates us from things but deafness separates us from people.” Helen Keller