Some Thoughts on the Future of Audiology

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• The opinions expressed in this talk are strictly my own.
• They do not reflect the policies or opinions of:
  • NIH or NIDCD
  • NASEM
  • Mayo Clinic
  • My co-investigators
The Baby Boomer Bump – 2000 Census

U.S. Population

Age in Years

Baby Boomer Bump
The Baby Boomer Bump – 2010 Census

U.S. Population

Age in Years

2000
2010

Baby Boomer Bump
The Baby Boomer Bump – 2015 Projection

U.S. Population

Age in Years

Baby Boomer Bump

- 2000
- 2010
- 2015 Projection
The Baby Boomer Bump – 2015 Projection

U.S. Population

Age in Years

2000
2010
2015 Projection
Prevalence of Communicatively Significant Hearing Loss (2010)

• Prevalence:
  • 1 in 5  60 - 70 year olds (6,000,000)
  • 1 in 2  70 - 80 year olds (8,500,000)
  • 3 in 4  80 + year olds (8,900,000)

• Served by
  • 1300  ENTs
  • 1300  Audiologists
  • 600  Neurotologists / Otologists
  • 900  Hearing Instrument Dispensers
Prevalence of Communicatively Significant Hearing Loss (2010)

• Prevalence:
  • 1 in 5 60 - 70 year olds (6,000,000)
  • 1 in 2 70 - 80 year olds (8,500,000)
  • 3 in 4 80 + year olds (8,900,000)

In 2010: ~5700 Seniors / Hearing Healthcare Provider
In 2015: ~6850 Seniors / Hearing Healthcare Provider
In 2020: ~8000 Seniors / Hearing Healthcare Provider

• 900 Hearing Instrument Dispensers
Accessibility and Affordability: Part 1 - Time Line

- 2009: National Institute Deafness and Communicative Disorders
  - Report on the Accessibility and Affordability of Hearing Healthcare

- 2015: President's Council of Advisors on Science and Technology (PCAST)
  - Report investigated age-related mild to moderate hearing loss

- 2016: National Academy of Sciences, Engineering and Medicine (NASEM)
  - Hearing Health Care for Adults: Priorities for Improving Access and Affordability

- 2016 / 2017: Federal Drug Administration (FDA)
  - Eliminated Medical Waiver System
  - Workshop on Hearing Health and Technology

- 2016/ 2017: Elizabeth Warren (D-Mass.) and Chuck Grassley (R-Iowa)
  - Over the Counter (OTC) Hearing Aid Act

- 2016 / 2017: Consumer Electronics Association (CEA)
  - Standards and performance measurements for PSAPs and OTC HAs
Over-the-counter hearing aids could be coming soon. Why would that be a bad thing?

Published 5:50 p.m. ET July 30, 2017 | Updated 6:35 p.m. ET July 30, 2017

Some Costco stores offer no-cost screenings and hearing aids for less than $1,500

Hearing aids can be pricey, but here are a few tips to possibly help lower the costs. Info from Consumer Reports.

Worth the risks?


Over-the-counter hearing aids would be designed for adults with mild to moderate hearing loss, according to the legislation awaiting U.S. Senate approval.

But the commission, as well as audiologists and hearing-aid dispensers throughout the state, question the diagnostic abilities of untrained consumers.

"Only 25% of consumers can accurately assess their degree of loss, and they don't know if they have the loss in one or both ears," said Bob Flaher, an Arizona hearing-aid dispenser with Miracle Ear.

"If they're not getting professional hearing tests and physical exams, you could have a situation where someone thinks they need a hearing aid when they just have their ears totally impacted with wax," he said.

Audiologists also uncover serious nerve problems, infections and tumors during exams, according to Tucson-based audiologist Judy Huch.

"People might say, 'OK, you've found three tumors in 20 years,'" she said. "But for me,
“Only 25% of consumers can accurately assess the degree of hearing loss, and they don’t know if they have the loss in one or both ears.” said Bob Barber, and Arizona hearing aid dispenser with Miracle Ear.
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Audiologists also uncover serious nerve problems, infections and tumors during exams, according to Tucson based audiologist Judy Huch. “People might say: “OK, you found 3 tumors in 20 years” she said. “But for me, missing one brain tumor is one too many.”
Humes et al, 2017

- Hearing aids make a difference
- Hearing aids similar to OTC hearing aids have almost as good of outcomes as those fit by audiologists using best practices
- Audiologists have the best Outcomes
Accessibility and Affordability: Part 2

• ADA: Audiology Patient Choice Act
  • Audiologists as Medicare Physicians
  • Medicare pays for hearing tests without physician referral

• ASHA / AAO: Medicare Audiology Services Enhancement Act
  • Plan of care will be developed by the audiologist and reviewed and signed periodically by a physician.
  • Medicare pays for hearing tests with physician referral

• AAA: Direct Access ???
What Should Insurance / Medicare Pay For...?

Audiology

Healthcare Practitioner / Medical Model
- Disease Detection, Diagnosis & Progression
- Auditory Rehabilitation following disease
- Auditory Rehabilitation for Age & lifestyle hearing problems

Wellness Care Consumer / Market Model
- Hearing Conservation
- Consumer Electronics & “Internet of things”
- Product Design

Auditory Rehabilitation for Age & lifestyle hearing problems
Note Pressures on Hearing Healthcare Definition

Audiology: Individualized Hearing Care

Disease Related (Medical Model)

Hearing devices as commodity items (Consumerism/Market Model)
What does the Community Need from Audiology?  
*(What does the Market Need?)*

1. **Prevention of hearing impairment** and associated communicative disorders on a societal level
2. **Detection and assessment of hearing impairment** and associated communicative disorders
3. Detection and **referral for treatment of diseases** causing hearing impairment
4. **Aural Rehabilitation**
5. **Prognosis:** individualized future risk for hearing impairment and how to mitigate
What does the Community Need from Audiology?  
(*What does the Market Need?*)

1. **Prevention of hearing impairment** and associated communicative disorders on a societal level

2. **Detection and assessment of hearing impairment** and associated communicative disorders

3. **Detection and referral for treatment of diseases causing hearing impairment**

4. **Aural Rehabilitation**

5. **Prognosis**: individualized future risk for hearing impairment and how to mitigate
Models for Hearing Healthcare Delivery

Option #1

1. Hearing Impaired Person
2. Hearing aid
3. Audiologist
4. Hearing aid

Option #2

1. Hearing Impaired Person
2. Hearing aid
3. Audiologist
4. Hearing aid

Option #3

1. Hearing Impaired Person
2. Primary Care Provider
3. Audiologist
4. Hearing aid

Option #4

1. Hearing Impaired Person
2. Primary Care Provider
3. Ear, Nose & Throat Provider
4. Hearing aid
Which Model Has the Best Outcomes?

<table>
<thead>
<tr>
<th>Cost / Disease Dx?</th>
<th>Cost / hearing aid?</th>
<th>Cost / hearing benefit?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option #1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing Impaired Person</td>
<td>Hearing aid</td>
<td>Audilogist</td>
</tr>
<tr>
<td>Hearing aid</td>
<td>Hearing Impaired Person</td>
<td>Hearing aid</td>
</tr>
<tr>
<td><strong>Option #2</strong></td>
<td></td>
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</tr>
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<td>Hearing Impaired Person</td>
<td>Hearing aid</td>
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</tr>
<tr>
<td>Hearing aid</td>
<td>Hearing Impaired Person</td>
<td>Primary Care provider</td>
</tr>
<tr>
<td><strong>Option #3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing Impaired Person</td>
<td>Hearing aid</td>
<td>Audilogist</td>
</tr>
<tr>
<td>Hearing aid</td>
<td>Hearing Impaired Person</td>
<td>Ear, Nose &amp; Throat Provider</td>
</tr>
<tr>
<td><strong>Option #4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing Impaired Person</td>
<td>Primary Care provider</td>
<td>Hearing aid</td>
</tr>
</tbody>
</table>
Which Model Has the Best Outcomes?

Cost / Disease Dx?  Cost / hearing aid?  Cost / hearing benefit?

Option #1
- Hearing Impaired Person
- Hearing aid

Option #2
- Hearing Impaired Person
- Audiologist
- Hearing aid

Option #3
- Hearing Impaired Person
- Primary Care provider
- Hearing aid
- Audiologist

Option #4
- Hearing Impaired Person
- Primary Care provider
- Ear, Nose & Throat Provider
- Hearing aid
Ear Disease Prevalence (age >= 50 yrs)

Cases / 1,000,000

- Age related hearing loss: 10
- Vestibular schwannoma: 1,900
- Meniere’s disease: 300
- Sudden sensorineural hearing loss: 126
- Cholesteatoma: 130
- Otosclerosis: 3,060
- Suppurative OM: 4,000
- Acute OM: 4,000
- Otitis externa: 4,000
- Cerumen impaction: 4,000
Diseases (age >= 50 yrs)

Cases / 1,000,000

- Age related hearing loss: 527,924
- Vestibular schwannoma: 10
- Meniere’s disease: 1,900
- Sudden sensorineural hearing loss: 300
- Cholesteatoma: 126
- Otosclerosis: 130
- Suppurative: 3,060
- Acute OM: 5,460
- Otitis externa: 4,000
- Cerumen impaction: 20,000

- 200,000
- 400,000
- 600,000
Which Model Has the Best Outcomes?


Option #1  Option #2  Option #3  Option #4

Hearing Impaired Person  Hearing Impaired Person  Hearing Impaired Person  Hearing Impaired Person

Hearing aid  Audiologist  Hearing aid  Primary Care provider

Hearing aid  Audiologist  Ear, Nose & Throat Provider  Hearing aid

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Which Model Has the Best Outcomes?

Cost / diagnosis?

Option #1
- Hearing Impaired Person
- Hearing aid

Option #2
- Hearing Impaired Person
- Audiologist
- Hearing aid

Cost / hearing aid?

Option #3
- Hearing Impaired Person
- Primary Care provider
- Hearing aid
- Audiologist

Cost / hearing benefit?

Option #4
- Hearing Impaired Person
- Primary Care provider
- Ear, Nose & Throat Provider
- Hearing aid
Health and Disease: What Conditions Should be Identified Prior to Hearing Aid Procurement?

Health and Disease: What Conditions Should be Identified Prior to Hearing Aid Procurement?


Audiology / PCP collaboration is important!
Medical Home Concept

• **Proscriptive Hearing Care?**
  • Physician determines when and which type of hearing care to pursue
    • *Why? Answer: recognition of systemic disease with auditory symptoms (?)*

• **Collaborative Care?**
  • Consumer / Patient driven direct access to audiology services – with PCP notification / communication
    • *Also achieves recognition of systemic disease with auditory symptoms*
Which Model Has the Best Outcomes?

Cost / diagnosis?

Option #1
- Hearing Impaired Person
- Hearing aid

Option #2
- Hearing Impaired Person
- Audiologist
- Hearing aid

Option #3
- Hearing Impaired Person
- Primary Care provider
- Hearing aid
- Audiologist

Option #4
- Hearing Impaired Person
- Primary Care provider
- Ear, Nose & Throat Provider
- Hearing aid
Safety of Audiology Direct Access for Medicare Patients Complaining of Impaired Hearing

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Abstract

Background: Allowing Medicare beneficiaries to self-refer to audiologists for evaluation of hearing loss has been advocated as a cost-effective service delivery model. Resistance to audiology direct access is based, in part, on the concern that audiologists might miss significant otologic conditions.

Purpose: To evaluate the relative safety of audiology direct access by comparing the treatment plans of audiologists and otolaryngologists in a large group of Medicare-eligible patients seeking hearing evaluation.

Research Design: Retrospective chart review study comparing assessment and treatment plans developed by audiologists and otolaryngologists.

Study Sample: 1550 records comprising all Medicare-eligible patients referred to the Audiology Section of the Mayo Clinic Florida in 2007 with a primary complaint of hearing impairment.

Data Collection and Analysis: Assessment and treatment plans were compiled from the electronic medical record and placed in a secured database. Records of patients seen jointly by audiology and otolaryngology practitioners (Group 1: 352 cases) were reviewed by four blinded reviewers, two otolaryngologists and two audiologists, who judged whether the audiology treatment plan, if followed, would have missed
Can Audiologists Assess Ear Disease Risk?

>1500 Medicare eligible adults seeking relief from hearing loss…

Zapala, et al. (2010)
Conclusion

• There was essentially no difference between Otolaryngologist and Audiologist decisions concerning who was or was not at risk for ear disease.

  • Audiologists over-referred slightly
  • Neurotologists and Audiologists had the same sensitivity for vestibular schwannoma
Which Model Has the Best Outcomes?

Cost / diagnosis?  
Cost / hearing aid?  
Cost / hearing benefit?

Option #1: Hearing Impaired Person → Hearing aid

Option #2: Hearing Impaired Person → Audiologist → Hearing aid

Option #3: Hearing Impaired Person → Primary Care provider → Hearing aid → Audiologist

Option #4: Hearing Impaired Person → Primary Care provider → Ear, Nose & Throat Provider → Hearing aid
Consumer Ear Disease Risk Assessment (CEDRA)

- Questionnaire designed for hearing aid seeking consumers
- Asks questions about health status and ear disease symptoms
- Provides a prediction of ear disease risk in real time
## Example Questions

<table>
<thead>
<tr>
<th>Category</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Health</strong></td>
<td>Overall, how would you rate your health?</td>
</tr>
<tr>
<td>Dizziness</td>
<td>How often do you have dizziness?</td>
</tr>
<tr>
<td>Balance</td>
<td>How would you rate your balance?</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>Do you have tinnitus, such as ringing, roaring, or cricket-like sounds in your ears?</td>
</tr>
</tbody>
</table>

**Hearing Loss:**

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset</td>
<td>Did the hearing loss in either of your ears develop suddenly?</td>
</tr>
<tr>
<td>Fluctuation</td>
<td>Does your hearing change from day to day?</td>
</tr>
<tr>
<td>Asymmetry</td>
<td>Do you hear better in one ear than the other?</td>
</tr>
<tr>
<td></td>
<td>When talking on a telephone, do you understand what people say better in one ear than the other?</td>
</tr>
</tbody>
</table>
Interim CEDRA Results

- Initial risk probability algorithm
  - Developed from a cohort of 192 cases of disease and age related hearing loss
  - Cross validated in a cohort of 54 similar cases

- Performance validation
  - 90% of ear disease cases identified (10% Miss Rate)
  - 71% of age related hearing loss cases accurately identified
Relative Performance of CEDRA

- AAO: -75% (94% Hit Rate)
- FDA: -22% (82% Hit Rate)
- CEDRA (Criterion: <=4): -30% (87% Hit Rate)

False Positive Rate (Red) / Hit Rate (Blue)
Relative Performance of CEDRA

**False Positive Rate (Red) / Hit Rate (Blue)**

- **AAO**
  - Age / Noise: -75%
  - Disease: 94%

- **FDA**
  - Age / Noise: -22%
  - Disease: 82%

- **CEDRA (Criterion: <=2)**
  - Age / Noise: -61%
  - Disease: 96%
Performance in Adults >= 50 Years

- AAO: 395,943 referrals, 12,479 disease, 797 miss rate
- FDA: 116,143 referrals, 10,886 disease, 2390 miss rate
- CEDRA: 158,377 referrals, 11,550 disease, 1726 miss rate
CEDRA

• Self Assessment of Ear Disease Risk is feasible but imperfect

  • There is a cost in missed ear disease when consumers decide when they have ear disease.

  • Is the cost worth governmental interference in the free market?
Standardizing Ear Disease Risk Assessment by Audiologists
Professional Ear Disease Risk Analytics (PEDRA)

Structured Interview

Simple Standardized Physical Examination

Algorithmic Disease Detection Analytics

Real-Time Estimate of Ear Disease Risk
Semi-Structured Interview

- **History / Risk Factors**
  - Family History of Hearing Loss
  - Ear Infections / Surgeries
  - Exposures
    - Noise
    - Ototoxic
    - Trauma

- **General Medical Conditions**
  - Heart disease
  - Diabetes

- **Onset, progression, laterality of hearing loss and related symptoms**
  - Otologic
    - Pain, pressure, fullness,
    - Tinnitus
    - Dizziness
  - Neurologic
    - Diplopia, Dysarthria, headache
  - Constitutional
    - Night fevers
Examination

- Inspection
  - Otoscopic
  - Check for facial asymmetry

- Test Data
  - Basic Comprehensive Examination
    - Pure tone air / bone
    - SRT
    - WR
  - Immitance

- Analytics
  - Hearing asymmetry calculation
    - Age
    - Sex
    - Pure tone asymmetry (Zapala et al, 2012)
  - Word Recognition Performance Modeling
  - Acoustic Reflex Modeling
PEDRA Analytics

- Individualized reference values for:
  - Word Recognition
  - Acoustic Reflex Thresholds

- Estimated probability of Age Related Hearing Loss
  - \( (p) = 0.002 \) or 2:1000 cases
PEDRA / Mayo Audiology

- AAO: -75% False Positive Rate / 94% Hit Rate
- FDA: -22% False Positive Rate / 82% Hit Rate
- CEDRA (Criterion: >=4): -30% False Positive Rate / 87% Hit Rate
- Audiologist Judgement / PEDRA: -5% False Positive Rate / 96% Hit Rate

False Positive Rate (Red) / Hit Rate (Blue)
Goal: “NIDCD Ear Disease Risk Scale”
All audiologists perform diagnostic tests with the same precision and referral accuracy
Performance in Adults >= 50 Years

Referrals / 1,000,000

No Disease
Disease
Miss rate

AAO
FDA
CEDRA
PEDRA

12,479 797
10,886 2390
11,550 1726
26,396 12,745 531

12,479 797
10,886 2390
11,550 1726
26,396 12,745 531
Things that didn’t work out as planned…

Yet!
Word Recognition

- Speech recognition scores classified by category:
  - Excellent >90%
  - Good >80%
  - Fair >70%
  - Poor <=60%
- Z Score Difference from AI Predication
Word Recognition Contribution *

Validation of Mayo Asymmetry Method

Lowest Word Recognition score

Expected - Observed Difference in Standard Deviation Units

* Preliminary
Acoustic Reflex Thresholds

Reflex Threshold in dBHL

Deflection (0.5 mm/division)

0.5kHz 1kHz 2kHz 4kHz

Titan Default

GSI

Maico
PEDRA

- Audiology can play an important role in otologic disease detection with PEDRA
  - Position – we will see more hearing impaired patients
  - Cost – we are less expensive
  - Reason for Medicare Payment of option #2?
- Critical point: We must integrate into healthcare system
  - Coordinate with PCP / Medical Home**
  - Find disease and refer aggressively
  - Team approach – no profession can do it alone

** Proscriptive (option #3) versus collaborative (option #2) care
Which Model Has the Best Outcomes?

Cost / diagnosis?
- Option #1: Hearing Impaired Person → Hearing aid
- Option #2: Hearing Impaired Person → Audiologist → Hearing aid

Cost / hearing Aid?
- Option #3: Hearing Impaired Person → Primary Care provider → Hearing aid → Audiologist
- Option #4: Hearing Impaired Person → Primary Care provider → Ear, Nose & Throat Provider → Hearing aid

Cost / hearing benefit?
- Option #3 (top)
- Option #4 (bottom)
What Should Insurance / Medicare Pay For...?

1. Prevention of hearing impairment and associated communicative disorders on a societal level

2. Detection and assessment of hearing impairment and associated communicative disorders

3. Detection and referral for treatment of diseases causing hearing impairment

4. Aural Rehabilitation

5. Prognosis: individualized future risk for hearing impairment and how to mitigate
What Should Insurance / Medicare Pay For...?

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Wellness Care Consumer / Market Model
- Consumer Electronics & “Internet of things”
- Product Design

Consumer / Market Model
- Auditory Rehabilitation for Age & lifestyle hearing problems
Note Pressures on Hearing Healthcare Definition

Audiology: Individualized Care

Disease Related (Medical Model)

Hearing devices as commodity items (Consumerism/Market Model)
Pressures on Hearing Healthcare Definition

Audiology: Individualized Hearing Care

- Disease Related (Medical Model)
- Devices as commodity items (Consumerism/Market Model)

Audiologist’s Choice!
Thank You
Zapala.david@ Mayo.edu
Questions & Discussion
Audiology Evaluation and Management

**Audiological Evaluation**

**Presentation**
- Person > 50 yrs. of age with complaint of hearing difficulty or suspected hearing loss
- Self referred or referred by PCP or other source

**Assessment**
- Communication Assessment
- History
- Preliminary Need: Cultural / Social / Environmental Factors
- Audiogram
- Questionnaire, Interview / Observation based

**Impressions**
- Type, Magnitude and Likely cause of Hearing Loss
- Nature & Magnitude of Communication Difficulties

**Plan**
- Interaction with Healthcare Providers
  - Communication with Medical home if High Disease Risk
  - Initiate Medical referral:
    - Otolaryngology
    - ENT
    - Other
- Counselling re: Rehabilitation Options
  - Technology Aids
    - PSAP
    - Hearing Aids
    - Cochlear Implants & other implantables
  - Adaptive Skills
    - Listening / conversation repair skills
    - Assertiveness and managing social fear / isolation
    - Lip reading and non-verbal cues
  - Environmental / Situational Accommodations
    - Significant others and clear speech
    - Understanding and controlling the acoustic environment
    - Assistive Technologies & connectivity

**Audiological Rehabilitation**

**Rehabilitation**

**Implementation of Plan**
- Hearing aid selection visit
- Cochlear Implant Evaluation
- Group Aural Rehabilitation Program
- Etc.

**Outcome Assessment**
- Revised Needs Assessment
- Revised Plan