

# **Making the Case for Cochlear Implants in Developing Countries**

**James E. Saunders, M.D.**

**David Barrs, M.D.**

**Debra Tucci, MD**

**Blake Wilson, PhD**

**Jan Osterman, MPH**

**Wengfong Gong, MPH**

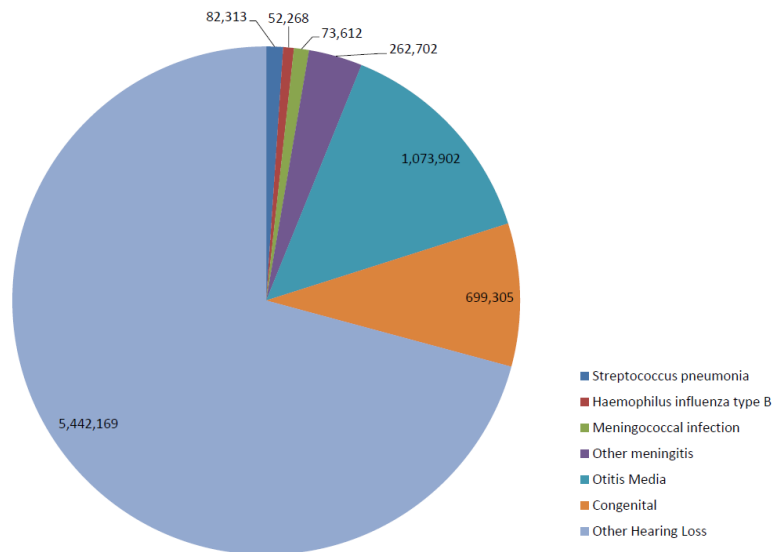
# Congenital Profound HL:

## How Big is the Problem?

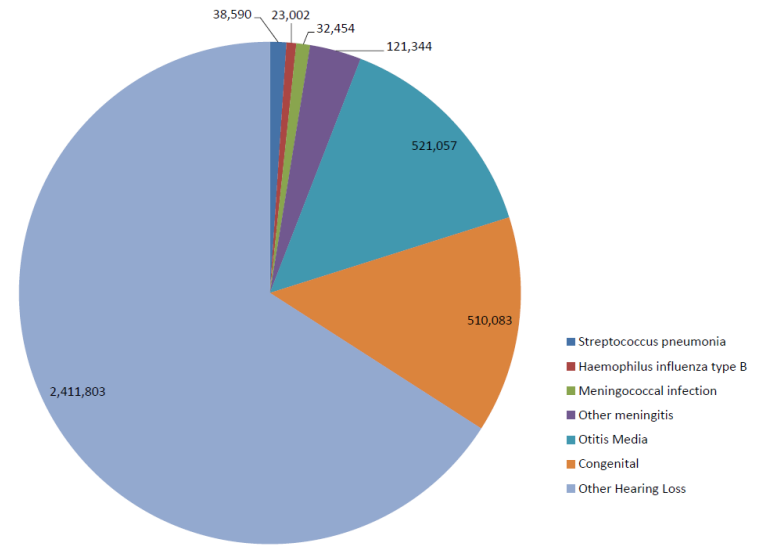
### Hearing Loss in the World

- **WHO**
  - 278 million hearing impaired in the world (4 - 6% of world population)
  - 0.2% of world's population – 14 million
- **GBD Estimates**
  - 11.7 million (4% of 303 million w/ hearing loss)
  - ~30% congenital / early onset – 3.9 million

Profound Hearing Loss Cases by Etiology, Global 2010



Complete Hearing Loss Cases by Etiology, Global 2010

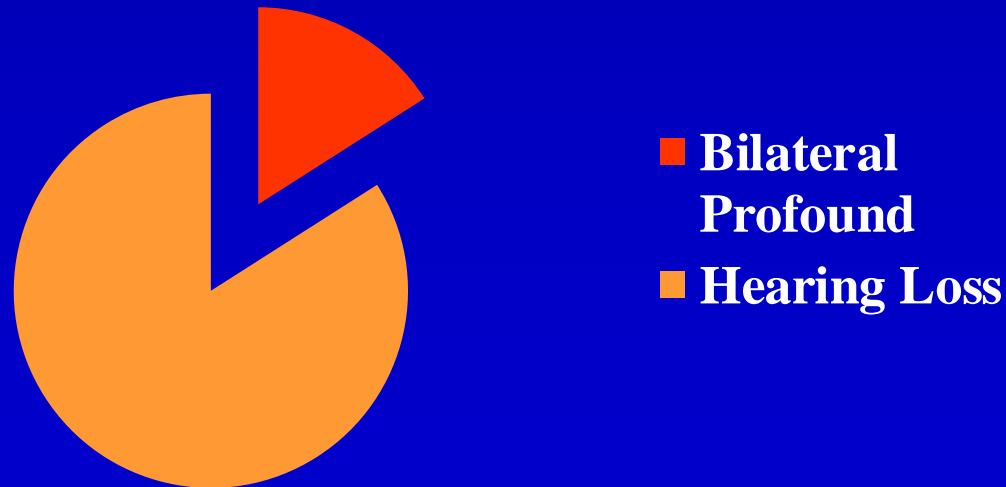


# Congenital Profound HL: How Big is the Problem?

## Congenital Hearing Loss

- 3 - 6 per 1,000 births (0.3 - 0.6%)
- 0.54% adjusted mean
- 37.8 million with congenital HL in world
- ~10% of HI are profound - 3.78 million

## Childhood HL per 1000



# Basic Premise

**Profound HL in childhood has devastating consequences**

**Childhood Profound HL treatment**

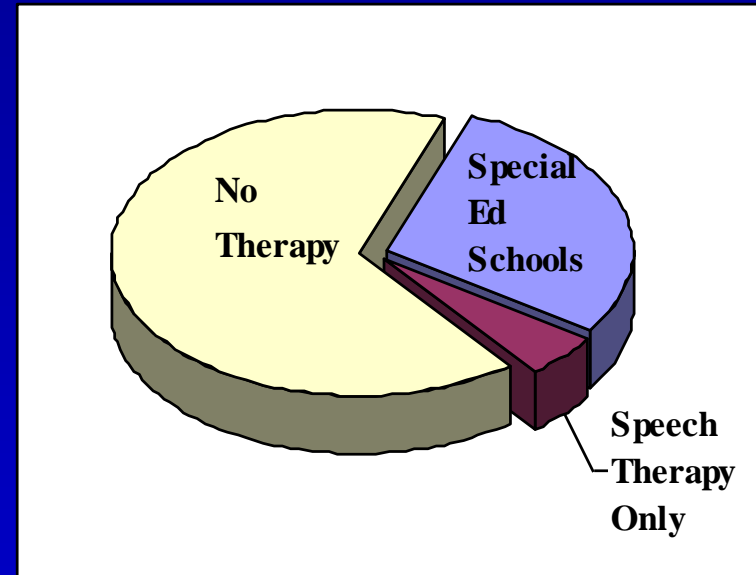
- **Cochlear Implant**
- **Sign language**
- **Hearing aids are not viable option for most cases**

# Unmet need

**Many children receive no treatment**

**Nicaragua – 2/3 of deaf children receive no services**

**Africa – only 9% of failed screening exams receive Audiograms (Odomi et al)  
??? Access to deaf ed**



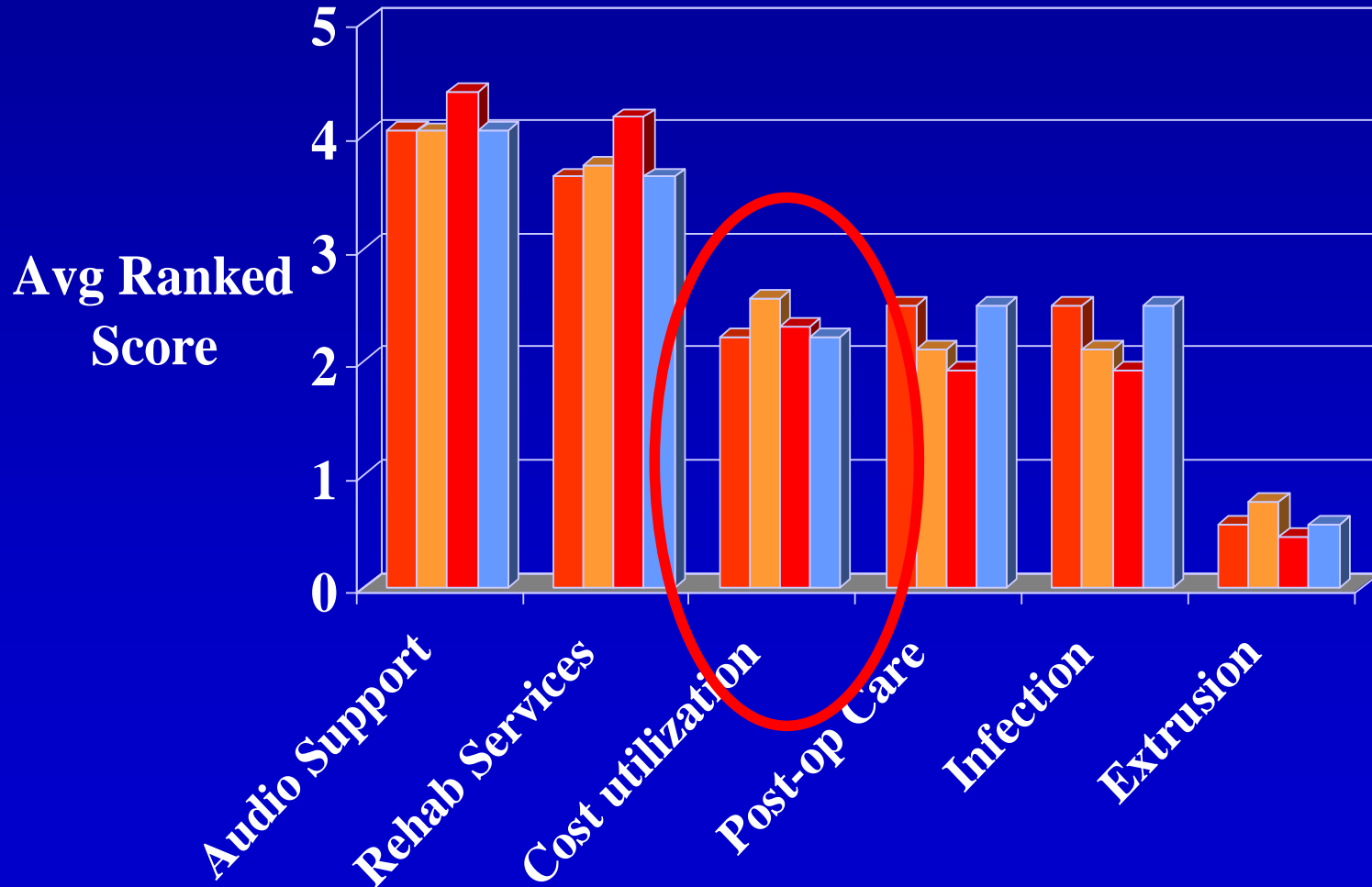
**Only a small fraction receive cochlear implants**

**~250,000 implants including ~100,000 children**

**100,000 / 3.78 million = 2.6%**

# Ranked Level of Concern

## Survey of 198 US Cochlear Implant Surgeons



# Cost Effectiveness of Cochlear Implants

Costs of surgery vs. special education

UK Cochlear Implant Group

Cost-effective (€25,629 / QALY)

Cost - Benefit dependent on:

- Age at implantation
- Duration of deafness

Germany (age of implantation)

<2 yrs: \$113,100

2-3.9 yrs: \$152,000

4-6.9 yrs: \$160,000

HA (profound): \$160,000

U.S. (Francis & Niparko 1999)

- 2x more likely to be mainstream / Cost-effective

Costs /Benefits may not apply to Developing World

*Barton 2006, Bond 2009, Sach 2003, Sumerfield 1997,  
Schulze-Gatterman 2002, Oneil 2000, Francis 1999*

## **Economic evaluation of health interventions for hearing loss: How to define impact? DALY**

- **Years of Life Lost = measure of mortality**
- **Years Lived with Disability**
- **Disability Weights for different diseases**
  - **Scale: 0 (perfect health) to 1.0 (death)**
- **Disability-adjusted life year,**  
 **$DALY = YLL + YLD$**   
**One DALY = one year of healthy life lost**
- **Can reflect the large impact of non-morbid conditions on populations; used primarily in developing countries**



# Economic evaluation of health interventions for hearing loss: Disability Weights

Severity	Disability Weight GBD 2000	Disability Weight GBD 2010??
Mild (26 – 40 dB)	0.00	0.012
Moderate (41 – 60 dB)	0.12	0.022
Severe – Profound (61+ dB)	0.33	
Severe (61 – 80 dB)		0.052
Profound (81 – 95 dB)		0.062
Complete (95+ dB)		0.068
Moderate with Hearing Aid	0.04	
Severe to Profound with Hearing Aid	0.12	<b>Deaf Ed</b>

# Initial analysis of SNHL treatments: DALYs averted

- Calculate discounted and mortality-adjusted cost per DALY for interventions
- Compare Cost/DALY averted for each intervention and compared with no treatment
- World Health Report 2002:
  - < 3 times GDP per capita for each DALY averted represented good value for the money
- Major difficulty with these calculations is in deciding what costs to include for each intervention

# **Initial analysis of SNHL treatments: DALYs averted – Nicaragua**

## **Congenital Profound HL**

**Common starting point**

**Good habilitation potential**

**Implanted < 3 yrs of age**

## **Otolaryngology & Audiology Status**

- **Basic training exist, but not CI training (Level 2)**

## **Estimated Costs :**

**- costs of ‘deaf’ education including residential program, teacher salary, teacher training, classroom interpreters, building, utilities**

**- costs of CI surgery including device (donated), surgery, surgical training, equipment, mapping, rehab, device maintenance**

# Deaf Education Costs

- Residential Housing /Deaf Class
  - Jinotega, Nicaragua

- Costs per student

• Deaf Educator Training	\$40
• Deaf Ed Teacher Salaries	\$1344
• Additional Ed Expense	\$840
• Residential Costs	\$16716
• School Interpreter Training	\$50
• School Interpreters Salaries	\$1380
• Mainstream Ed Cost	\$300
<b>Total</b>	<b><u>\$20,670</u></b>

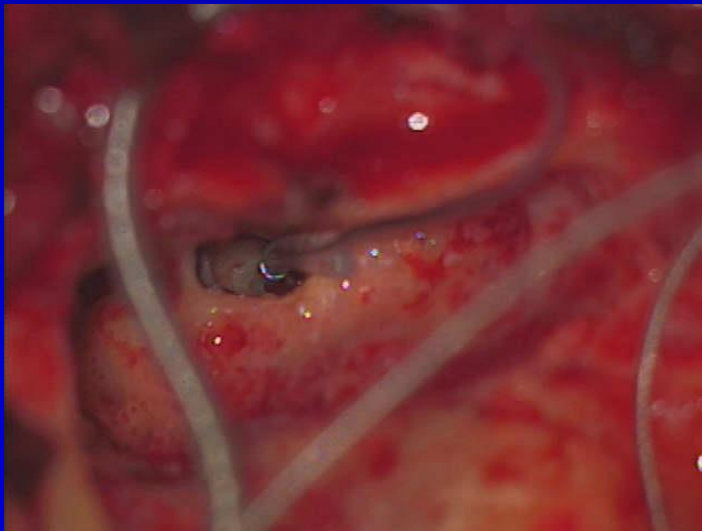


# Cochlear Implant Costs

Implant Costs

Labor costs (Professional Fees / Salaries)

Infrastructure Costs (Equipment, etc...)



# Is an Inexpensive Implant the Answer?

## Current Cost in Developing World

- \$5,000 - \$15,000 for single devices
- Large bulk order in China

## Implants in Development (Target \$500 - \$3,500)

- Nurobiosys & Seoul National University
- Shanghai Medical University
- Neurotron Biotechnology
- Allhear (single channel)
- Indian Naval Scientific Technology Lab
- Multicoil Four Channel Device

Estimated costs of implant at \$10,000

**Implant cost is only a fraction of overall expense**

# Labor Cost Estimates and Amortization

**Full Time Effort (FTE): 30 clinical  
hrs/week x 48 weeks/yr = 0.069% FTE/  
clinical hour**

## **Salaries (100% FTE)**

- **Surgeon - \$15,000**
- **Audiologist - \$10,000???**
- **Speech / Auditory therapist - \$10,000???**

## **Initial Equipment and Training Costs**

- **Amortized over 40 implants / yr x 10 yrs**

# Infrastructure Expenses

## Pre-op Costs

- ABR? / audiogram / hearing aid trial
- CT Scan

## Surgical Costs

- Surgeon and surgical equipment
- Surgical training

## Audiology Costs

- Repair / mapping visits
- Telemedicine mapping support
- Audiology training



# Infrastructure Expenses

## Rehabilitation Costs

- Speech therapy / auditory therapy
- Therapy Training

## Device Costs

- Device Failure 5%
- Minor repairs ~ every 3 mo?
- Battery Costs

## Social Costs / Issues

- Access to care
- Transportation

# Preop Costs = \$375.82

## Audiology Training

$\$2,500 * 2 = \$5,000 / 400 \text{ implants} = \$12.50$

## Audiological evaluation

- 10 hr = .69 FTE = \$69

## ABR

- 1 hr + equipment (amortized) = \$14.32
- Required for either intervention?

## Hearing Aid Trial

- $\$50 \times 2 = \$100$

## CT scan (absolutely necessary?)

- \$180

# **Surgery Costs = \$10,716.87**

**Device Cost = \$10,000**

**Surgeon Training**

- **\$10,000 / 400 Implants = \$25**

**Surgeons Fees / Salary**

- **0.5% FTE = \$82.50**

**Equipment**

- **Microscope, facial nerve monitor, drill, instruments**
- **\$19.37**

**Other (OR Room, Anesthesia, Antibiotics)**

- **\$590.00**

# Rehabilitation Expenses = \$2,919.50

## Audiology Mapping

- 4.52% FTE = \$452.00
- 40 visits in first 20 years, biannual adult visits

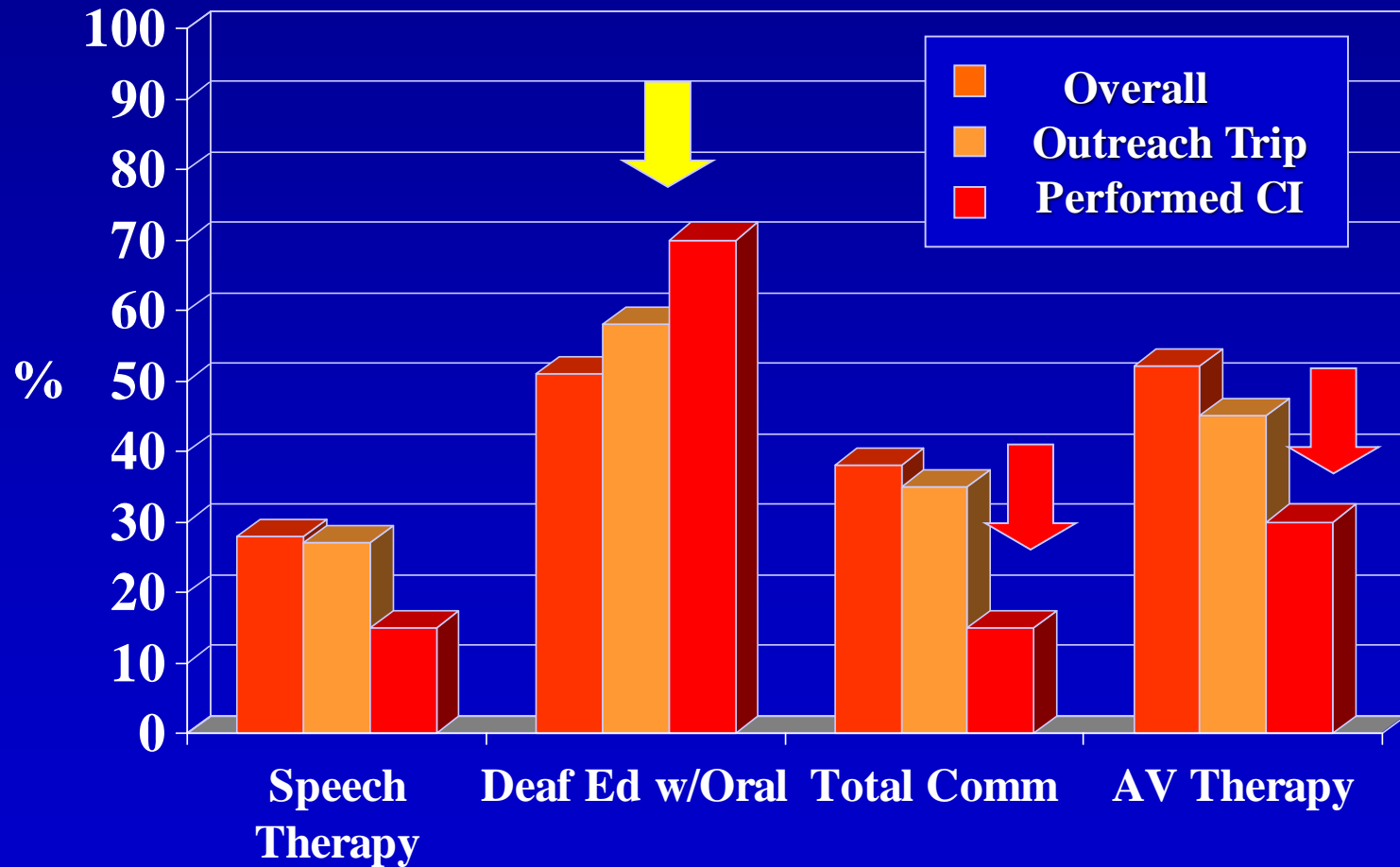
## Speech Therapy / Auditory Rehab??

- 17.25% FTE (lifetime) = \$1,725
  - 3x/week x 3 yrs, then 1x/week x 2 yrs
- Training??? -  $\$3000 \times 3 / 400 = \$22.50$

## Mainstream Education Costs

- \$720 (enters school system earlier than deaf ed)

# Minimum Rehabilitation for Children



**Differ from U.S. practice?: 66%**

# Device Costs = \$9,765.00

## Device Failure

- \$543 (1 in 20 will need to be replaced)
- 5% lifetime for children
- includes device and surgery

## Non-Use

- \$110.00 (1% of preop and surgery costs)
- Estimated 1% (should be low for congenital HL)

## Battery Costs

- \$104 x lifetime – 3 yrs = \$7072.00

## External Repairs???

- \$30 x lifetime – 3 yrs = \$2040.00

# Initial analysis of SNHL treatments: DALYs averted – Nicaragua GBD 2000 Disability Weights

	No Treatment	Deaf Education	Cochlear Implant
Differential cost (c/w no treatment)	0	\$20,670	\$23,777.19
Differential DALY	20.01	-4.36*	-8.54**
Cost per DALY Averted	0	\$4,740	\$2,784
Cost per DALY Averted /GDP (\$3200)	0	1.48	0.87

\* Reduced to 0.12

\*\*Reduced to 0.04

# Initial analysis of SNHL treatments: DALYs averted – Nicaragua GBD 2010 Disability Weights

	No Treatment	Deaf Education	Cochlear Implant
Differential cost (c/w no treatment)	0	\$20,670	\$23,777.19
Differential DALY	20.01	-0.82*	-.57*
Cost per DALY Averted	0	\$25,207	\$36,263
Cost per DALY Averted /GDP (\$3200)	0	7.88	11.33

\*Reduced to 0.04



# **Economic evaluation of health interventions for hearing loss: Where do we go from here?**

**Improved DALY measures and Disability Weights for hearing loss!!!**

**Refine methodology:**

**Appropriate Rehabilitation Strategy**

**Audiology / Speech Therapy Salary and Training**

**Audiology and Speech Therapy Mid Level Providers?**

**External Repairs**

**Improve data from index countries**

**Develop global database that compares interventions in different contexts**

- **extrapolate data from similar countries**

**Please contact me if you have data / ideas to share**

***“IF WE TEACH TODAY LIKE  
WE TAUGHT YESTERDAY,  
WE ROB OUR CHILDREN OF  
TOMORROW”***

- **John Dewey, Educator and Philosopher**

# Thank YOU!



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# Cost vs. Benefit

Comparable services (\$3,500/device)

100 Cochlear Implants (\$350,000)

1400 Hearing aids (\$250 – not for profound HL)

Pneumococcal vaccine in West Africa

- 70,000 vaccines (\$5 each)
- Incidence of Meningitis 14 – 42/100,000 (<5yrs)
- Prevent 4.9 – 14 cases / yr  
(77% efficacy x 65% of serotypes = 50%)
- 24.5 – 70 cases over 5 yrs
- 53% survive = 12.9 – 37.1 cases
- 33% HL = prevention of **4.28 – 12.24 cases**

**Doesn't include surgical costs, vaccine program costs, mortality, other neurological morbidity**

# Cochlear Implants in the Developing World

## Lahore, Pakistan (Khan& Mukhtar et al. 2007)

- 52 patients
- Minor wound complications (5.77%)
- Device failure (3.84%)
- No extrusions

## Latin America (Goycoolea et al. 2005)

- 3768 patients (questionnaire survey)
- Low Infection (0.7%) and extrusion (0.4%)
- Multiple Cochlear Implant Centers (private?)

## Potential cochlear implant candidates

Latin America : 81,200 candidates (10% of deaf)

China : 320,000 - 900,000 candidates

Zeng FG: Audiology 34:61 -75 1995 Madriz JJ: Audiology 39:212-220 2000

Berruecos P: Audiology 2000: 39:221

# **Cost effectiveness of Treatments for SNHL in Developing Countries**

**Given a fixed sum of money to use for prevention and treatment of hearing loss, how are the dollars best allocated?**

**Possible expenditures include:**

- Prevention: vaccination; medical care of pregnant mother and newborn**
- Early identification of HL: newborn/childhood hearing screening; education of parents & providers**
- Rehabilitation: hearing aids & cochlear implant**
- Education: either mainstream education or ‘deaf’ education in special schools**
- Infrastructure: otolaryngologists trained to do ear surgery; audiologists; imaging capability; operating room and other medical facilities; telemedicine**

# **Economic evaluation of health interventions for hearing loss:**

## **Limitations of current assessment**

- **DALY available for adults only**
- **WHO office of Global Burden of Disease currently working on revision hearing loss estimates as well as disability weights for the GBD 2010 project. New estimates and DALY for hearing loss in children expected to be released later this year.**



# Health interventions analyzed by per capita income (in US dollars), World Bank classification

Low	Lower Middle	Upper Middle	High	Nicaragua
< \$995	\$996 – \$3,945	\$3,946 - \$12,195	> \$12,196	\$1000

Intervention	Cost per DALY averted compared with per capita income (\$1000)
Residential Deaf Education	11,454/1000 = 11.5 x
Cochlear Implant	\$5,347/1000 = 5.3 x
Hearing Aids	\$367 = well under per capital annual income