



## Age-Related Hearing Loss: Demographics and Risk Factors

ARC, San Diego, CA  
April 14, 2010

Karen J. Cruickshanks, Ph.D.  
Professor  
University of Wisconsin  
School of Medicine and Public Health

**President Clinton** was fitted for small hearing aids in both ears today after tests confirmed that he had moderate loss of high-frequency hearing. Mr. Clinton has complained privately for several years that he has difficulty hearing in crowded rooms and at noisy rallies.

Experts said that the type of hearing loss suffered by the President is common after the age of 40, particularly among those exposed to loud noise like rock music, gunfire and crowds.

Mr. Clinton has experienced all three, said Michael D. McCurry, his press secretary, listing hunting rifles and rock and roll as a youth and political rallies.

"This is a big baby-boomer thing," Mr. McCurry said. "It's a new thing we're all going to have to get used to."

New York Times, October 4, 1997

## An Early View of Aging from the Precepts of Ptah-Hotep, c. 2200 BCE

Old age has struck, age has descended,  
Feebleness has arrived, weakness is here again.  
Sleep is upon him in discomfort all day.  
Eyes are grown small, ears deaf,  
Mouth silent, unable to speak,  
Heart emptied, unable to recall yesterday.  
Bones ache his whole length.  
Goodness has turned to evil,  
All taste is gone.  
What old age does to people is evil in every way.

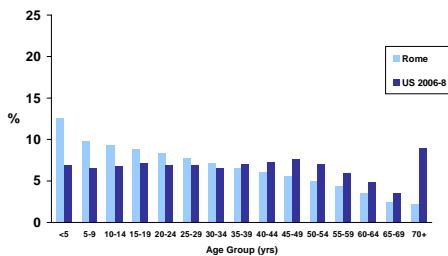
<http://www.digitalegypt.ucl.ac.uk/literature/ptahhotep.html>

## Hippocrates' View of Aging, c. 400 BCE

**To old people** dyspnoea, catarrhs accompanied with coughs, dysuria, pains of the joints, nephritis, vertigo, apoplexy, cachexia, pruritus of the whole body, insomnolency, defluxions of the bowels, of the eyes, and of the nose, dimness of sight, cataract (glaucoma), and **dullness of hearing**.

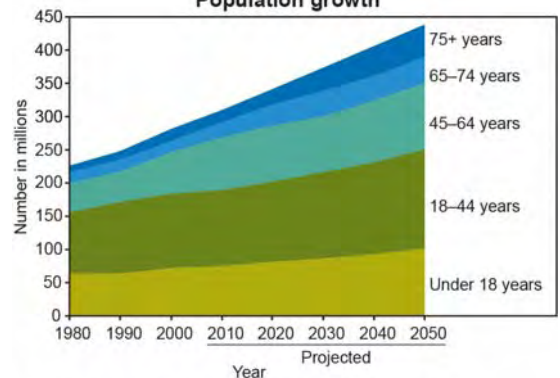
Aphorisms, Hippocrates, translated by Francis Adams  
<http://classics.mit.edu/Hippocrates/aphorisms.3.iii.html>

## Estimated Age Distribution: Ancient Rome and the United States



<http://www.utexas.edu/depts/classics/documents/ife.htm>  
and US Census Bureau, 2006-2008 American Community Survey

## Population growth



SOURCE: CDC/NCHS, Health, United States, 2009, Figure 1A. Data from the U.S. Census Bureau.

## Epidemiology

The study of the distribution and determinants of health-related states or events in specified populations and the application of this study to control of health problems

Last JM, A Dictionary of Epidemiology, IEA, 1988

## The Role of Epidemiology in Health Research

- Good data are needed to develop health policies and practices
- Longitudinal population-based epidemiologic studies provide data about the "typical" experience
- By measuring behavioral, social and environmental factors while people are healthy, we can identify the factors that predict who will develop disorders
- Identify strategies and test interventions to prevent or delay onset and improve outcomes

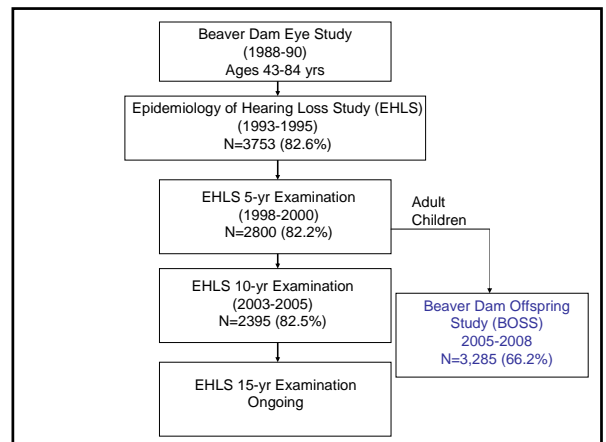
*Bench to Bedside to Community*

## Doll and Peto Model: Evidence of an "Environmental Disorder"

- Geographic variation
- Risk changes with migration
- Temporal trends
- Risk factors

Doll and Peto, 1981, The Causes of Cancer, Oxford Press

- Descriptive epidemiology
  - by person, place and time
- Risk factors
- Future directions



### Prevalence of Hearing Impairment

Study	Age (yrs)	%HI
US (EHLS)	48-92	46
US (CHS)	72-96	55
US (FHS)	57-89	47
US (Health ABC)	73-84	74
Australia (BMHS)	49+	45
Taiwan	65+	44

### Prevalence of Hearing Impairment

Study	Age (yrs)	%HI
US (BOSS)	21-84	14
US (NHANES)	20-69	16
Norway (N-T)	20-101	27
Great Britain	17-80	26

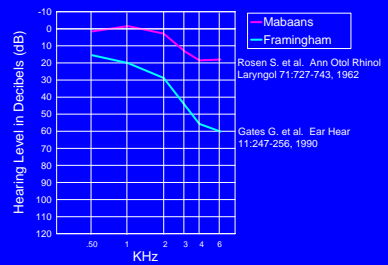
### Racial/Ethnic Differences in the Prevalence of Hearing Impairment

Study	NHW	AA
US (NHANES)	18	8
US (Health ABC)	62	56
US (CHS- Men <80 yr)	78	67
US (CHS – Women <80 yr)	61	52

	MA	CA	PR
US (NHANES)	10		
US (HHANES – Men 55-74 yrs)	46	48	23
US (HHANES – Women 55-74 yrs)	35	43	33

### Hearing Thresholds in Men 60-69 Years of Age

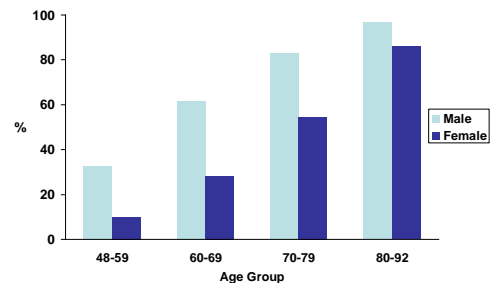


### Back in the USSR: Rosen (1970) Mean Threshold at 4000 cps

	40-49 yrs	50-59 yrs
Georgia Clerical (n=81)	10.1	18.2
Georgia Factory (n=107)	12.5	18.2
Moscow Clerical (n=188)	21.2	23.6
Moscow Factory (n=47)	40.8	44.3

Rosen, et al., Arch Otolaryngol 1970;91:424-8

### Prevalence of Hearing Impairment by Age and Gender: Epidemiology of Hearing Loss Study, Beaver Dam, WI, 1993-95

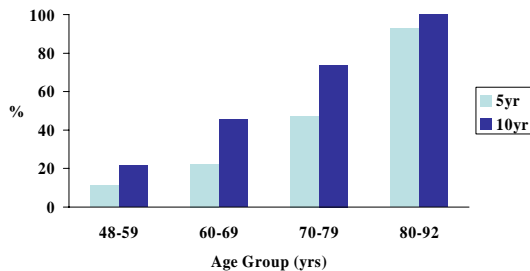


Cruickshanks, et al., AJE 1998; 148(9):879-886

### Incidence of Hearing Impairment

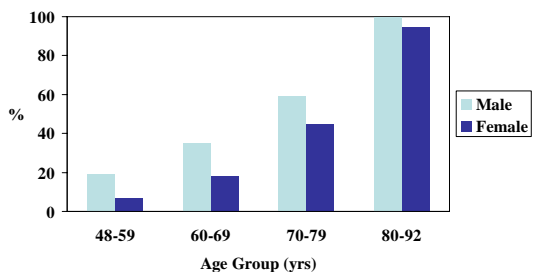
Study	Age (yrs)	%HI	
US (EHLS)	- 5 yr	48-92	21
	- 10 yr		37
US (FHS)	- 6 yr	57-89	8 (R)/14 (L)
US (BLSA)	- 8 yr	60+	13-17
Great Britain	- 2 yr	17-80	12

### 5- and 10-yr Cumulative Incidence of Hearing Impairment by Age: Epidemiology of Hearing Loss Study, Beaver Dam, WI



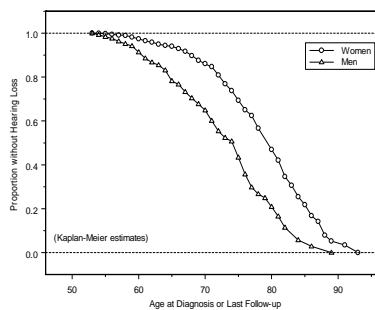
Cruikshanks, et al., Hear Res., In Press

### 5-yr Incidence of Hearing Loss by Age and Gender: The Epidemiology of Hearing Loss Study, Beaver Dam, WI



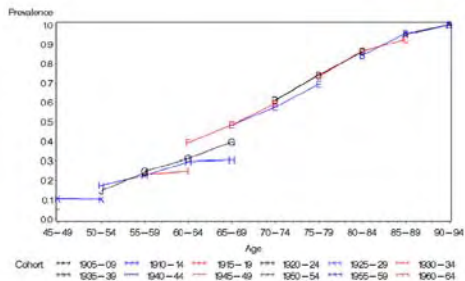
Cruikshanks, et al., Arch Otolaryngol Head Neck Surg 129: 1041-1046, 2003.

### Age at Detection of Hearing Impairment by Gender



Cruikshanks, et al., Hear Res., In Press

### Age-specific Prevalence of Hearing Impairment by Birth Cohort



Zhan W, et al., Amer J Epidemiol 171:260-66, 2010.

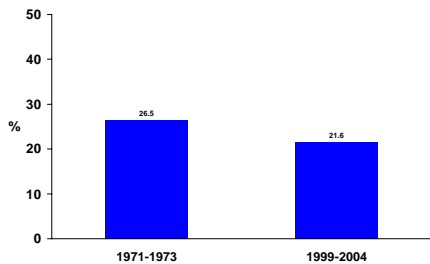
Table 3. Prevalence of Hearing Impairment (%) by Birth Cohort, Age, and Sex: Epidemiology of Hearing Loss Study (1990-2005) and Beaver Dam Offspring Study (2009-2020)\*

Birth Cohort	Age Group, years									
	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94
Men (n = 4,048)										
1990-1964	9.9									
1990-1959	15.4	16.7								
1990-1954	21.2	33.9								
1945-1949			32.7	36.4						
1945-1944			25.8	36.4	41.3	45.0				
1935-1939				41.6	50.4	58.9				
1930-1934					58.1	70.0	79.3			
1925-1929						64.8	73.1	82.5		
1920-1924							78.0	91.4	94.6	
1915-1919								87.2	93.5	97.8
1910-1914									95.0	100.0
1905-1909										100.0
Women (n = 5,302)										
1990-1964	3.9									
1990-1959	6.0	4.4								
1990-1954			8.6	16.9						
1945-1949					10.0	12.2				
1940-1944						11.8	19.0			
1935-1939							10.5	14.3	23.1	
1930-1934								22.7	28.8	44.3
1925-1929									34.3	45.4
1920-1924										48.6
1915-1919										65.7
1910-1914										77.8
1905-1909										85.8
										93.3
										100.0

\* For reliable estimates of prevalence, only results for subgroups with 30 or more participants are displayed.

Zhan W, et al., Amer J Epidemiol 171:260-66, 2010.

### Temporal Trends in Age-sex-race-adjusted Prevalence of Hearing Impairment: NHANES



Cheng, Y.J, et al., Preventive Medicine 2009;49:360-364

### Descriptive epidemiology of ARHL by person, place and time

- Risk
  - Increases with age
  - Higher for men than women
  - Higher in NHW than AA or Latinos?
  - Varies by geographic location?
  - Decreasing by birth cohort/time?

- Descriptive epidemiology
  - by person, place and time
- Risk factors
- Future directions

### Environmental Factors Influence Hearing?

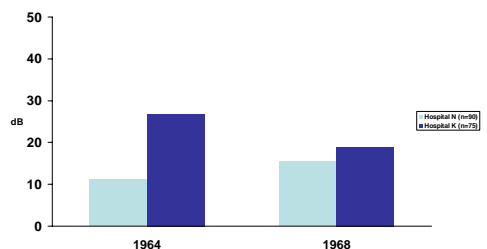
With regard to the states of the weather which continue but for a day, **that which is northerly**, braces the body, giving it tone, agility, and color, **improves the sense of hearing**, dries up the bowels, pinches the eyes, and aggravates any previous pain which may have been seated in the chest. **But the southerly** relaxes the body, and renders it humid, **brings on dullness of hearing**, heaviness of the head, and vertigo, impairs the movements of the eyes and the whole body, and renders the alvine discharges watery.

Aphorisms, Hippocrates, translated by Francis Adams  
<http://classics.mit.edu/Hippocrates/aphorisms.3.iii.html>

### Early Epidemiological Studies by Rosen

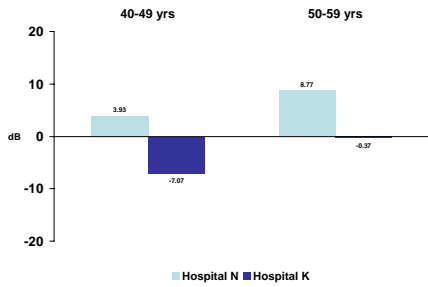
- Hearing in rural Africans
- Hearing in countries with high/low rates of CVD
- Hearing and diet in Finnish hospitals
  - Diet intervention 1959-64
  - Hospital N: high unsaturated fats, low saturated fats
  - Hospital K: usual Finnish diet
  - In 1964 Cholesterol was 51 mg/dl lower in Hospital N
  - REVERSED DIETS in 1965
  - Measured hearing in 1964 and 1968

### Hearing Threshold at 4000 cps in 1964 and 1968 by Hospital : Patients 40-49 yrs old



Rosen, S et al., Acta Otolaryngol 1970;70:242-7

### 4-yr Change in Threshold at 4000 cps



Rosen, S et al., Acta Otolaryngol 1970;70:242-7

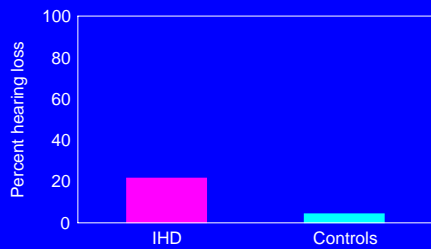
“Anything that impairs [the blood supply to the cochlea] is likely to affect the efficiency of the inner ear.”

“High frequency hearing loss may be the earliest indication of the beginnings of degeneration of the vascular system.”



- Samuel Rosen, M.D., 1973

### Hearing Loss and Ischemic Heart Disease



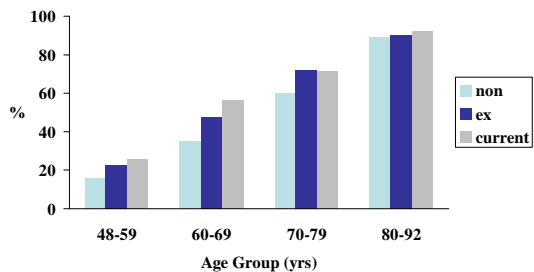
Susmano A, Rosenbush SW. AJO 9:403-408, 1988.

### CVD and ARHL

Study	Association
EHLS	+
FHS	+
BLSA	0
NHANES	0
Health ABC	+ (BM)
CHS	NR
BMHS	0
BOSS	0

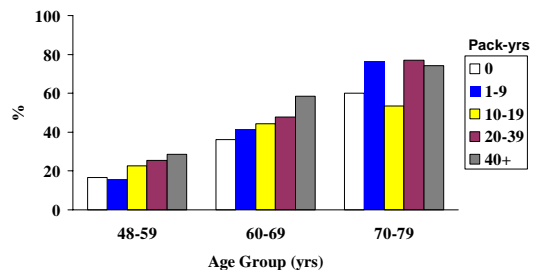
0 No association, + positive, - negative, NR not reported

### Prevalence of Hearing Impairment by Smoking Status: Epidemiology of Hearing Loss Study, Beaver Dam, WI



Cruickshanks, et al., JAMA, 1998;279:1715-1719

### Prevalence of Hearing Impairment by Pack-years: Epidemiology of Hearing Loss Study, Beaver Dam, WI



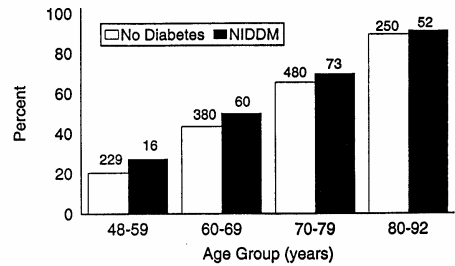
Cruickshanks, et al., JAMA 1989;279:1715-1719

## Smoking and ARHL

Study	Association
EHLS	+
FHS	0
BLSA	0
NHANES	+
Health ABC	+ (BW)
CHS	0
BMHS	+
BOSS	0

0 No association, + positive, - negative, NR not reported

## Prevalence of Hearing Impairment by Diabetes Status: Epidemiology of Hearing Loss Study, Beaver Dam, WI



Dalton, et al., Diabetes Care 1998;21:1540-44

## Diabetes and ARHL

Study	Association
EHLS	+
FHS	0
BLSA	NR
NHANES	+
Health ABC	+ (W)
CHS	NR
BMHS	+
BOSS	0

0 No association, + positive, - negative, NR not reported

## Socioeconomic Status (SES) and 10-yr Incidence of ARHL: Epidemiology of Hearing Loss Study, Beaver Dam, WI

Risk Factors	Model 1	Model 2
	Hazard Ratio (95%CI)	Hazard Ratio (95%CI)
Age (5 yr)	1.81 (1.69,1.94)	1.81 (1.70,1.94)
Men (vs. Women)	2.29 (1.81, 2.90)	2.49 (1.96,3.15)
Education (<16 yrs vs 16 or more yrs)	1.40 (1.05, 1.87)	1.56 (1.19,2.06)
Marital Status (Not Married vs Married)	1.29 (1.03, 1.62)	1.32 (1.06,1.66)
Occupation – Longest Held Job (Production, Operator or Farmer vs Managerial, Technical or Service)	1.34 (1.06, 1.69)	Not included
Reported Noisy Job	Not included	1.00 (0.81,1.24)

Cruikshanks, et al., Hear Res. Oct 22, 2009. [Epub ahead of print]

## SES and ARHL

Study	Association
EHLS(Prev and Inc)	-
FHS	NR
BLSA	NR
NHANES	-
Health ABC	+ (BW)
CHS	0
BMHS	-
BOSS	-

0 No association, + positive, - negative, NR not reported

## Other CVD Risk Factors

- Blood pressure (BLSA, Health ABC)
- Alcohol consumption (EHLS and Health ABC)
- Exercise (BOSS)

## RCT of Folate and ARHL

- Ages 50-70 yrs
- N=728
- 800 µg/day folic acid or placebo
- 3-yr follow-up
- Treated group had a smaller decline in PTA (1 vs 1.7 dB)

Durga et al., Ann Intern Med 2007;146:1-9

## Estimates of Familial or Genetic Effects

Study	Subjects	Estimate
Karlsson, 1997	Male twins	47-58%
Christensen, 2001	Twins	53%
Viljanen, 2007	Twins	MZ=.81 DZ=.44
Gates, 1999	FHS	28%
Raynor, 2009	EHLS	47%

## Genetic Markers

### FHS (DeStafano 2003)

- > chromosomes 10q (LOD=2.0), 11q13.5 (LOD=2.1), and 18q (LOD=2.7)

### European Consortium

- > (Huyghe, 2008) chromosome 8q (LOD=4.2)
- > (Friedman, 2009) GRM7

## Doll and Peto Model:

### Evidence of an “Environmental” Disease

Geographic variation : **Some**

Risk changes with migration: **No Studies**

Temporal trends: **Some**

Risk factors: **Fair (CVD Risk factors)**

*Evidence supports the notion that at least some of ARHL IS preventable*

## Summary

- Risk of developing a hearing impairment
  - > About 1 in 25 people each year
- Risk may be lower for more recent generations
- CVD risk factors and markers of inflammation and atherosclerosis are associated with hearing impairment
- Factors that improve vascular health may help preserve good hearing

## In the Year 2030

- 69 million hearing impaired adults age 45+ yrs
- Of whom, 58 million will be untreated
- **IF Birth Cohort Effect continues:**  
“only” 51 million hearing impaired adults

Then and Now:  
Participants Ages 50-59 yrs

	EHLS	BOSS
% taking statins	3.4%	21.1%
Mean Cholesterol (mg/dl)	236	208
% Smokers	56.5	49.2

- Descriptive epidemiology
  - by person, place and time
- Risk factors
- Future directions

- Standardized definition of clinically relevant endpoint
- Longitudinal studies to evaluate the impact of factors in human populations
- Randomized controlled trials (RCT) of interventions for primary prevention
  - Effect of statins and other medications, exercise, smoking cessation, etc.
- RCT for treatments
  - Hearing aids, training programs, medications
- Collaboration between basic and clinical investigators to lead to improvements in public health and hearing health care

*Bench to Bedside to Community*

EHLS and BOSS

University of Wisconsin

- Ted Tweed
- Ronald Klein
- Barbara Klein
- Rick Chappell
- Charles Acher
- Javier Nieto
- Guan-Hua Huang
- Mary Fischer
- Dayna Dalton
- Carla Schubert
- David Nondahl

U Minnesota, Boston U, U Penn

- James Pankow
- Nathan Pankratz
- Clint Baldwin
- Michael Tsai
- Brendan Keating

Current Students

- Wenjun Zhong
- Scott Nash
- Grete Wichmann

Disclaimer

The project described was supported by R37AG11099 from the National Institute on Aging and R01AG021917 from the National Institute on Aging, National Eye Institute, and National Institute on Deafness and Other Communication Disorders. The content is solely the responsibility of the authors and does not necessarily reflect the official views of the National Institute on Aging or the National Institutes of Health.