Using Conceptual Modeling to Plan and Execute Quasi-Experimental Studies – An Example from Hearing Loss

Annie N. Simpson and Kit N. Simpson

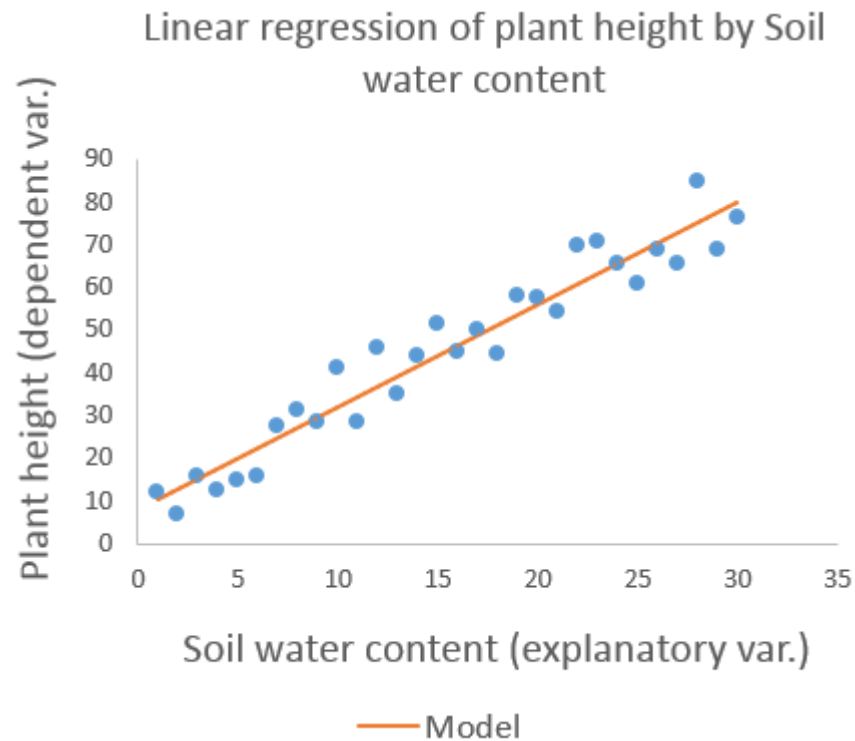Department of Healthcare Leadership and Management
Department of Otolaryngology-Head and Neck Surgery
Medical University of South Carolina
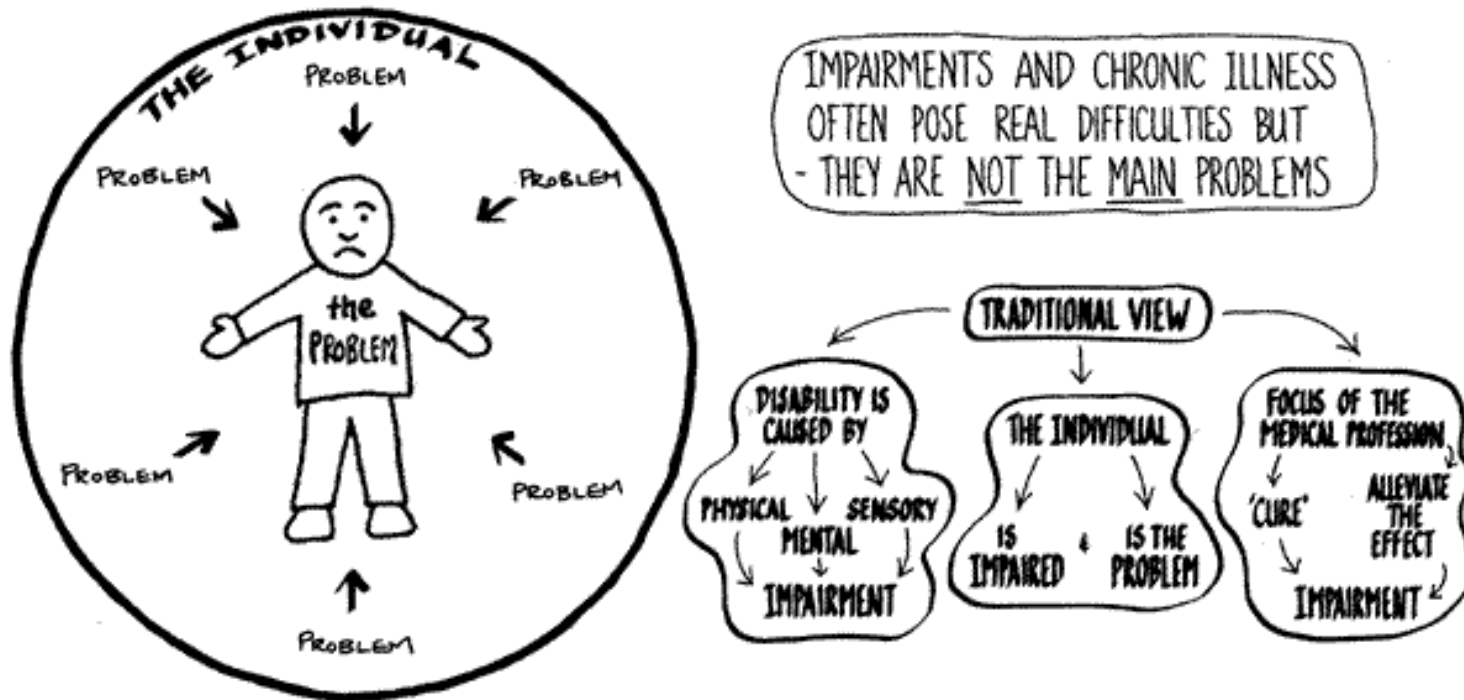Charleston, South Carolina

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HEARING
RESEARCH
PROGRAM

A Statistical Model –
A Mathematical Formulaic Model

Linear regression of plant height by Soil water content

The Classical Medical Model – A Theoretical Framework

THE MEDICAL MODEL OF DISABILITY

THE INDIVIDUAL
PROBLEM
PROBLEM
PROBLEM
PROBLEM
PROBLEM
PROBLEM
PROBLEM
the PROBLEM

IMPAIRMENTS AND CHRONIC ILLNESS OFTEN POSE REAL DIFFICULTIES BUT - THEY ARE NOT THE MAIN PROBLEMS

TRADITIONAL VIEW

DISABILITY IS CAUSED BY
PHYSICAL   SENSORY
MENTAL
IMPAIRMENT

THE INDIVIDUAL
IS IMPAIRED & IS THE PROBLEM

FOCUS OF THE MEDICAL PROFESSION
'CURE'   ALLEVIATE THE EFFECT
IMPAIRMENT

An Alternative Framework

THE SOCIAL MODEL OF DISABILITY

SOCIETY

BARRIERS · BARRIERS · BARRIERS · BARRIERS · BARRIERS · BARRIERS

SOCIAL 'BARRIERS'

ENVIRONMENT
INACCESSIBLE
BUILDINGS / LANGUAGE
SERVICES COMMUNICATION

ATTITUDES
PREJUDICE
STEREOTYPING
DISCRIMINATION

ORGANISATIONS
INFLEXIBLE
PROCEDURES PRACTICES
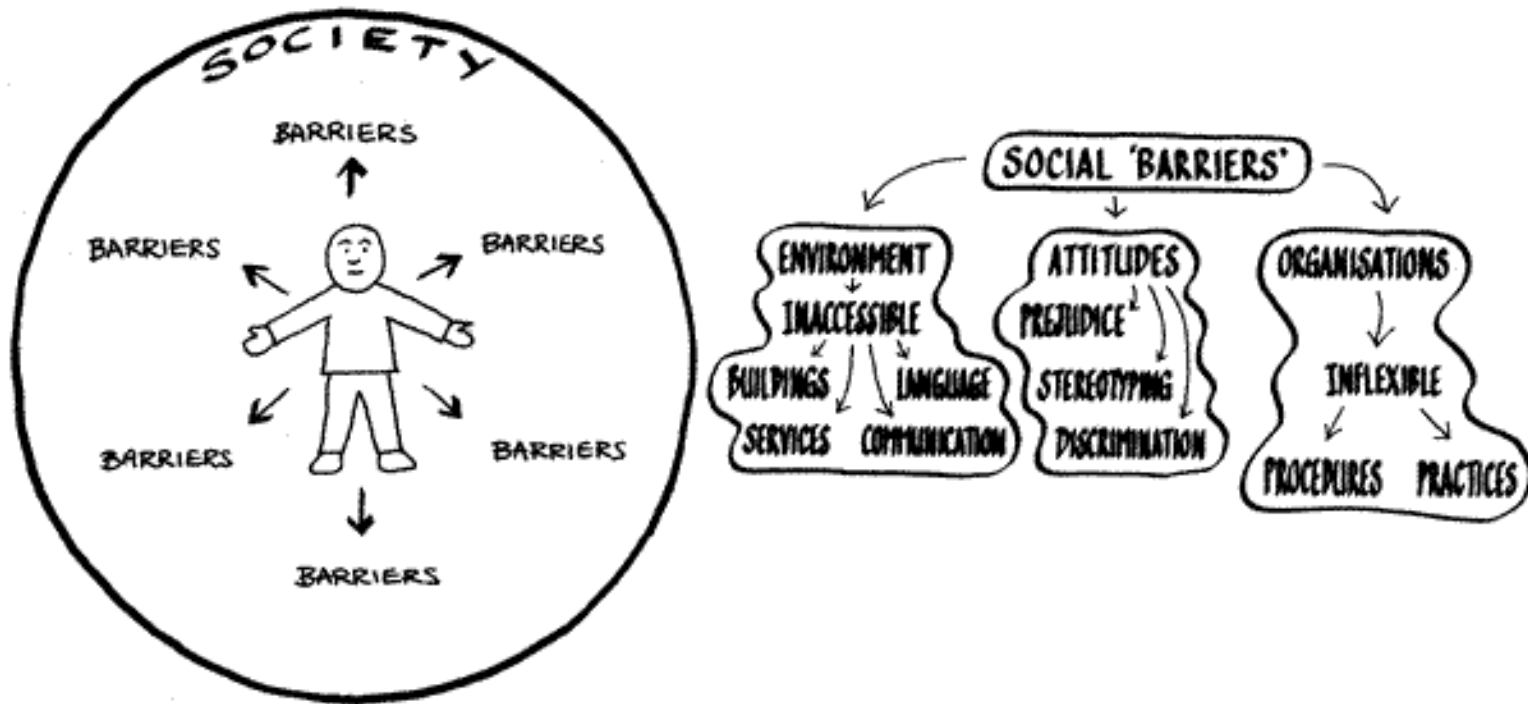
Model: The International Classification of Functioning, Disability and Health (ICF)
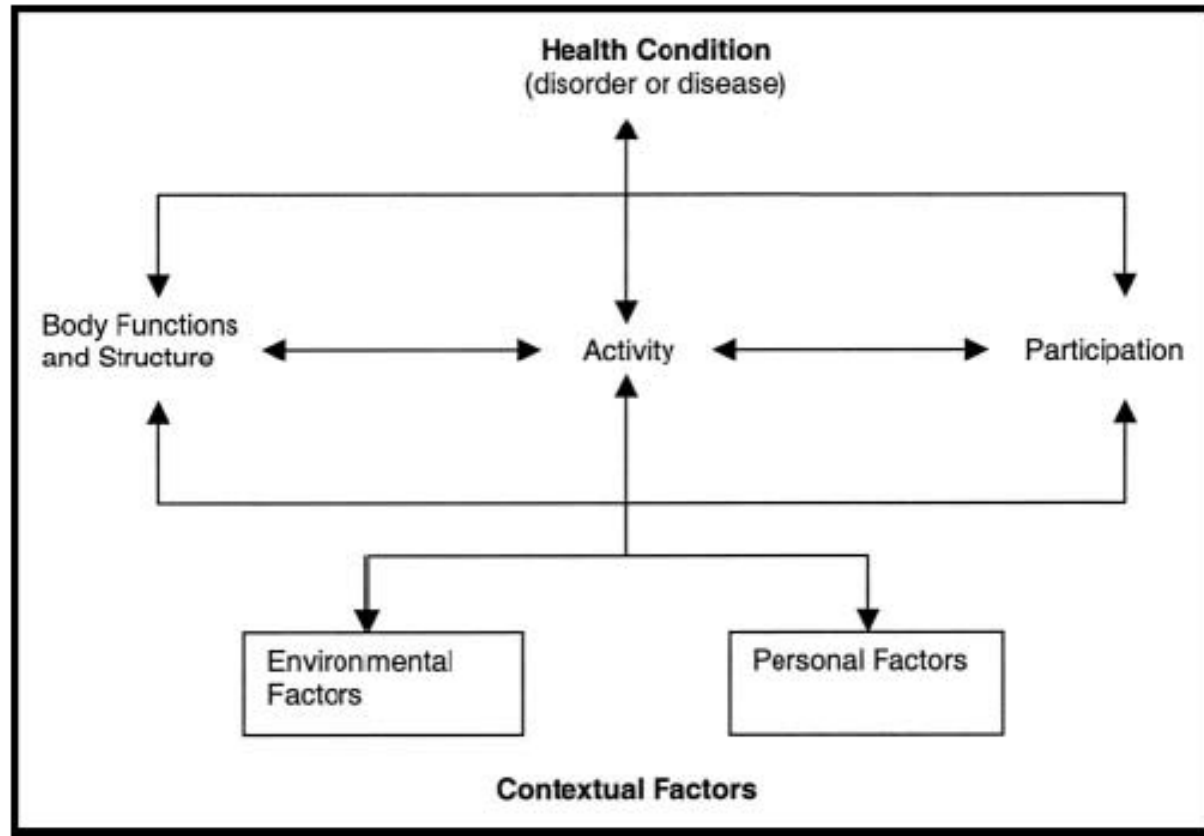
# Differences between Theoretical Framework/Models and Conceptual Models?

Conceptual Framework/Model

- This consists of concepts that are placed within a logical and sequential design
- Represents less formal structure and used for studies in which existing theory is inapplicable or insufficient
- Based on specific concepts and propositions, derived from empirical observation and intuition
- May deduce theories from a conceptual framework

Purposes of Conceptual Framework
- To clarify concepts and propose relationships among the concepts in a study
- To provide a context for interpreting the study findings
- To explain observations
- To encourage theory development that is useful to practice

Andersen Healthcare Utilization Model
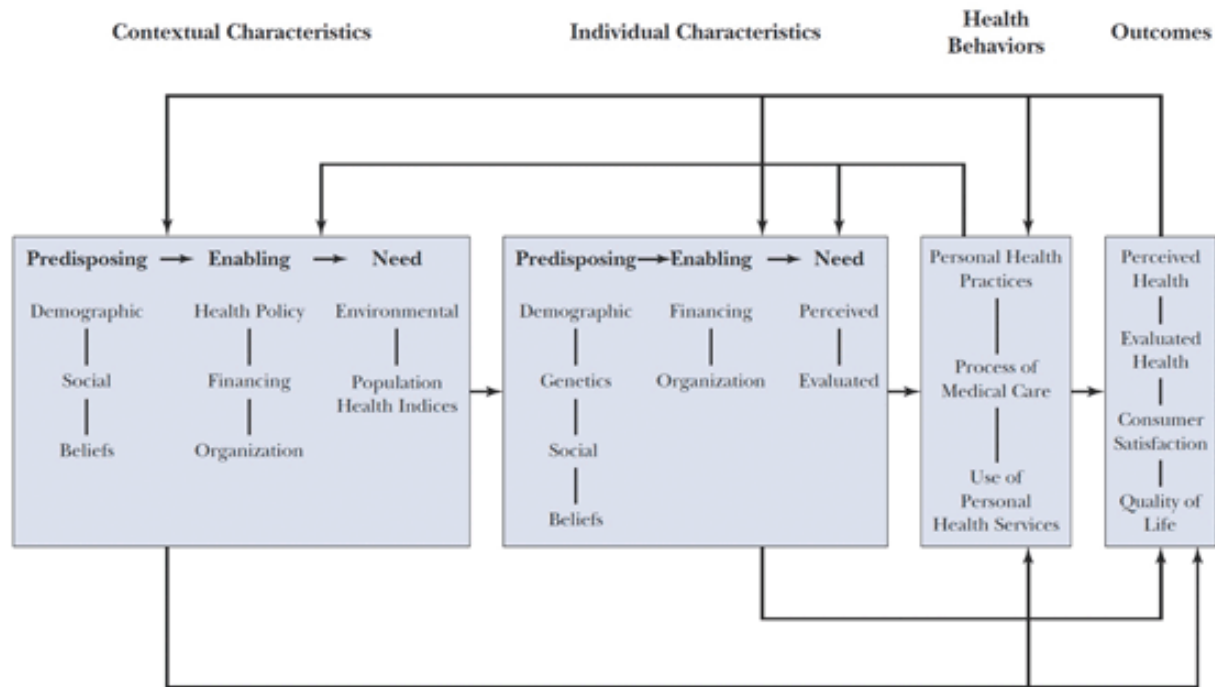
Sources: Andersen RM, Davidson PL, Baumeister SE. Improving access to care in America. In: Kominski EF, editor. Changing the U.S. health care system: key issues in health services, policy, and management. 4th edition. San Francisco, CA: Jossey-Bass; 2013. p. 33–69.
Andersen, Ronald (1995). "Revisiting the behavioral model and access to medical care: does it matter?". J Health Soc Behav. *36* (1): 1–10. doi:10.2307/2137284. PMID 7738325.
Aday, Lu Ann; Andersen R (1974). "A framework for the study of access to medical care". Health Serv Res. *9* (3): 208–20.

# Donabedian's Quality Improvement Model

Structure

- Physical and organisational characteristics where health care occurs

Process

- Focus on the care delivered to patients (e.g. services or treatments)

Outcome

- Effect of health care on the status of patients and populations

Sources: *Donabedian, A. (1988). "The quality of care: How can it be assessed?". JAMA. **260** (12): 1743–8. Donabedian, A (2005). "Evaluating the quality of medical care. 1966". The Milbank quarterly. **83** (4): 691–729.*

Adapted Conceptual Model Based on the EPIS Framework of Implementation and Dissemination

Figure 2: EPIS Model adapted to ICU Innovations
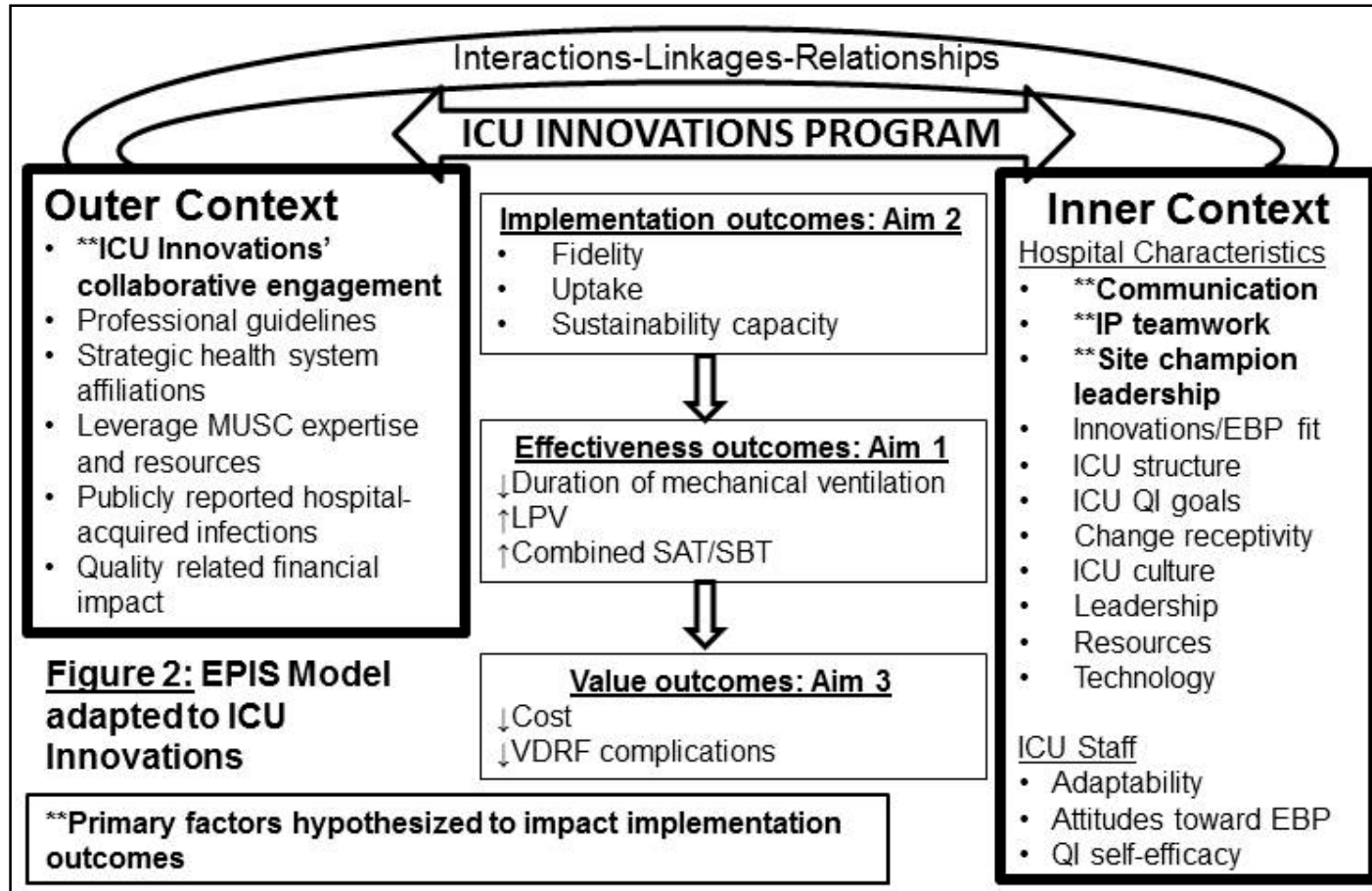
Sources: Aarons GA, Hurlburt M, Horwitz SM. Advancing a conceptual model of evidence-based practice implementation in public service sectors. Administration and policy in mental health. 2011;38(1):4-23. Epub 2011/01/05. doi: 10.1007/s10488-010-0327-7. PubMed PMID: 21197565; PMCID: Pmc3025110.
Aarons GA, Green AE, Willging CE, Ehrhart MG, Roesch SC, Hecht DB, Chaffin MJ. Mixed-method study of a conceptual model of evidence-based intervention sustainment across multiple public-sector service settings. Implement

Most Common Chronic Conditions, by Age and Gender

	MALE	FEMALE
ALL AGES	• Orthopedic impairments • Sinusitis • Hearing impairments • Hypertension • Hay Fever	• Sinusitis • Arthritis • Orthopedic impairments • Hypertension • Hay Fever
0–17	• Asthma • Hay Fever • Sinusitis • Bronchitis • Dermatitis	• Sinusitis • Asthma • Hay Fever • Bronchitis • Dermatitis
18–44	• Orthopedic impairments • Sinusitis • Hay Fever • Hearing impairments • Hypertension	• Sinusitis • Orthopedic impairments • Hay Fever • Migraine • Asthma
45–74	• Hypertension • Arthritis • Hearing impairments • Orthopedic impairments • Heart Disease	• Arthritis • Hypertension • Sinusitis • Orthopedic impairments • Hay Fever
75+	• Hearing impairments • Arthritis • Heart Disease • Hypertension • Cataracts	• Arthritis • Hypertension • Hearing impairments • Heart Disease • Cataracts

SOURCE: *National Academy on an Aging Society analysis of National Health Interview Survey data.*

- Hearing loss is one of the most common chronic health conditions, especially among older adults

- Affects ~360 million people worldwide

- Affects >60% of US adults over age 70

- Associated with decreased quality of life, and increased risk of hospitalization and functional and cognitive declines.

- Little is known about the impact of HL on healthcare use and cost

Figure 1: Conceptual Model of the Effects of HL
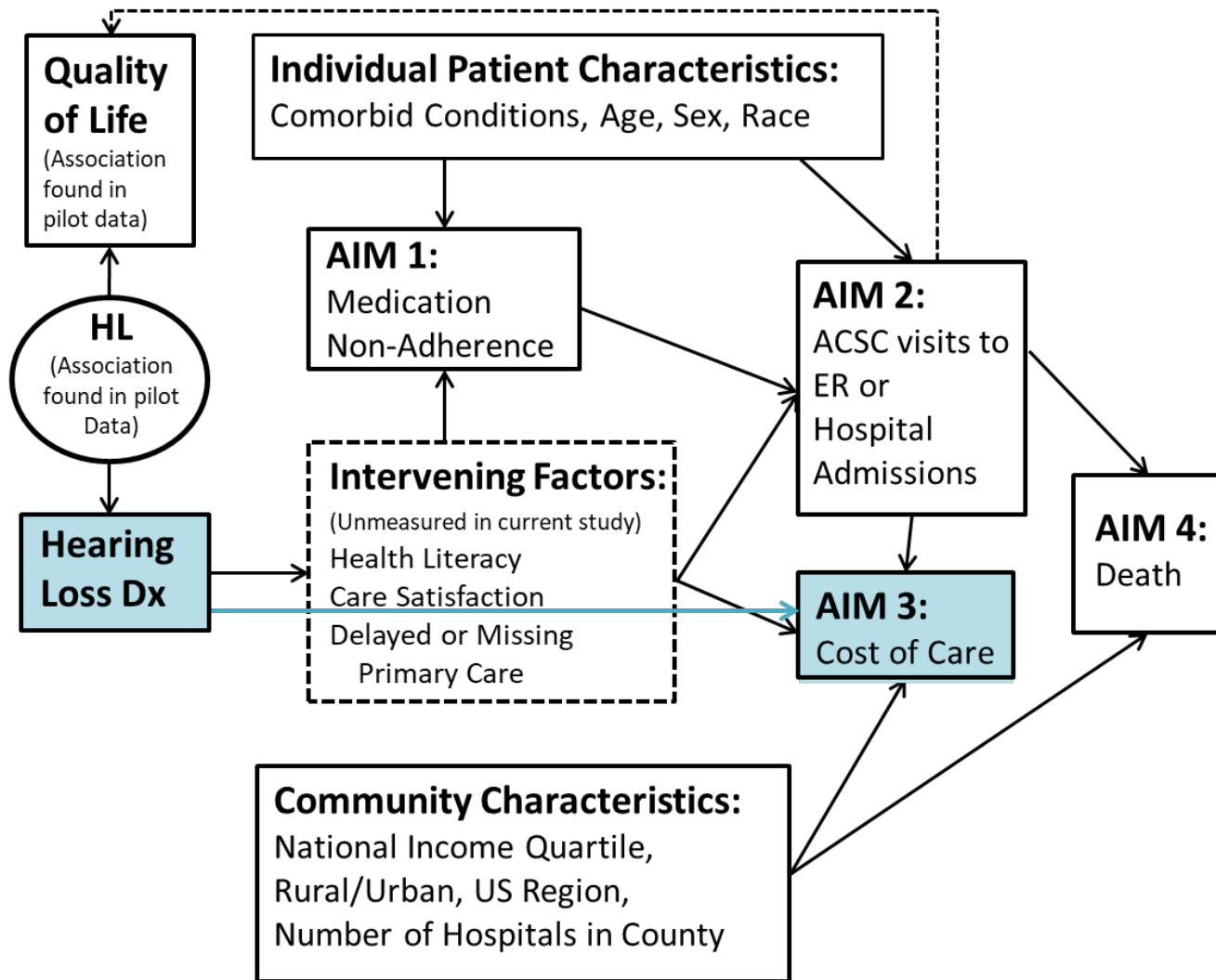
Simpson AN, Simpson KN, Dubno JR. Higher Health Care Costs in Middle-aged US Adults With Hearing Loss. JAMA Otolaryngol Head Neck Surg 2016;142:607-609.

Study Design

- 2 cohorts of patients over age 65
- ICD-9 code of HL (V41.2, V72.1x, 388.00, 388.01, 388.40, 388.43, 388.44, 388.5, 389.1x, 389.2x)
- Baseline Matching based on 6 months of bills prior to index date
- Included only individuals
  - with at least 18 months of continuous insurance coverage
  - > 65 years of age
- Excluded individuals with diagnoses of late effects of stroke, coma or paralysis

Defining "Cost" and Comparison Groups

- Healthcare bills (provider plus any out-of-pocket) up to 18-months post index were summed by patient to calculate total payments for:
  *inpatient   *prescription medication
  *Outpatient   *cost of hearing services (HS)
- Three Comparison Groups
  - Individuals with no hearing loss diagnosis
  - Individuals with hearing loss:
    - With Hearing Services were defined for bills with ICD-9 procedure codes 9548, 69710, 69711, V532, V5014, V5267, V5298, V5010, V5011, or V5275.
    - Without Hearing Services

2 Cohorts plus 1 Subgroup

- First cohort: Medicare plus Supplemental privately insured individuals (MS) was extracted using the 2009-2013 Market Scan® data base
- Second cohort: Medicare (M5%) extracted from the 2012-2013 Medicare Limited Data Set standard analytic files (SAF) National 5% sample, Medicare as primary insurance.
- Subgroup: Dually eligible (DE) Medicare/Medicaid. A subgroup of the Medicare group who were dually eligible for Medicaid.

Table 1. Patient Descriptive Characteristics

	MS		M5%		DE	
	Hearing Loss (n= 391,108)	No Hearing Loss (n = 391,108)	Hearing Loss (n = 75,148)	No Hearing Loss (n = 75,148)	Hearing Loss (n = 8,729)	No Hearing Loss (n = 8,509)
Age, m(sd)	75.9 (7.8)	75.9 (7.8)	77.1 (8.0)	77.0 (7.9)	79.0 (8.2)	78.6 (8.1)
Charlson Score, m(sd)	0.1 (0.4)	0.1 (0.4)	0.2 (0.7)	0.1 (0.7)	0.3 (1.0)	0.2 (0.9)
Follow Up Days, m(sd)	540.0 (29.3)	537.5 (33.2)	191.1 (59.1)	195.2 (67.0)	199.5 (76.1)	203.7 (82.0)
Sex						
Male	192,038 (49.1)	194,133 (49.6)	29,221 (38.9)	29,265 (38.9)	2,343 (26.8)	2,298 (27.0)
Female	199,070 (50.9)	196,975 (50.4)	45,927 (61.1)	45,883 (61.1)	6,386 (73.2)	6,211 (73.0)
White Race	NA	NA	66,669 (88.7)	66,958 (89.1)	5,304 (60.8)	5,288 (62.2)
Hearing Services	109,968 (28.1)	0 (0.0)	2,873 (3.8)	0 (0.0)	262 (3.0)	0 (0.0)
Chronic Conditions						
Hypertension	51,411 (13.1)	48,711 (12.5)	47,346 (63.0)	47,647 (63.4)	6,506 (74.5)	6,339 (74.5)
Diabetes	21,520 (5.5)	20,538 (5.3)	20,147 (26.8)	20,222 (26.9)	3,398 (38.9)	3,238 (38.1)
CondHF	16,499 (4.2)	15,146 (3.9)	16,504 (22.0)	16,431 (21.9)	2,058 (23.6)	1,890 (22.2)
Heart Valve	8,802 (2.6)	7,737 (2.0)	8,364 (11.1)	8,051 (10.7)	1,005 (11.5)	905 (10.6)
COPD	8,522 (2.2)	7,561 (1.9)	7,958 (10.6)	8,016 (10.7)	1,405 (16.1)	1,335 (15.7)
CHF	4,195 (1.1)	3,518 (0.9)	5,545 (7.4)	5,237 (7.0)	1,229 (14.1)	1,034 (12.2)
PHD	1,024 (0.3)	845 (0.2)	1,551 (2.1)	1,366 (1.8)	178 (2.0)	153 (1.8)
Asthma	4,943 (1.3)	4,313 (1.1)	3,946 (5.3)	3,930 (5.2)	624 (7.2)	584 (6.9)
Diverticulitis	4,625 (1.2)	4,213 (1.1)	4,082 (5.4)	4,026 (5.4)	410 (4.7)	374 (4.4)
CRF	3,791 (1.0)	3,467 (0.9)	4,889 (6.5)	4,691 (6.2)	819 (9.4)	717 (8.4)
Dementia	2,827 (0.7)	2,473 (0.6)	4,428 (5.9)	4,250 (5.7)	1,254 (14.4)	1,103 (13.0)
RA	2,082 (0.5)	1,778 (0.5)	1,947 (2.6)	1,880 (2.5)	275 (3.2)	246 (2.9)
Carditis	1,909 (0.5)	1,550 (0.4)	1,829 (2.4)	1,702 (2.3)	222 (2.5)	187 (2.2)
Epilepsy	888 (0.2)	731 (0.2)	846 (1.1)	793 (1.1)	181 (2.1)	167 (2.0)
Parkinson's	833 (0.2)	700 (0.2)	902 (1.2)	897 (1.2)	167 (1.9)	148 (1.7)
SLE	688 (0.2)	620 (0.2)	633 (0.8)	602 (0.8)	55 (0.6)	53 (0.6)
Hepatitis	382 (0.1)	334 (0.1)	490 (0.7)	390 (0.5)	156 (1.8)	110 (1.3)
MS	193 (0.1)	174 (0.0)	84 (0.1)	81 (0.1)	9 (0.1)	5 (0.1)
Schizophrenia	104 (0.0)	82 (0.0)	192 (0.3)	153 (0.2)	113 (1.3)	93 (1.1)
HIV	62 (0.0)	43 (0.0)	46 (0.0)	35 (0.0)	13 (0.2)	13 (0.2)
CF	12 (0.0)	10 (0.0)	10 (0.0)	8 (0.0)	1 (0.0)	2 (0.0)
SCA	12 (0.0)	12 (0.0)	9 (0.0)	8 (0.0)	2 (0.0)	0 (0.0)

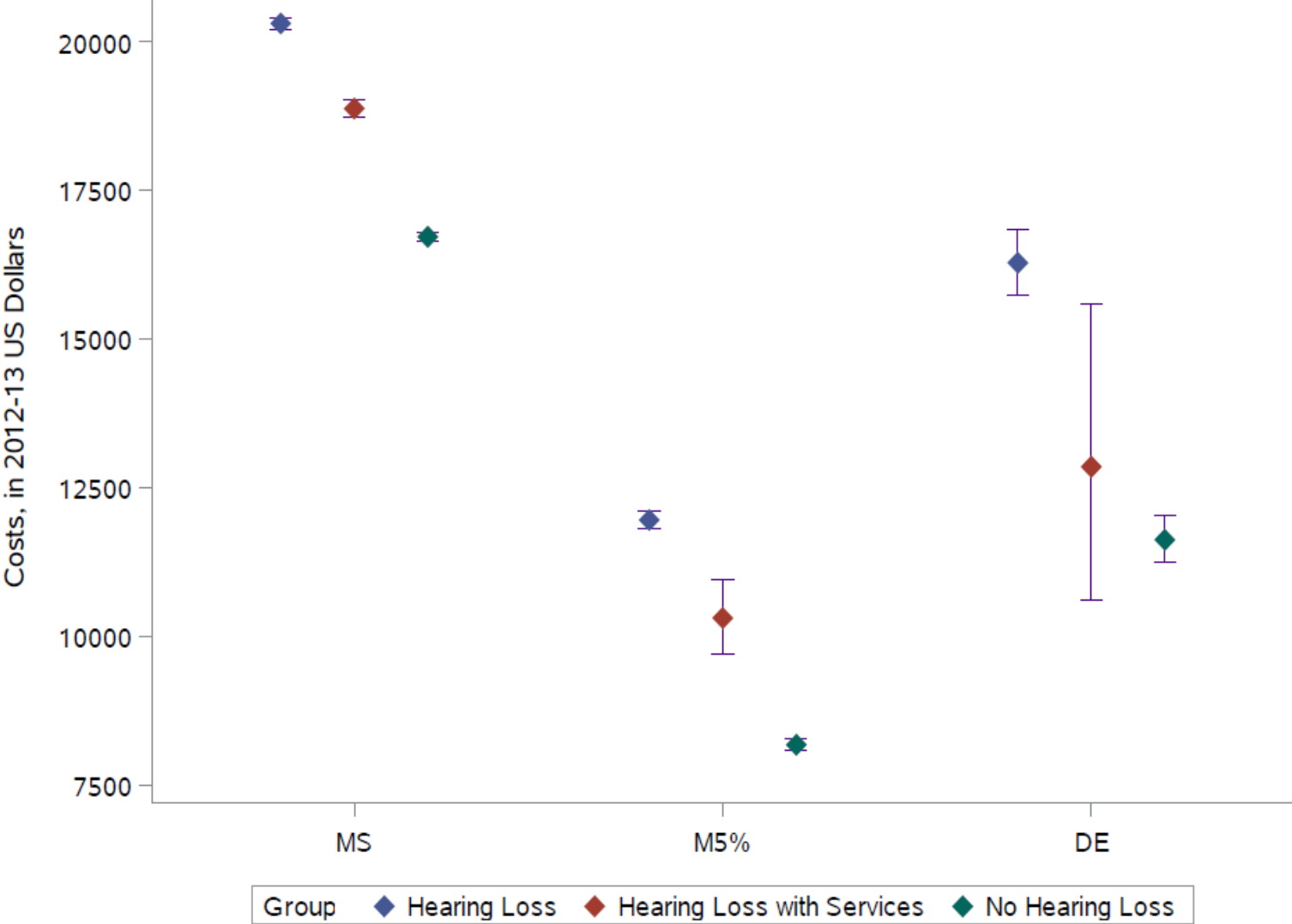# Table 2. Adjusted 18-month Total Healthcare Payments by Hearing Loss[†]

	Adjusted Mean (95% Confidence Interval), $		
	Hearing Loss	Hearing Loss with Hearing Services	No Hearing Loss
MS*	20,304 (20,211-20,398)	18,873 (18,735-19,012)	16,717 (16,652-16,782)
M5%**	11,957 (11,815-12,101)	10,309 (9,713-10,942)	8,178 (8,083-8,275)
DE**	16,281 (15,737-16,843)	12,850 (10,599-15,579)	11,624 (11,237-12,024)

*Includes prescription payments; **Payments do not include prescription medication.
[†]Estimates are adjusted for age, sex, race (when available), Charlson Score, HS use, time in study and 22 chronic conditions.
All p-values <0.001 within cohort.

Comparison of Adjusted Mean Costs by Hearing Loss
(Point Estimate and 95% CI)

Figure 1. Adjusted 18-month Total Healthcare Payments by Hearing Loss
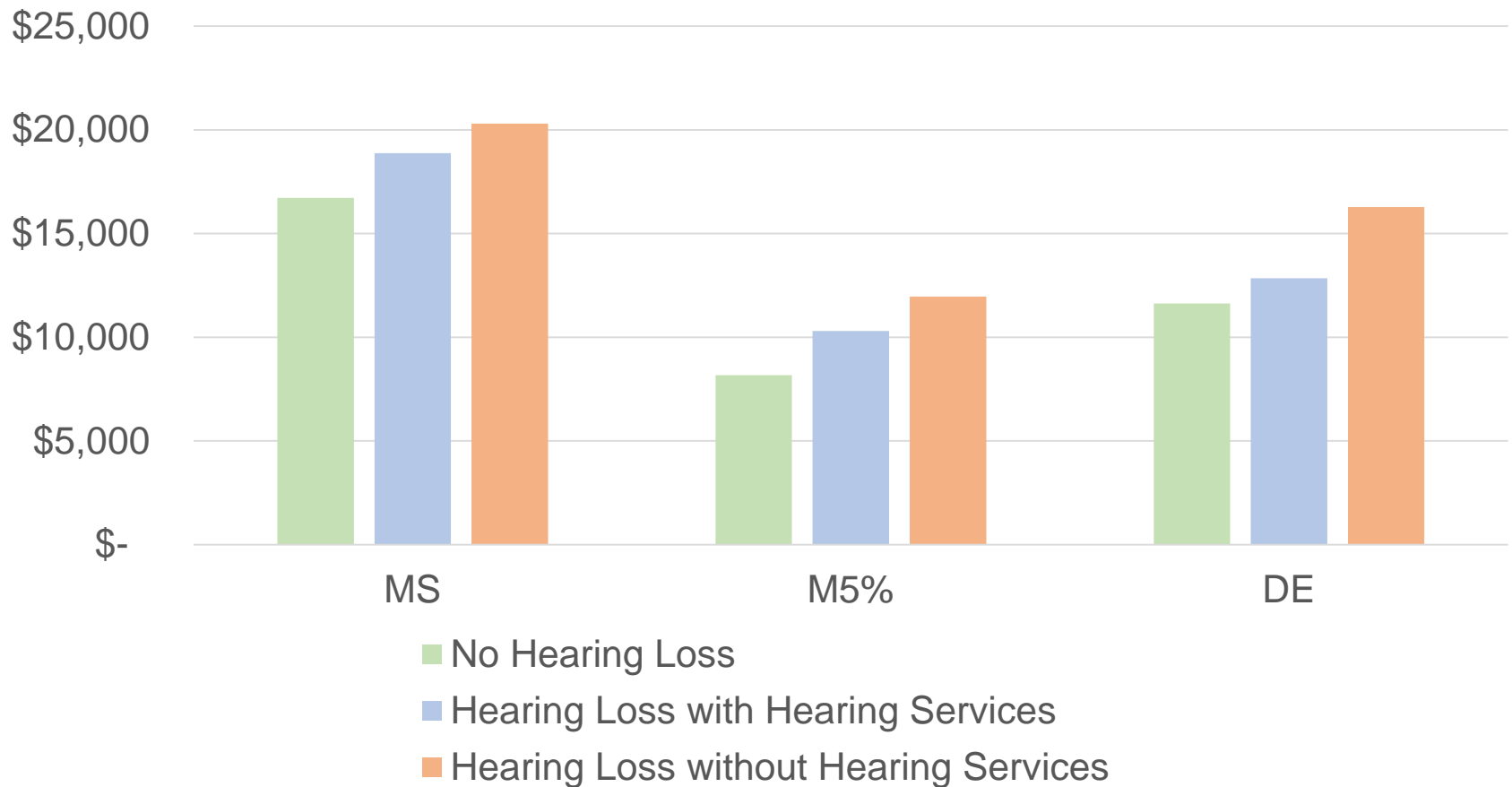
Principal Findings

- Study Goal: Compare the average healthcare costs in US older adults with and without hearing loss

- Multiple data sources enables us to examine health care cost for Medicare patients who have substantially different levels of financial resources

- After propensity score matching and covariate adjustment, we observed >20% higher payments over a 1.5-year time period for a group of insured patients with HL
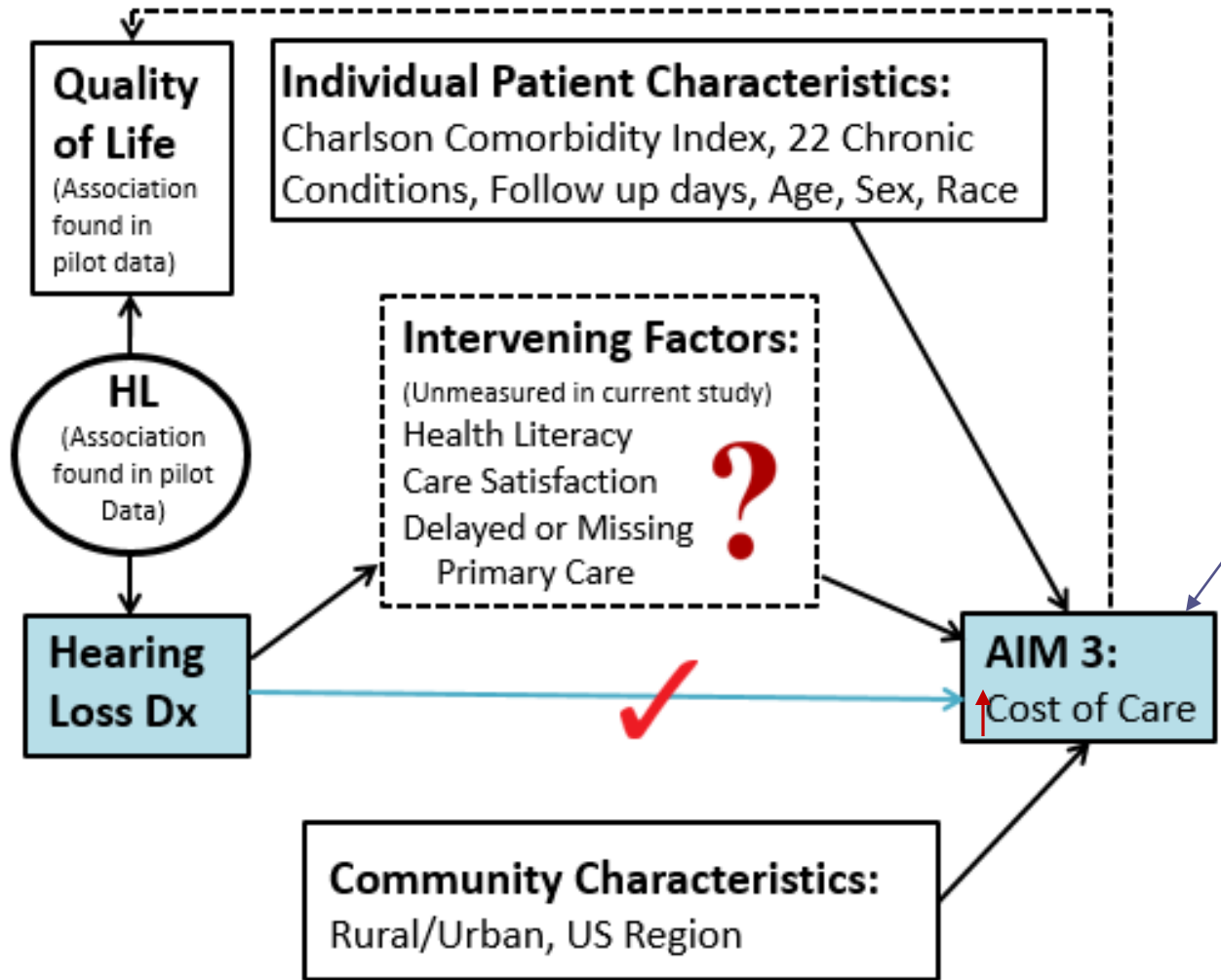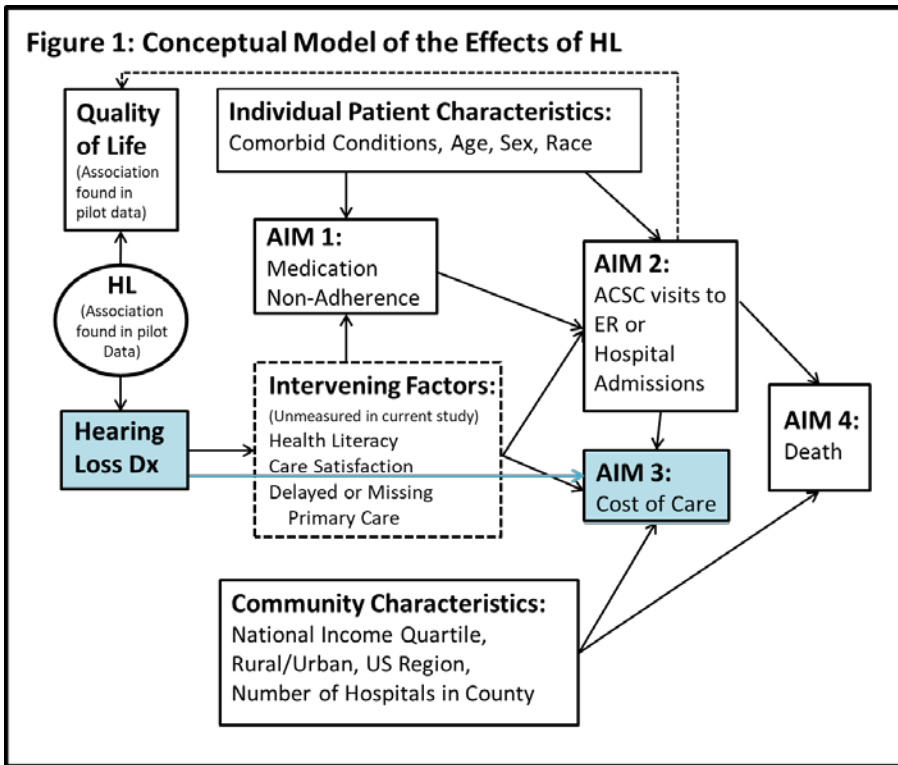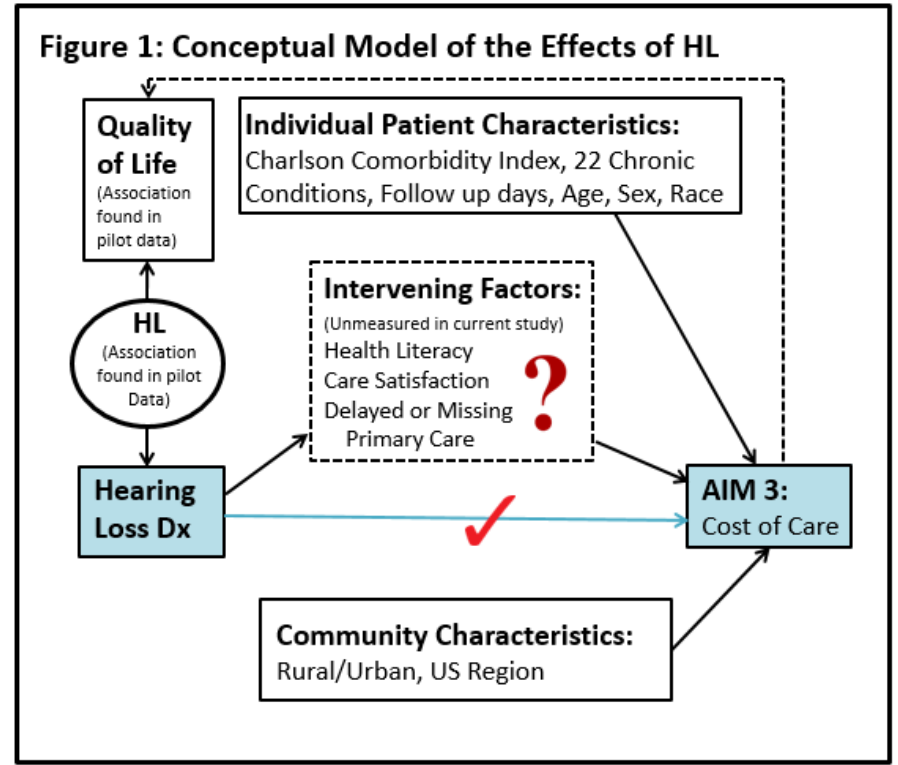
Figure 1: Conceptual Model of the Effects of HL

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Limitations

- This study is limited by:
    - The lack of audiometry confirmation of HL
    - Inability to differentiate between successful HL interventions and failed interventions
- Residual selection bias may remain due to unmeasured variables
- Billing data contain coding errors and variation
- Billing data contain limited clinical information

Acknowledgements

Medical University of South Carolina
Departments of Healthcare Leadership and Management and Otolaryngology-Head and Neck Surgery

For more information contact Annie Simpson:

simpsona@musc.edu

Conclusions

- All three data sets defined by patients' insurance type;
  - patient with untreated HL had the highest cost, followed by patients with treated HL, with patients without HL have lowest cost
- MS cohort had the highest means cost (Drug Costs)
- M5% cohort had the lowest cost
- DE group (poorest patients), had consistently ↑costs across the HL categories, and marginal cost difference between the treated and the untreated HL group
  - Economic effect of untreated HL may be exacerbated by poverty

Discussion and Policy Implications

- Findings consistent with earlier cost study in Adults 55-64 years of age (Simpson).
- Supported by study finding increased hospitalization risk in people with hearing loss (Genther).
- No Medicare coverage for hearing aids, nor for most hearing services
- Private insurance and Medicaid has limited hearing coverage
- Medicaid coverage varies widely by state

Procedure Codes for Hearing Services

- 9548 – Fitting of Hearing Aid
- 69710 – Surgical Procedures on the Middle Ear
- 69711 – Other Procedures on the Middle Ear
- V532 – Adjustment Hearing Aid
- V5014 – Repair/Modification Hearing Aid
- V5267 - Hearing aid or assistive listening device/supplies/accessories
- V5298 – Hearing Aid not otherwise classified
- V5010 – Assessment for Hearing Aid
- V5011 - Fitting/orientation/checking of hearing aid
- V5275 – Ear impression

Diagnosis Codes for Hearing Loss

- V41.2 – Problems with hearing
- V72.1x – Examination of Ears and Hearing

388 Other Disorders of the Ear

- 388.00 – Degenerative and vascular disorders
- 388.01 – Presbyacusis
- 388.40 – Abnormal Auditory Perception
- 388.43 – Impairment of Auditory Descrimination
- 388.44 – Auditory Recruitment
- 388.5 – Disorders of Acustic Nerve

389 Hearing Loss

- 389.1x – Sensorineural Hearing Loss
- 389.2x - Mixed conductive and sensorineural hearing loss