CEA Fundamentals: Valuing Costs

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Learning Objectives and Outline

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Learning Objectives

- Identify theoretical and methodological differences between different economic evaluation techniques
- Grasp the foundations of cost-effectiveness analysis
- Describe the steps of valuing costs in economic evaluations & identify ways to curate cost parameters

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Outline

1. Introduction to economic evaluations
2. Valuing costs

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Introduction to economic evluations

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So far...

We've touched on the basic framework for decision analysis, focusing on:

- Decision trees & probabilities
- Bayes theorem & probability revision
- Constructing decision trees using Amua

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Today…

- We will touch on some of the core concepts for representing costs and health benefits within decision problems

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Economic Evaluation

- Relevant when decision alternatives have different costs and health consequences.
- We want to measure the relative value of one strategy in comparison to others.
- This can help us make resource allocation decisions in the face of constraints (e.g., budget).

Balancing $$ and health outcomes

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Features of Economic Evaluation

- Systematic quantification of costs and consequences.
- Comparative analysis of alternative courses of action.

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Techniques for Economic Evaluation

Type of study	Measurement/valuation of costs	Identification of consequences	Measurement / valuation of consequences
Cost analysis	Monetary units	None	None

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Cost analysis

- Only looks at healthcare costs
- Relevant when alternative options are equally effective (provide equal benefits)
  - Rarely the case in reality!
- Costs are valued in monetary terms (e.g., U.S. dollars)
- Decision criterion: often to minimize cost

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Techniques for Economic Evaluation

Type of study	Measurement/Valuation of costs	Identification of consequences	Measurement / valuation of consequences
Cost analysis	Monetary units	None	None
Cost-effectiveness analysis	Monetary units	Single effect of interest, common to both alternatives, but achieved to different degrees.	Natural units (e.g., life-years gained, disability days saved, points of blood pressure reduction, etc.)

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Cost-Effectiveness Analysis (CEA)

> Most useful when decision makers consider multiple options within a budget, and the relevant outcome is common across strategies

- Costs are valued in monetary terms ($)
- Benefits are valued in terms of clinical outcomes (e.g., cases prevented or cured, lives saved, years of life gained)
- Results reported as a cost-effectiveness ratio

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Cost-Effectiveness Analysis

- Suppose we are interested in the prolongation of life after an intervention.
- Outcome of interest: life-years gained.
- The outcome is common to alternative strategies; they differ only in the magnitude of life-years gained.
- We can report results in terms of $/Life-years gained

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Techniques for Economic Evaluation

Type of study	Measurement/Valuation of costs both alternative	Identification of consequences	Measurement / valuation of consequences
Cost analysis	Monetary units	None	None
Cost-effectiveness analysis	Monetary units	Single effect of interest, common to both alternatives, but achieved to different degrees.	Natural units (e.g., life-years gained, disability days saved, points of blood pressure reduction, etc.)
Cost-utility analysis	Monetary units	Single or multiple effects, not necessarily common to both alternatives.	Healthy years (typically measured as quality-adjusted life-years)

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Cost-Utility Analysis

- Essentially a variant of cost-effectiveness analysis.
- **Major feature:** use of summary measure of health: **QALY**.
- Quality-Adjusted Life Year (QALY): A metric that reflects both changes in life expectancy and quality of life (pain, function, or both).
- By far the most widely published form of economic evaluation.

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Techniques for Economic Evaluation

Type of study	Measurement/Valuation of costs both alternative	Identification of consequences	Measurement / valuation of consequences
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Cost-utility analysis	Monetary units	Single or multiple effects, not necessarily common to both alternatives.	Healthy years (typically measured as quality-adjusted life-years)
Cost-benefit analysis	Monetary units	Single or multiple effects, not necessarily common to both alternatives	**Monetary units**

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Cost-Benefit Analysis

- Also known as Benefit-Cost Analysis
- Relevant for resource allocation between health care and other areas (e.g., education)
- **Costs and health consequences are valued in monetary terms (e.g., U.S. dollars)**
- Valuation of health consequences in monetary terms ($) is obtained by estimating individuals willingness to pay for life saving or health improving interventions.
  - e.g. US estimate of value per statistical life ~$9 million
- Cost-benefit criterion: the benefits of a program > its costs
  - Notice that we're not making comparisons *across* strategies–only comparisons of costs and benefits for the same strategy
- To read more: Robinson et al, 2019

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Cost-Benefit Analysis

Preventing deaths and injuries from house fires: a cost–benefit analysis of a community-based smoke alarm installation programme

Merissa A Yellman,[1] Cora Peterson,[2] Mary A McCoy,[1] Shelli Stephens-Stidham,[1] Emily Caton,[3] Jeffrey J Barnard,[4] Ted O Padgett Jr,[3] Curtis Florence,[2] Gregory R Istre[1]

ABSTRACT

Background Operation Installation (OI), a community-based smoke alarm installation programme in Dallas, Texas, targets houses in high-risk urban census tracts. Residents of houses that received OI installation (or programme houses) had 68% fewer medically treated house fire injuries (non-fatal and fatal) compared with residents of non-programme houses over an average of 5.2 years of follow-up during an effectiveness evaluation conducted from 2001 to 2011.

Objective To estimate the cost–benefit of OI.

significant resources, including supplies and personnel costs. One previous economic evaluation of a distribution programme by fire professionals and volunteers going door-to-door in high-risk areas of Oklahoma City (distribution in 1990 of 10 100 alarms to 9291 homes, injury outcomes observed over subsequent five years) reported favourable cost-effectiveness results.[9] Two studies modelled distribution programmes in hypothetical high-risk communities and reported favourable cost-effectiveness results for both giveaway and installa-

https://pubmed.ncbi.nlm.nih.gov/28183740/

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Cost-Benefit Analysis

Maureen L. Cropper*, Sarath Guttikunda, Puja Jawahar,
Zachary Lazri, Kabir Malik, Xiao-Peng Song and Xinlu Yao

Applying Benefit-Cost Analysis to Air Pollution Control in the Indian Power Sector

Abstract: Air pollution is a persistent and well-established public health problem in India: emissions from coal-fired power plants have been associated with over 80,000 premature deaths in 2015. Premature deaths could rise by four to five times this number by 2050 without additional pollution controls. We site a model 500 MW coal-fired electricity generating unit at eight locations in India and examine the benefits and costs of retrofitting the plant with a flue-gas desulfurization unit to reduce sulfur dioxide emissions. We quantify the mortality benefits associated with the reduction in sulfates (fine particles) and value these benefits using estimates of the value per statistical life transferred to India from high income countries. The net benefits of scrubbing vary widely by location, reflecting differences in the size of the exposed population. They are highest at locations in the densely populated north of India, which are also among the poorest states in the country.

https://www.cambridge.org/core/product/identifier/S2194588818000271/type/journal_arti

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Back to Cost-Effectiveness Analysis!

- Relevant when healthcare alternatives have different costs & health consequences

$$\frac{\text{Cost (Intervention A) - Cost (Intervention B)}}{\text{Benefit (A) - Benefit (B)}}$$

- Relative VALUE of an intervention in comparison to its alternative is expressed as a cost-effectiveness RATIO (the focus of next lecture!)

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Who uses economic evaluations?

- Health Technology Advisory Committees
  - NICE (The National Institute for Health and Care Excellence, **UK**)
  - **Canada**'s Drug and Health Technology Agency
  - PBAC (Pharmaceutical Benefits Advisory Committee in **Australia**)
  - **Brazil**'s health technology assessment institute
- Groups developing clinical guidelines
  - WHO
  - CDC
  - Disease-specific organizations: American Cancer Society; American Heart Association; European Stroke Organisation
- Regulatory agencies:
  - FDA (U.S. Food and Drug Administration)
  - EPA (U.S. Environmental Protection Agency)

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CEAs: Identifying Alternatives

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Identifying Alternatives

- Decision modeling / economic evaluation requires identifying strategies or alternative courses of action.
- These alternatives could include different therapies / policies / technologies.
- Or, our alternatives could capture different combinations or sequences of treatment (e.g., what dose? what age to start?)

Once we have identified the alternatives, we'll want to quantify their associated consequences in terms of:

- Health outcomes
- Costs

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CEA components

$$\frac{\text{Cost (Intervention A) - Cost (Intervention B)}}{\text{Benefit (A) - Benefit (B)}}$$

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Valuing Costs

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Valuing Costs: Steps

Source: Gold 1996, Drummond 2015, Gray 2012)

1. **Identify** – Estimate the different categories of resources likely to be required (e.g., surgical staff, medical equipment, surgical complications, re-admissions)

2. **Measure** – Estimate how much of each resource category is required (e.g. type of staff performing the surgery and time involved, post-surgery length of stay, re-admission rates)

3. **Value** – Apply unit costs to each resource category (e.g., salary scales from the relevant hospital or national wage rates for staff inputs, cost per inpatient day for the post-surgery hospital stay)

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We can identify different types of healthcare costs

- Direct Health Care Costs
  - Hospital, office, home, facilities
  - Medications, procedures, tests, professional fees
- Direct Non-Health Care Costs
  - Childcare, transportation costs
- Time Costs
  - Patient time receiving care, opportunity cost of time
- Productivity costs ('indirect costs')
  - impaired ability to work due to morbidity?
  - lost economic productivity due to death?
- Unrelated healthcare costs
  - Cumulative trajectory of total healthcare costs over time (unrelated to medical interventions)

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Identifying costs (continued)

- In practice, we count what is likely to matter
  - Exclude what is likely to have little effect or equal effects across alternatives
- Any exclusion must be noted & possible bias examined
- We are constrained by what data are available

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We can measure costs using different approaches

- **Micro-costing (bottom-up)**
  - Measure all resources used by individual patients, then assign the unit cost for each type of resource consumed to calculate the total cost
- **Gross-costing (top-down)**
  - Estimate cost for a given volume of patients by dividing the total cost by the volume of service use
  - Example: Downstream costs (e.g., hospitalization due to opioid overdose)
- **Ingredients-based approach (P x Q x C)**
  - Probability of occurrence (P)
  - Quantity (Q)
  - Unit costs (C)

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Whose perspective?

Table 1. Cost Components Included in the 2 Recommended Reference Case Perspectives

Cost Component	Reference Case Perspective	
	Health Care	Societal
Formal Health Care Sector[a]		
Costs paid by third-party payers	Yes	Yes
Costs paid out-of-pocket by patients	Yes	Yes
Informal Health Care Sector		
Patient-time costs	No	Yes
Unpaid caregiver-time costs	No	Yes
Transportation costs	No	Yes
Non–Health Care Sectors		
Productivity	No	Yes
Consumption	No	Yes
Social services	No	Yes
Legal or criminal justice	No	Yes
Education	No	Yes
Housing	No	Yes
Environment	No	Yes
Other (eg, friction costs)	No	Yes

[a] Includes current and future costs related and unrelated to the condition under consideration.

Sanders GD, Neumann PJ, Basu A, et al. Recommendations for Conduct, Methodological Practices, and Reporting of Cost-effectiveness Analyses: Second Panel on Cost-Effectiveness in Health and Medicine. JAMA. 2016;316:1093–1103.

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Whose perspective?

PERSPECTIVE MATTERS –

> **Formal Healthcare Sector:** Medical costs borne by third-party payers & paid for out-of-pocket by patients. Should include current + future costs, related & unrelated to the condition under consideration

> **Societal perspective:** Represents the wider “public interest” & inter-sectoral distribution of resources that are important to consider - reflects costs on all affected parties

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Whose perspective?

Healthcare sector perspective

MAMMOGRAPHY (Healthcare Sector):

- Costs associated with the screening itself [mammogram procedure + physician time]
- Costs of follow-up tests for both false-positive & true positive results
- Downstream costs (or savings) associated with cases of breast cancer, such as: Hospitalization + treatment costs
- Costs unrelated to medical intervention/disease; of living longer due to mammography

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Whose perspective?

Societal perspective

MAMMOGRAPHY (Societal perspective):

- Costs associated with the screening itself [mammogram procedure + physician time]
- Costs of follow-up tests for both false-positive & true positive results
- Downstream costs (or savings) associated with cases of breast cancer, such as: Hospitalization + treatment costs
- Costs unrelated to medical intervention/disease; of living longer due to mammography
- Patient productivity losses associated with the screening or cancer treatment
- Childcare/transportation costs

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Data collection

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Two approaches:

(1) Alongside **clinical trials**

(2) Using **secondary data**

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Costs (secondary data)

> International versus US will have different approaches

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Costs (International)

1. **In country/hospital/donor data registries** - key is to get as close to the "true" cost associated with each procedure per patient
    - E.g., "TB healthcare & diagnostics are from official price list of the National Health Laboratory Service in South Africa; Costs for follow-up reflect local clinic and culture-based screening for active-tuberculosis"
2. **Review of published literature**
3. **Tufts CEA Registry**
4. **DCP3: Disease Control Priorities**

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Costs (Published Literature)

Cost-effectiveness of post-treatment follow-up examinations and secondary prevention of tuberculosis in a high-incidence setting: a model-based analysis

Florian M Marx, Ted Cohen, Nicolas A Menzies, Joshua A Salomon, Grant Theron, Reza Yaesoubi

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Costs (Published Literature)

	Value	Source
Costs*		
Standard diagnostic evaluation (passive case finding)		
Clinic visit for initial diagnosis (excluding tests)	$14·36	Sinanovic et al (2015)[24]
Xpert MTB/RIF (treatment naive only)	$14·80	NHLS state price list[25]
Mycobacterium tuberculosis culture (treatment experienced only)	$7·58	NHLS state price list[25]
Drug-susceptibility testing	$14·99	NHLS state price list[25]
Smear microscopy	$1·34	NHLS state price list[25]
Chest x-ray	$23·84 (16·22–33·85)	Menzies et al (2012)[15]
Tuberculosis or HIV treatment		
Drug-susceptible tuberculosis, full course	$708·15 (477·30–939·00)	Vassall et al (2011),[26] Pooran et al (2013)[27]
Multidrug-resistant tuberculosis, full course	$5446·85 (3225·68–7669·57)	Vassall et al (2011),[26] Pooran et al (2013)[27]
ART, per month	$151·98 (122·47–184·44)	Menzies et al (2012)[15]
Post-treatment follow-up examination		
Follow-up clinic visit	$6·46	Sinanovic et al (2015)[24]
Mycobacterium tuberculosis culture screening for tuberculosis	$7·58	NHLS state price list[25]
Secondary IPT		
IPT including monthly outpatient follow-up, per year	$20·25 (11·97–34·11)	Kim et al (2018),[28] Johnson et al (2018)[29]
Management of drug-induced liver injury, per event	$35·86 (24·22–90·06)	Kim et al (2018)[28]
7-day hospitalisation costs per severe drug-induced liver injury event	$813·05 (334·60–886·48)	Kim et al (2018)[28]

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Costs (Tufts CEVR)

https://cevr.tuftsmedicalcenter.org/databases/cea-registry

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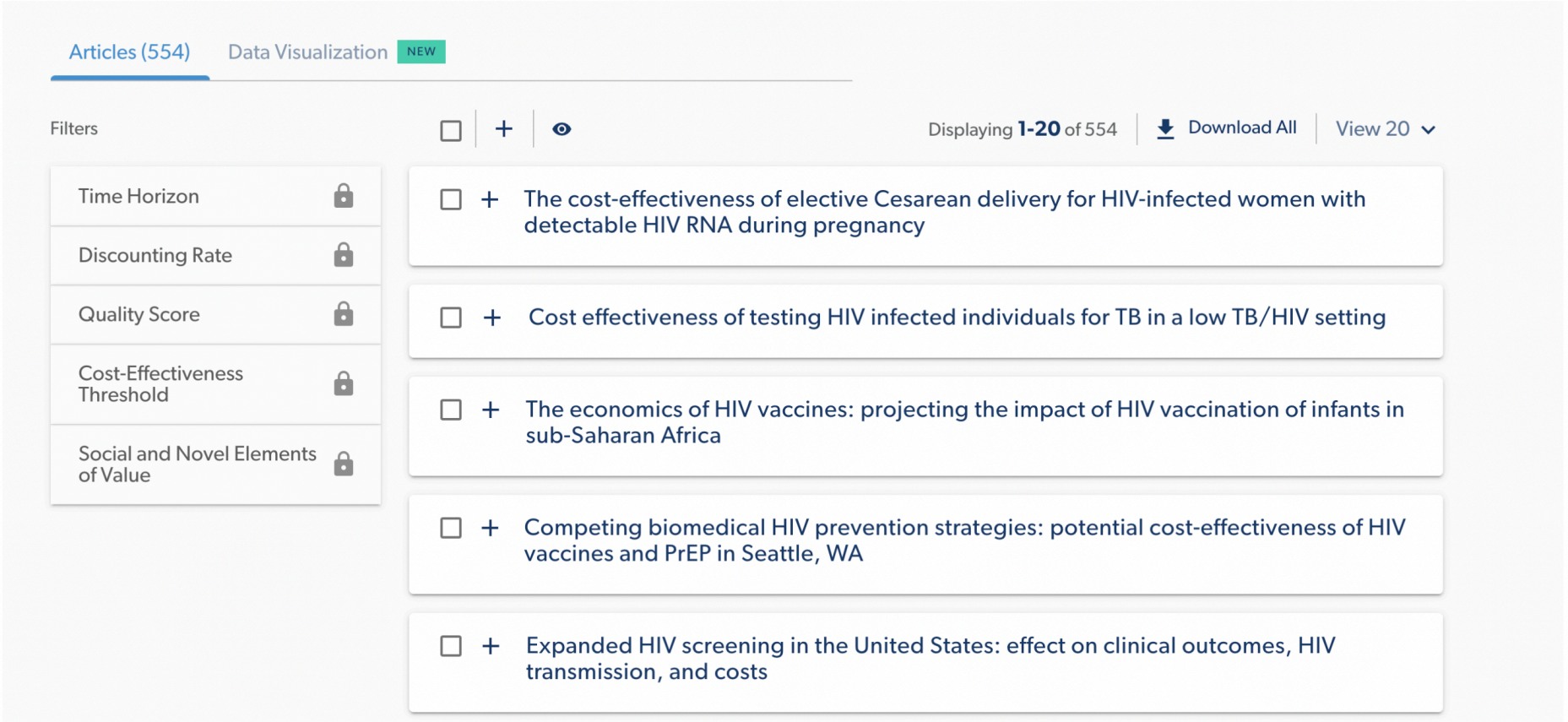
Costs (Tufts CEVR)



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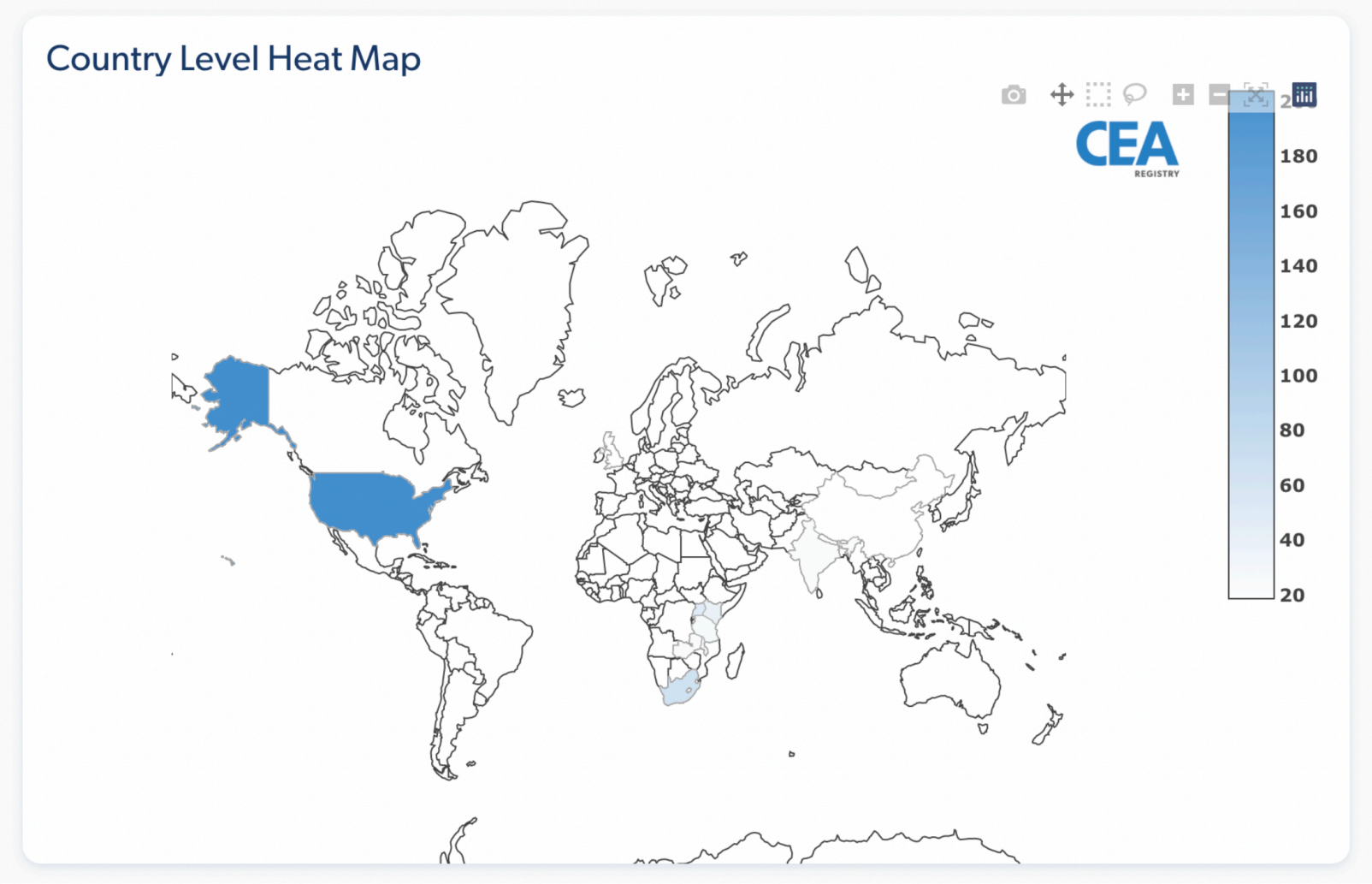
Costs (Tufts CEVR)



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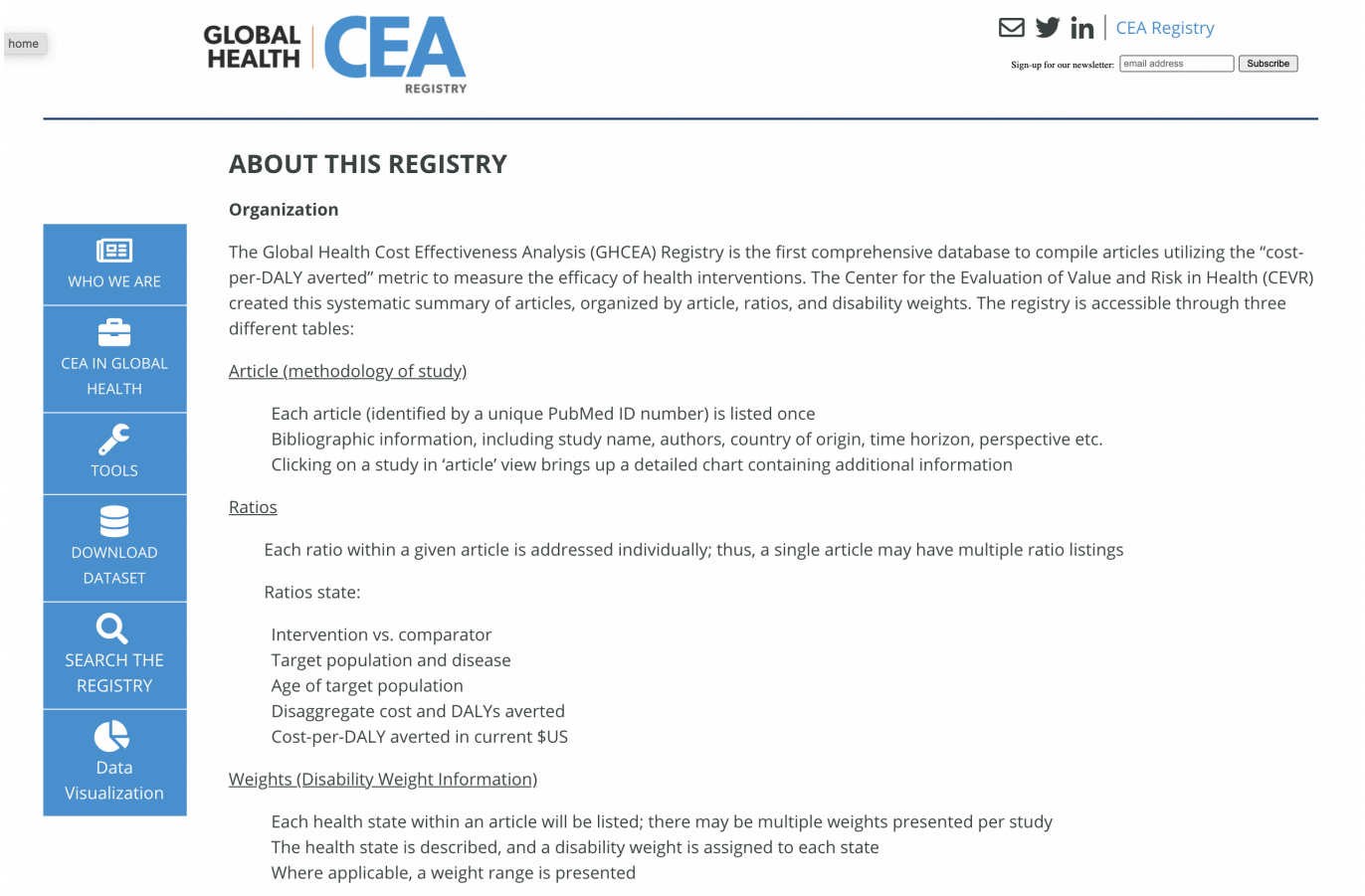
Costs (Tufts CEVR)



http://ghcearegistry.org/ghcearegistry/

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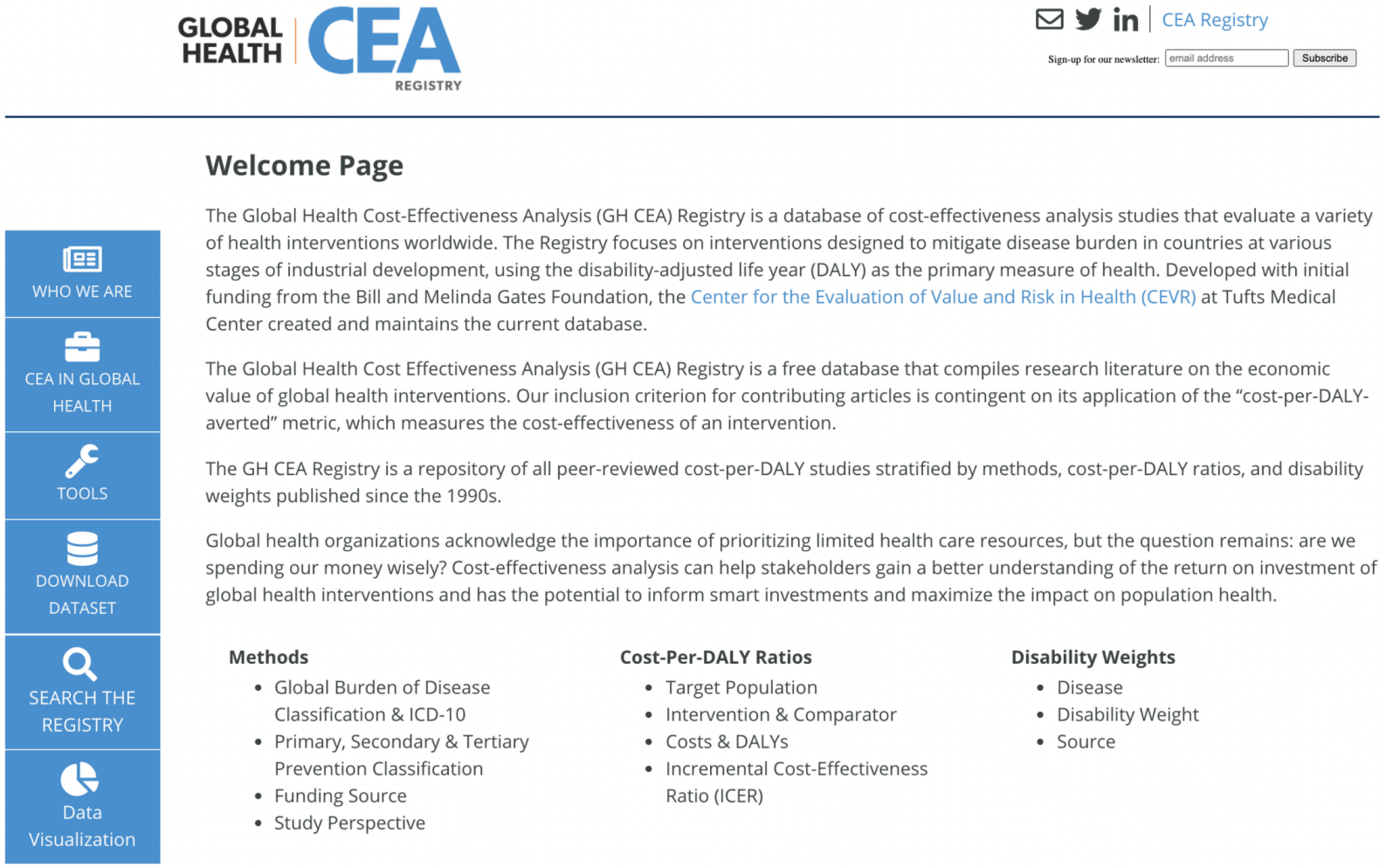
Costs (Tufts CEVR)



Costs (DCP3)

DCP3 | Disease Control Priorities

economic evaluation for health

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Adjustments needed for Valuing Costs

- Adjusting for currency and currency year
- Discounting

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Inflation Adjustment

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Inflation Adjustment: Motivation

- $100 in 2000 is not equivalent to $100 in 2020
  - $100 could buy a lot more in 2000!
- Important to adjust for the price difference over time, especially when working with cost sources from multiple years

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Inflation Adjustment: Example

HSR Health Services Research

DOI: 10.1111/1475-6773.12612
METHODS ARTICLE

Adjusting Health Expenditures for Inflation: A Review of Measures for Health Services Research in the United States

Abe Dunn, Scott D. Grosse, and Samuel H. Zuvekas

Objective. To provide guidance on selecting the most appropriate price index for adjusting health expenditures or costs for inflation.

Data Sources. Major price index series produced by federal statistical agencies.

Study Design. We compare the key characteristics of each index and develop suggestions on specific indexes to use in many common situations and general guidance in others.

Data Collection/Extraction Methods. Price series and methodological documentation were downloaded from federal websites and supplemented with literature scans.

Principal Findings. The gross domestic product implicit price deflator or the overall Personal Consumption Expenditures (PCE) index is preferable to the Consumer Price Index (CPI-U) to adjust for general inflation, in most cases. The Personal Health Care (PHC) index or the PCE health-by-function index is generally preferred to adjust total medical expenditures for inflation. The CPI medical care index is preferred for the adjustment of consumer out-of-pocket expenditures for inflation. A new, experimental disease-specific Medical Care Expenditure Index is now available to adjust payments for disease treatment episodes.

Conclusions. There is no single gold standard for adjusting health expenditures for inflation. Our discussion of best practices can help researchers select the index best suited to their study.

Key Words. Health care costs, expenditures, health care prices, inflation, cost-of-illness, cost-effectiveness

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Inflation Adjustment: Method

- Choose a reference year (usually the current year of analysis)
- Convert all costs to the reference year

Converting cost in Year X to Year Y (reference year):

$$\mathbf{Cost(Year\ Y)} = \mathbf{Cost(Year\ X)} \times \frac{\mathbf{Price\ index(Year\ Y)}}{\mathbf{Price\ index(Year\ X)}}$$

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Inflation Adjustment: Example

> Cost of hospitalization for mild stroke in the US was ~15,000 USD in 2016. What if we want to convert this number to 2020 USD?

- PCE (Personal Consumption Expenditure Health Price Index) in 2016: 105.430 (second column of Table 3 (PCE, health)
- PCE in 2020: 112.978

$$\begin{aligned}\mathbf{Cost(2020)} &= \mathbf{Cost(2016)} \times \frac{\mathbf{PCE(2020)}}{\mathbf{PCE(2016)}} \\ &= 15,000 \times \frac{112.978}{105.430} \\ &= 16,674 \ (2020 \text{ USD})\end{aligned}$$

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Currency Conversion

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Currency Conversion

- Isn't required for CEA but may be useful in some situations:
  - Example: may need to convert local currency to USD because cost-effectiveness thresholds are often estimated in the unit of USD per DALY.
- How do we convert 1,000 Turkish Liras to USD?
- Current exchange rate in 2024: 1 Turkish Lira = ~0.029 USD
- 1,000 Liras = 29 USD

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Discounting

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Why discounting?

- Adjust costs at social discount rate to reflect social “rate of time preference”
  - Pure time preference (“inpatience”)
  - Potential catastrophic risk in the future
  - Economic growth/return

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Discounting

A $ today is NOT worth a $ tomorrow

$100 now

2% net return = $102

["present value" of $102 next year is $100 today]
Similarly, $100 next year = $98.04 now

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Discounting

Inflation: We convert PAST cost to present-day values

Discounting: We convert FUTURE costs to present-day values

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How do we discount?

- Present value: $PV = FV/(1+r)^t$
  - FV = future value, the nominal cost incurred in the future
  - r = **annual discount rate** (analogous to interest rate)
  - t = number of years in future when cost is incurred
- Reasonable consensus around 3% per year
- May vary according to country guidelines

> ⚠ Adjust for inflation and currency first, then discount

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Intuition

- $r = 0.03$
- Recall that $PV = FV/(1+r)^t$, and we're at Year 0:
  - \$1 in Year 0 is valued as $1/1.03^0 = \$1$
  - \$1 in Year 1 is valued as $1/1.03^1 = \$0.97$
  - \$1 in Year 2 is valued as $1/1.03^2 = \$0.94$
  - \$1 in Year 3 is valued as $1/1.03^3 = \$0.92$
  - ...
  - In other words, we are converting what a \$1 would be in Year 2, for example, to the PRESENT VALUE of today. Today, it will be 0.94.

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Example

- Assume in year 5, a patient develops disease, and there is a treatment cost of $500
  - This is the future value (FV) of the cost!
- Present value $PV = FV/(1+r)^t = 500/(1+0.03)^5 = \$431.3$

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Next up: Benefits! (the denominator)

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