UNIVERSITY OF UTAH SCHOOL OF MEDICINE

Using Health Economics to Evaluate Antimicrobial Stewardship Activities

Vanessa Stevens, PhD

Research Assistant Professor
Division of Epidemiology
University of Utah School of Medicine
IDEAS 2.0 Center of Innovation
VA Salt Lake City Health Care System

Disclaimer:

I am not a health economist, I just play one on TV

Several slides generously provided by Richard Nelson, PhD (a real life health economist)

Overview

1. Learning objectives
2. Why do we care about health economics?
3. Economic Analyses
   - Budget Impact Analysis
   - Cost of Illness Studies
   - Cost Effectiveness Analysis
4. Challenges in AS research

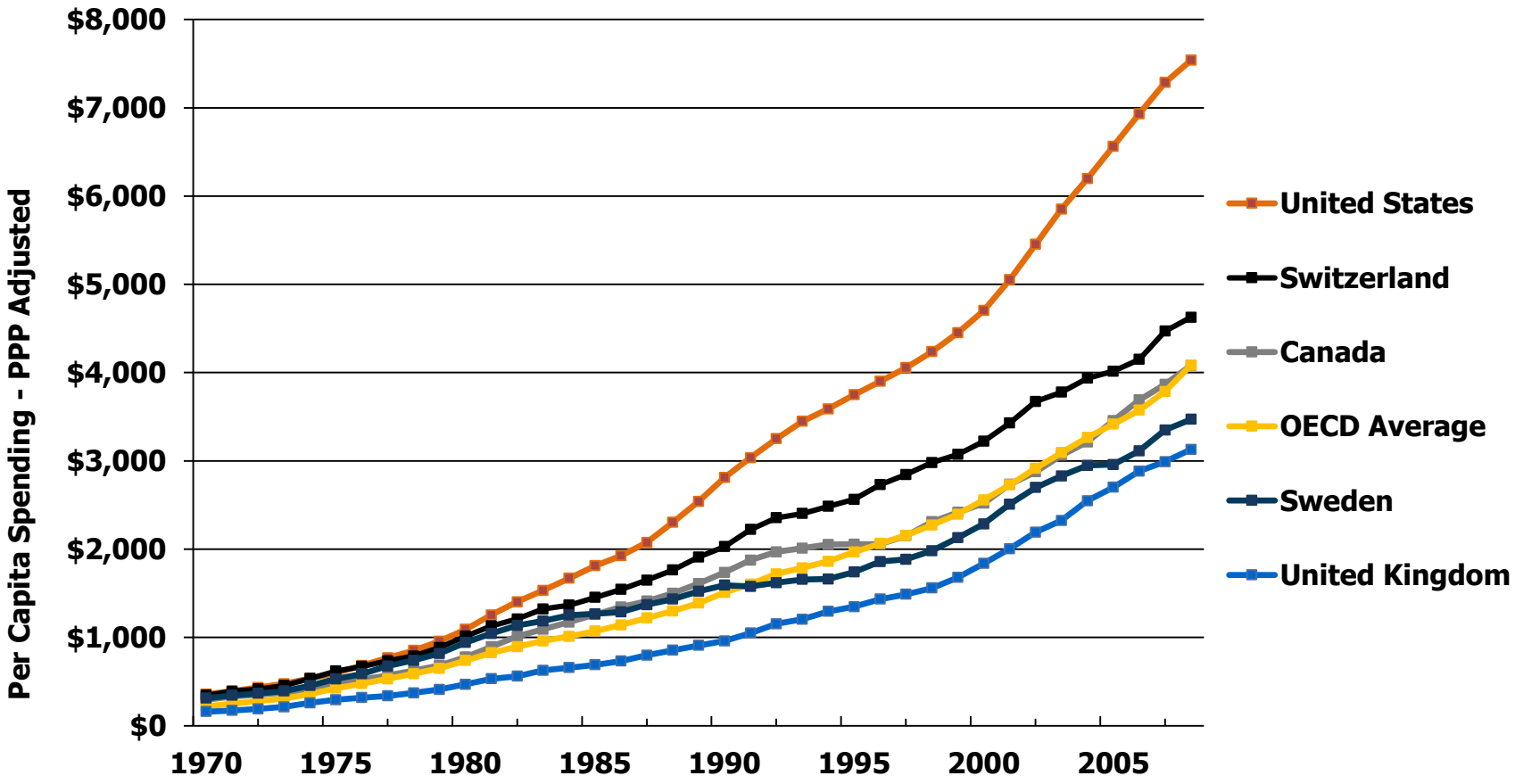
Learning Objectives

1. Identify different kinds of economic evaluations
2. Identify the main inputs to economic evaluations
3. Understand the challenges to economic evaluations in AS research
4. Critically evaluate health economic evaluations in AS research literature

Health Economics

- Allocation of scarce healthcare resources to satisfy unlimited demands
- The study of choices

Growth in Total Health Expenditure per Capita – 1970-2008



OECD. 2010

THE U.S. SPENDS MORE ON HEALTH CARE THAN ANY OTHER NATION

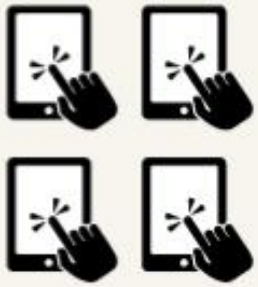
Here's what the U.S. could do today with the **$15.5 TRILLION** we'd save if our health care spending over the past 30 years had been the same as that of the second-highest spending country:

Transform our $11.6 trillion federal debt into a **$3.9 TRILLION SURPLUS**

Send **175,401,721 STUDENTS** to a four-year college

Cover an area the **SIZE OF SOUTH CAROLINA** with solar panels

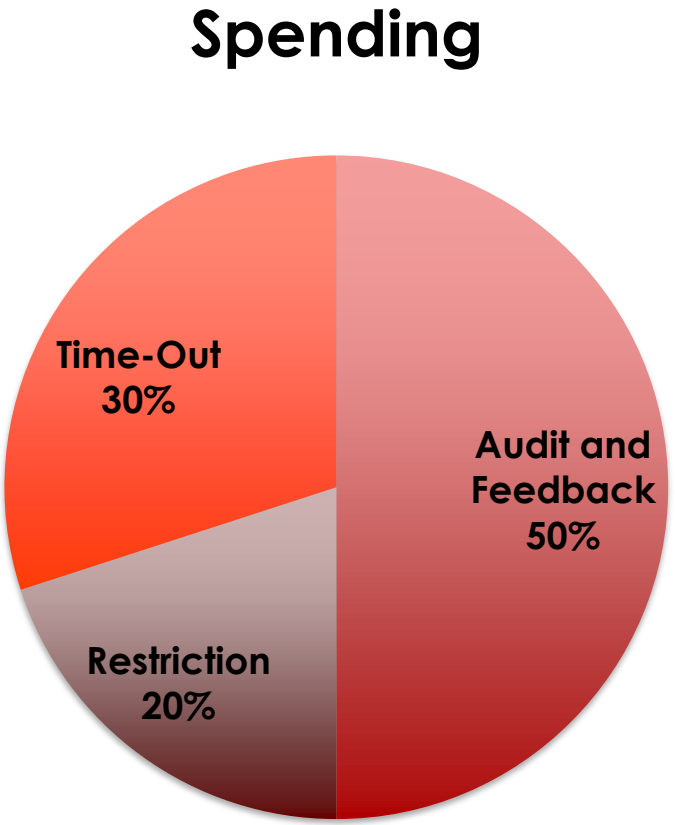
BUY EVERYONE in the world **4 iPADS**



Source: 2012 OECD Health Data.

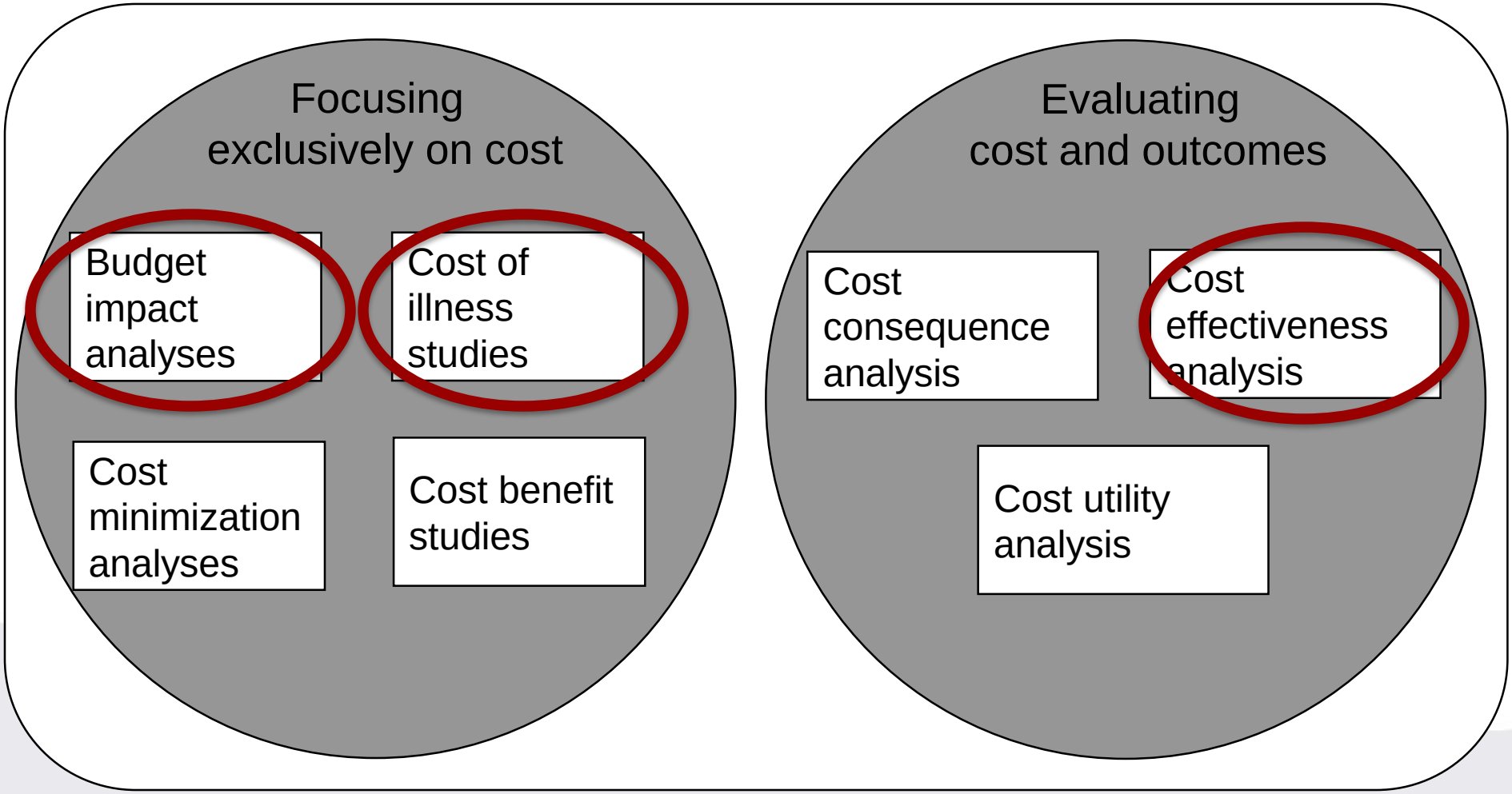
Commonwealth Fund 2013

How can heath economics help?



A summary of available AS economic research

Economic studies



Summary of economic methods

Type of Analysis	Costs	Outcomes
Budget impact analysis	**$**	**-**
Cost-minimization	**$**	**-**
Cost-of-illness	**$**	**-**
Cost-effectiveness	**$**	**Natural units**
Cost-utility	**$**	**QALYs**
Cost-benefit	**$**	**Monetary Units**
Cost-consequence	**$**	**All of the above**

Budget Impact Analysis (BIA)

How much will it (or did it) cost to implement a particular intervention?

- For resource allocation
- Payer perspective
- Short time horizon (1-5 years)
- Size of population explicitly accounted for

Example

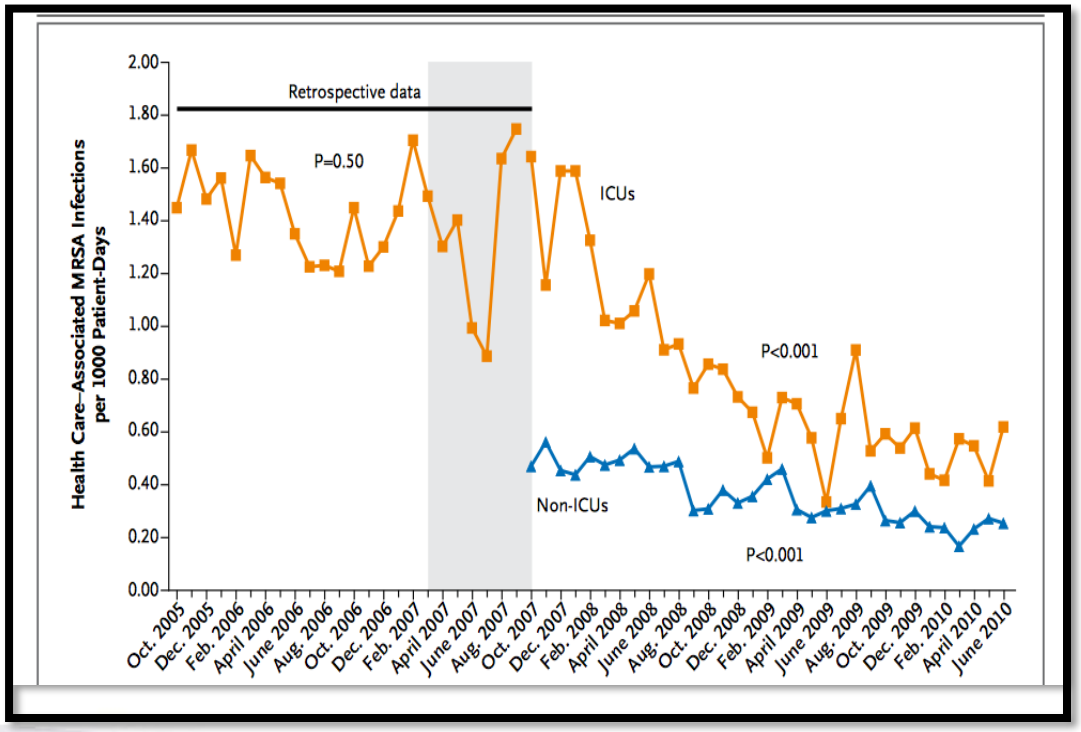
An AS intervention to review the chart of every outpatient prescribed an antibiotic is estimated to cost $30 per patient in a health system that prescribes antibiotics for 5,000 outpatients per month

Budget impact = $30*5,000*12 = $1.8 million annually

Economic Analysis of Veterans Affairs Initiative to Prevent Methicillin-Resistant *Staphylococcus aureus* Infections

Richard E. Nelson, PhD,[1,2] Vanessa W. Stevens, PhD,[1,3] Karim Khader, PhD,[1,2]

- Universal MRSA screening
- Isolation precautions
- Hand hygiene
- Shared responsibility



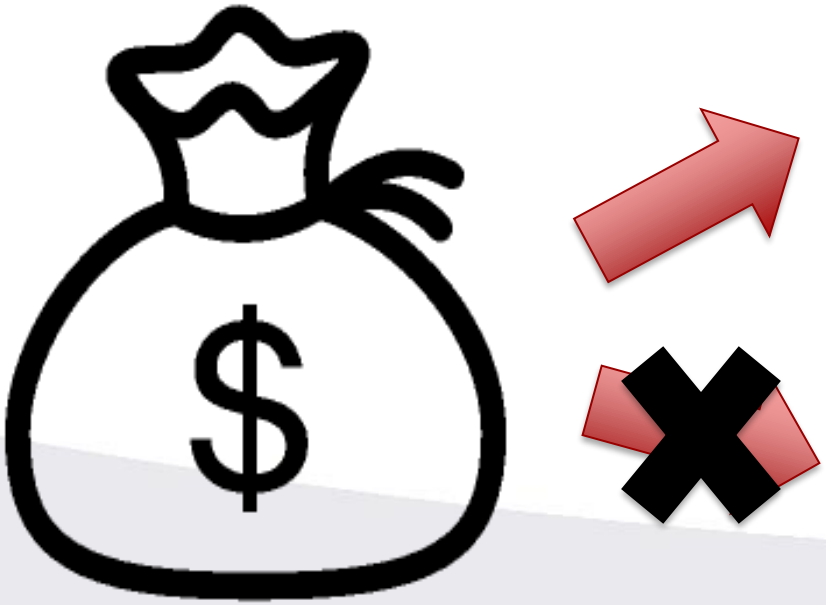
The initiative cost the VA between 130 and 180 million dollars

Questions

- Is $130 (or $180) million dollars a lot?
- Should we continue funding the VA MRSA prevention initiative?

Opportunity Cost

The cost incurred by choosing one intervention and not being able to do another



Preventing SSI

Preventing CDI

Cost of Illness Studies

What are the economic costs of an illness or other undesirable event?

- Identify and measure all costs of a particular condition
- Payer, patient, provider, societal perspectives
- Important input in cost-effectiveness analysis

Example

How much does each case of MRSA cost the healthcare system?

Relative to patients with MSSA, patients with MRSA cost on average $10,000 more*

This is the attributable cost of resistance in SA infections

*I made this number up

Inpatient costs, mortality and 30-day re-admission in patients with central-line-associated bloodstream infections

V. Stevens[1,2,3], K. Geiger[3,4], C. Concannon[2], R. E. Nelson[5,6], J. Brown[2,3,7] and G. Dumyati[2]

	Adjusted[a] total costs (2010 USD)			Adjusted[a] variable costs (2010 USD)		
Characteristic	**Coefficient**	**Excess cost**	**p**	**Coefficient**	**Excess cost**	**p**
CLABSI	0.198	49 618	0.04	0.211	32 412	0.03
Other HAI	0.561	122 217	<0.0001	0.595	78 832	<0.0001
Multiple catheters	0.362	96 000	<0.01	0.386	63 096	<0.01
ICU stay, per day	0.011	2921	<0.0001	0.011	1726	<0.0001
Step-down stay, per day	0.008	2111	<0.0001	0.008	1280	<0.0001

CLABSI, central-line-associated bloodstream infection; HAI, healthcare-associated infection.
[a]All costs were modelled by generalized linear regression with log link and gamma distribution. In addition to the variables listed in the table, estimates were also adjusted for gender, age, race, major surgical procedure, Acute Physiologic and Chronic Health Evaluation (APACHE) II score, Charlson Comorbidity Index, diagnosis-related group (DRG) weight, and DRG system (AP-DRG, CMS-DRG, or APR-DRG).

Questions

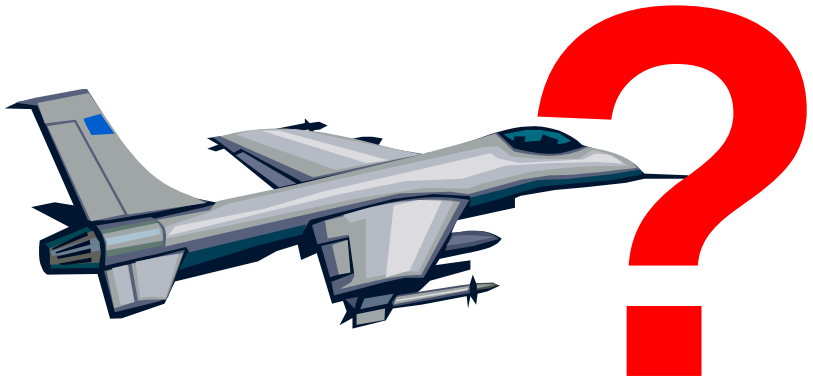
- Is $32,000 a lot?
- Should we spend our scarce resources to prevent CLABSI?

Cost Effectiveness Analysis (CEA)

What are we getting for what we are spending on an intervention?

- Integrates information on costs AND outcomes
- Provides information on the consequences of alternative options
- There must be a comparator (even if “do nothing”)

A non health-related example



New jet fighter (very expensive, clearly better than old)

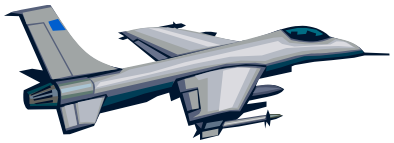
Old jet fighter (inexpensive, has done well)

1 new jet fighter = 4 old jet fighters in defense capacity (effectiveness)

1 new fighter

Hypothetical number of old fighters

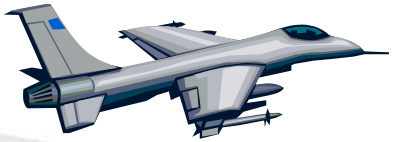
Who wins?



vs

new

For the same price, 14 old jets clearly dominates 1 new jet



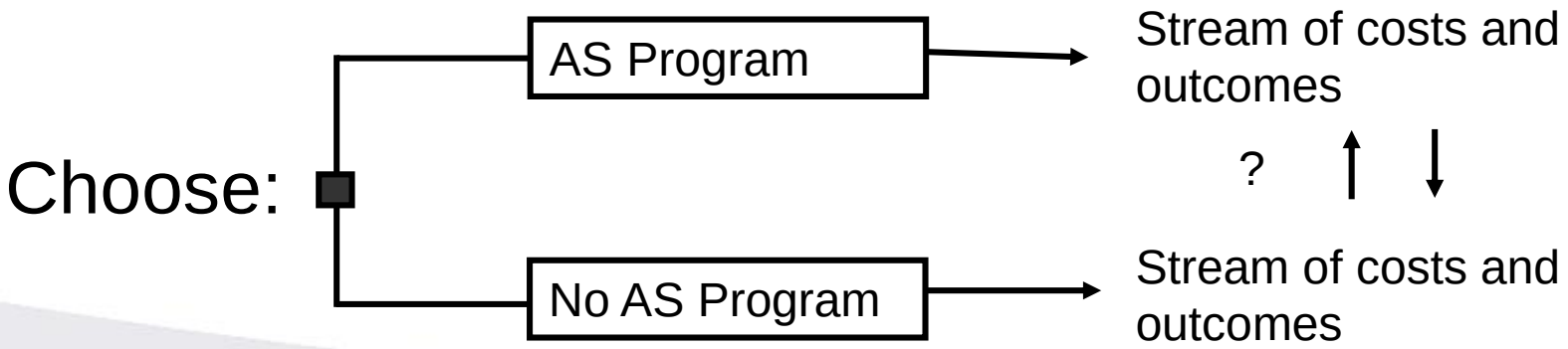
vs

probably new

?

More Relevant Example

- C-Suite is deciding whether or not to invest in an AS program
- These choices are formalized in a cost effectiveness analysis as:



What should be included?

Two types of outcome:

- **Cost outcomes**
  - The AS program could be cheaper or more expensive than no AS program
- **Effectiveness outcomes**
  - The AS program can more or less effective than no AS program
    - More lives saved
    - Less resistance
    - Fewer infections

Cost of AS program vs. No AS Program

Quadrant II – No AS is Dominant

AS is less effective and more costly than No AS

Quadrant I – Trade Off

AS is more effective and more costly than No AS

Effectiveness of AS vs. No AS

Quadrant III – Trade Off

AS is less effective and less costly than No AS

Quadrant IV – AS is Dominant

AS is more effective and less costly than No AS

Cost of AS program vs. No AS Program

Quadrant II – No AS is Dominant

AS is less effective and more costly than No AS

Quadrant I – Trade Off

AS is more effective and more costly than No AS

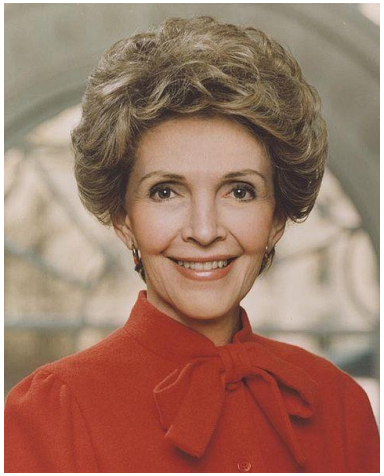
Effectiveness of AS vs. No AS

Quadrant III – Trade Off

AS is less effective and less costly than No AS

Just Do It

Cost of AS program vs. No AS Program



Just Say No

Quadrant I – Trade Off

AS is more effective and more costly than No AS

Effectiveness of AS vs. No AS

Quadrant III – Trade Off

AS is less effective and less costly than No AS

Just Do It

Costs

- Resources consumed when providing a treatment intervention or service
- Broad categories
  1. Healthcare resources
  2. Non-healthcare resources
  3. Caregiver time
  4. Patient time

Measuring Costs - Issues

1. Perspective?
2. Charges vs. Cost?
3. Fixed vs. Variable Cost?
4. Time Dependent Bias

Perspective

- From whose point of view is the study conducted?
- Natural hierarchy
  - Society
  - Healthcare system/provider
  - 3rd party payer
  - Patient or family

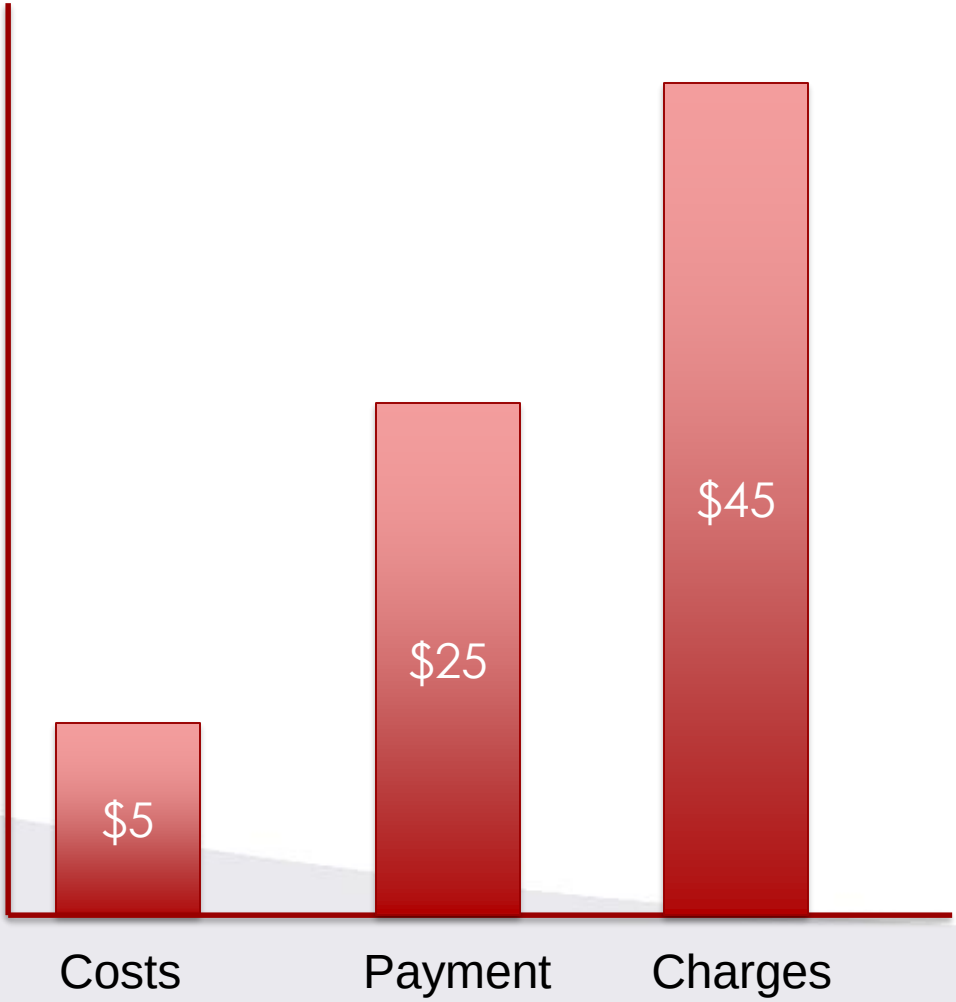
In a Hospital or Payer Perspective Analysis:

1. Healthcare resources
2. ~~Non-healthcare resources~~
3. ~~Caregiver time~~
4. ~~Patient time~~

Measuring Costs - Issues

1. Perspective?
2. Charges vs. Cost?
3. Fixed vs. Variable Cost?
4. Time Dependent Bias

Charges ≠ cost



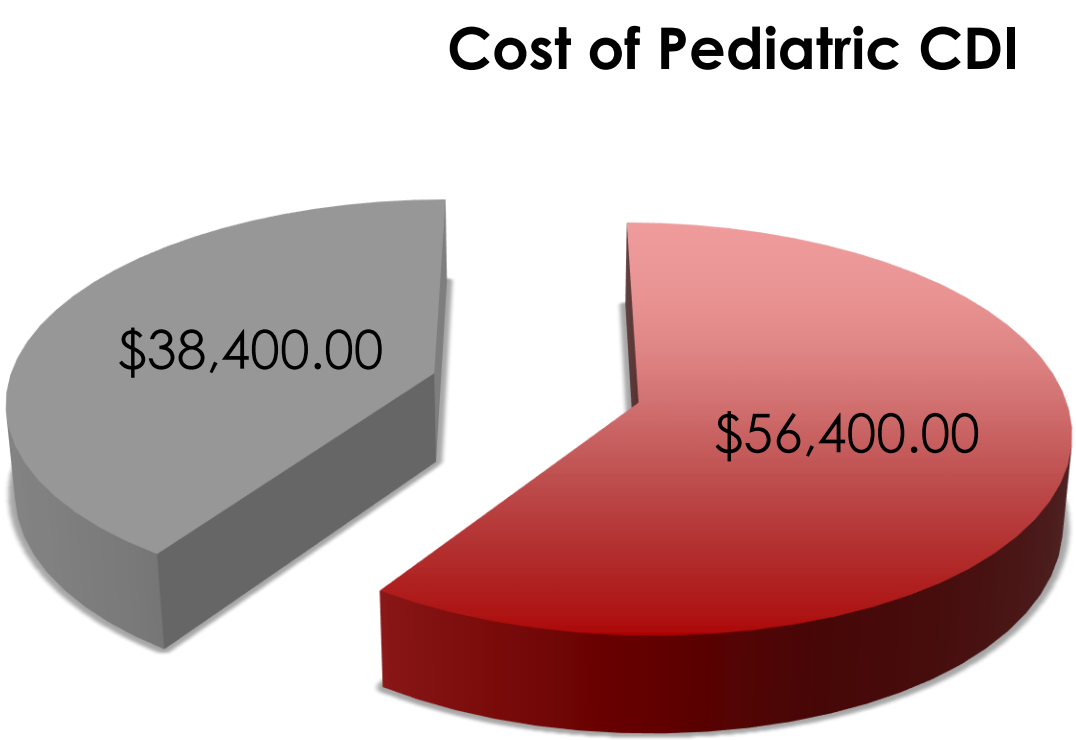
- Relationship between charges and costs is complex
- Money spent to acquire penicillin (for example) varies from hospital to hospital
- Charges for use of penicillin will also vary by hospital

Measuring Costs - Issues

1. Perspective?
2. Charges vs. Cost?
3. Fixed vs. Variable Cost?
4. Time Dependent Bias

Not all costs can be avoided

Not all costs can be avoided



- Maintenance
- Utilities
- Labor

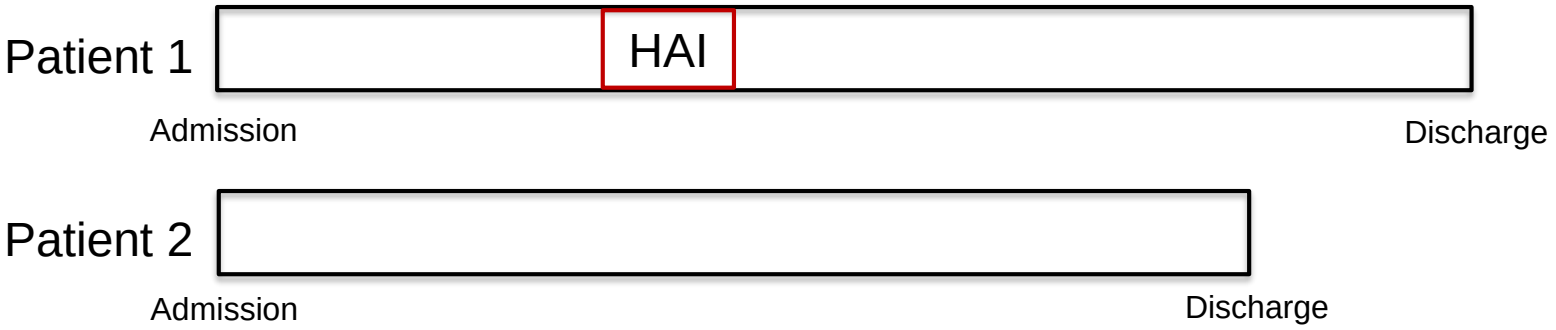
- Antibiotics
- Catheters
- Other consumables

Measuring Costs - Issues

1. Perspective?
2. Charges vs. Cost?
3. Fixed vs. Variable Cost?
4. Time Dependent Bias

Impact of HAI on Excess LOS and Costs

Many studies compare total LOS/Costs between patients with HAI and those without



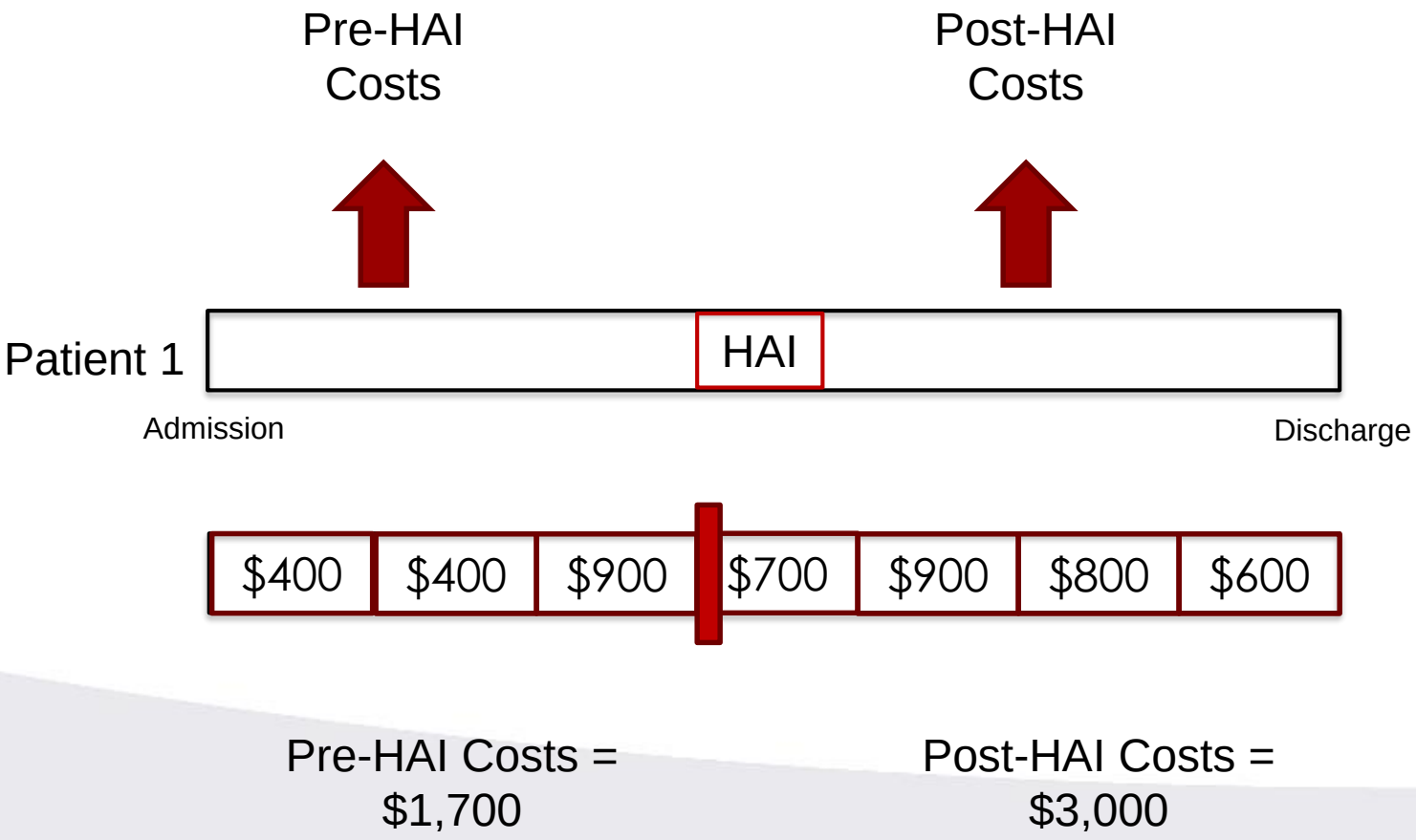
- But not all of the days/costs are attributable to the HAI
- This leads to "time-dependent bias"

Barnett et al *AJE* (2009)
Barnett et al *Value in Health* (2011)

Time-Dependent Bias: published studies of LOS

Study	Country	HAI type	HAI time-varying	HAI non-time-varying	Inflation factor
Wolkewitz (2013)	Switzerland	MRSA	5.9 (0.0-11.9)	24.5 (14.5-34.5)	312.3%
Barnett (2011)	Argentina	CLABSI, CAUTI, VAP	1.35 (0.8-1.9)	11.2 (10.1-12.4)	731.9%
Schumacher (2013)	Germany	Nosocomial pneumonia	6.2 (1.3-9.1)	21.9 (17.6-26.2)	253.2%
Roberts (2010)	US	Many pathogens	5.9	8.1	37.3%
Vrijens (2010)	Belgium	Bloodstream infections	6.7	21.0	253.2%

Addressing time-dependent bias in cost studies



Ideal Cost Data:

- ☑ Costs (Not Charges)
- ☑ Can Separate Fixed and Variable Cost
- ☑ Daily Costs

Effectiveness

The effects or outcomes associated with implementing an intervention

- Resistant infections avoided
- Adverse events or deaths avoided
- Quality-Adjusted Life Years (QALYs)
- Number of successfully treated patients

Special Challenges in AS Research

How do we measure the effectiveness of an AS program?

- Multi-faceted
- Impact multiple outcomes
- Short vs. long-term
- What is the primary goal of AS?
- Patients are not independent

Quantifying Cost-Effectiveness

Cost-effectiveness analysis always examines the ***NET*** effect of substituting one option for another

$$ICER = \frac{Cost_A - Cost_B}{Effectiveness_A - Effectiveness_B}$$

$$ICER = \frac{Incremental\ cost\ of\ changing\ from\ A\ to\ B}{Incremental\ effectiveness\ of\ changing\ from\ A\ to\ B}$$

Cost-effective Interventions

- What does it mean for an intervention to be cost-effective?
- Arbitrary threshold: $50,000 per QALY
- May depend on the time horizon

Economic Analysis of Veterans Affairs Initiative to Prevent Methicillin-Resistant *Staphylococcus aureus* Infections

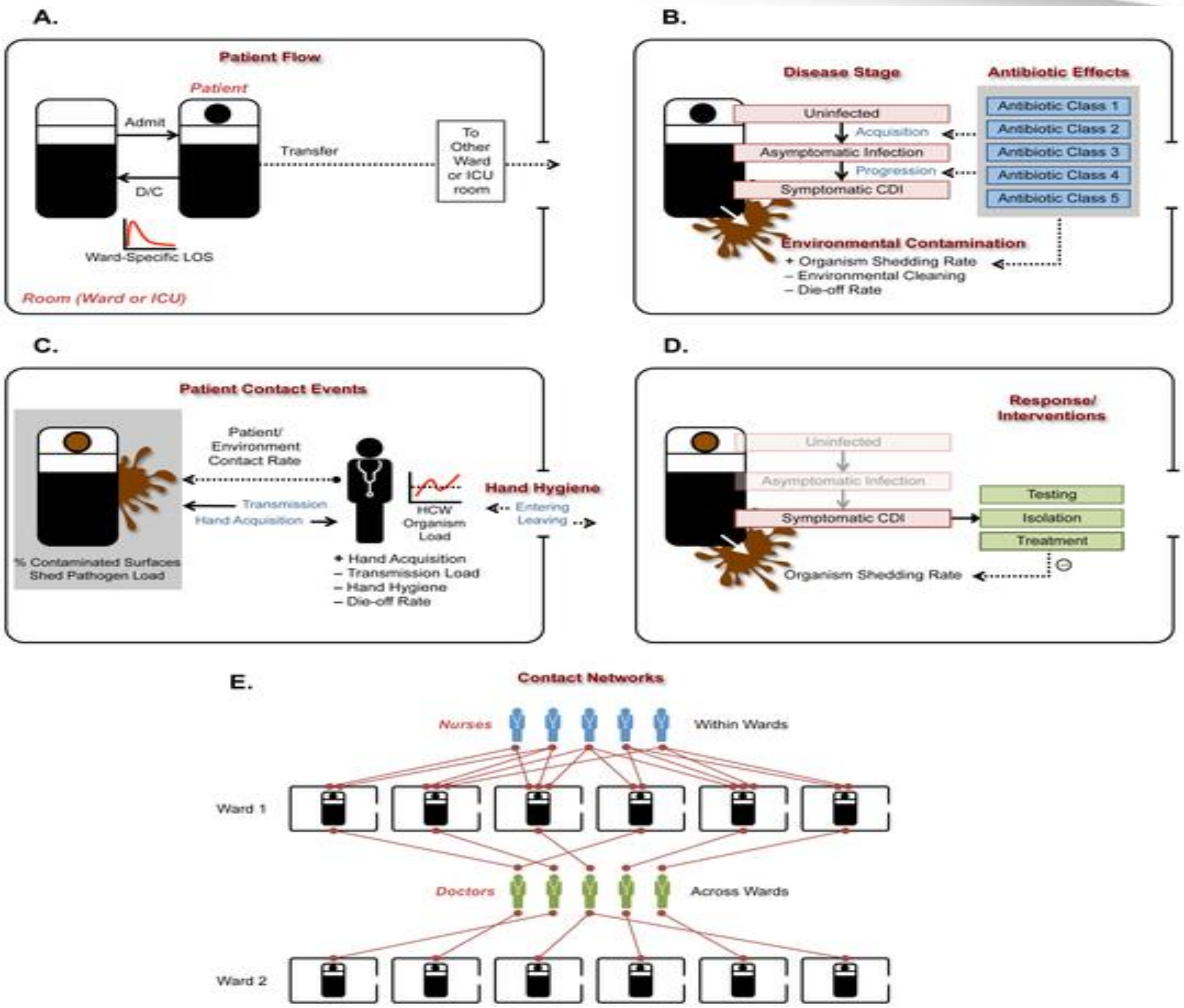
Richard E. Nelson, PhD,[1,2] Vanessa W. Stevens, PhD,[1,3] Karim Khader, PhD,[1,2]

	CEA	
Incremental LYs gained	Total cost	ICER,
504.8	114,605	
1,721.7	24,561	
2,453.4	12,687	
4,679.8	28,048	
335.0	180,801	
1,202.3	42,116	
1,614.8	27,628	
3,152.2	49,435	

The extra cost of the MRSA initiative relative to to previous control efforts was $49,435 per QALY

Other important components

- Sensitivity analyses
  - One and two-way
  - Probabilistic
- Discounting (3% by convention)
- Adjustment for inflation
- Static vs. Dynamic Models



Rubin MA, Jones M, Leecaster M, Khader K, Ray W, et al. (2013) A Simulation-Based Assessment of Strategies to Control Clostridium Difficile Transmission and Infection. PLOS ONE 8(11): e80671. doi:10.1371/journal.pone.0080671
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0080671

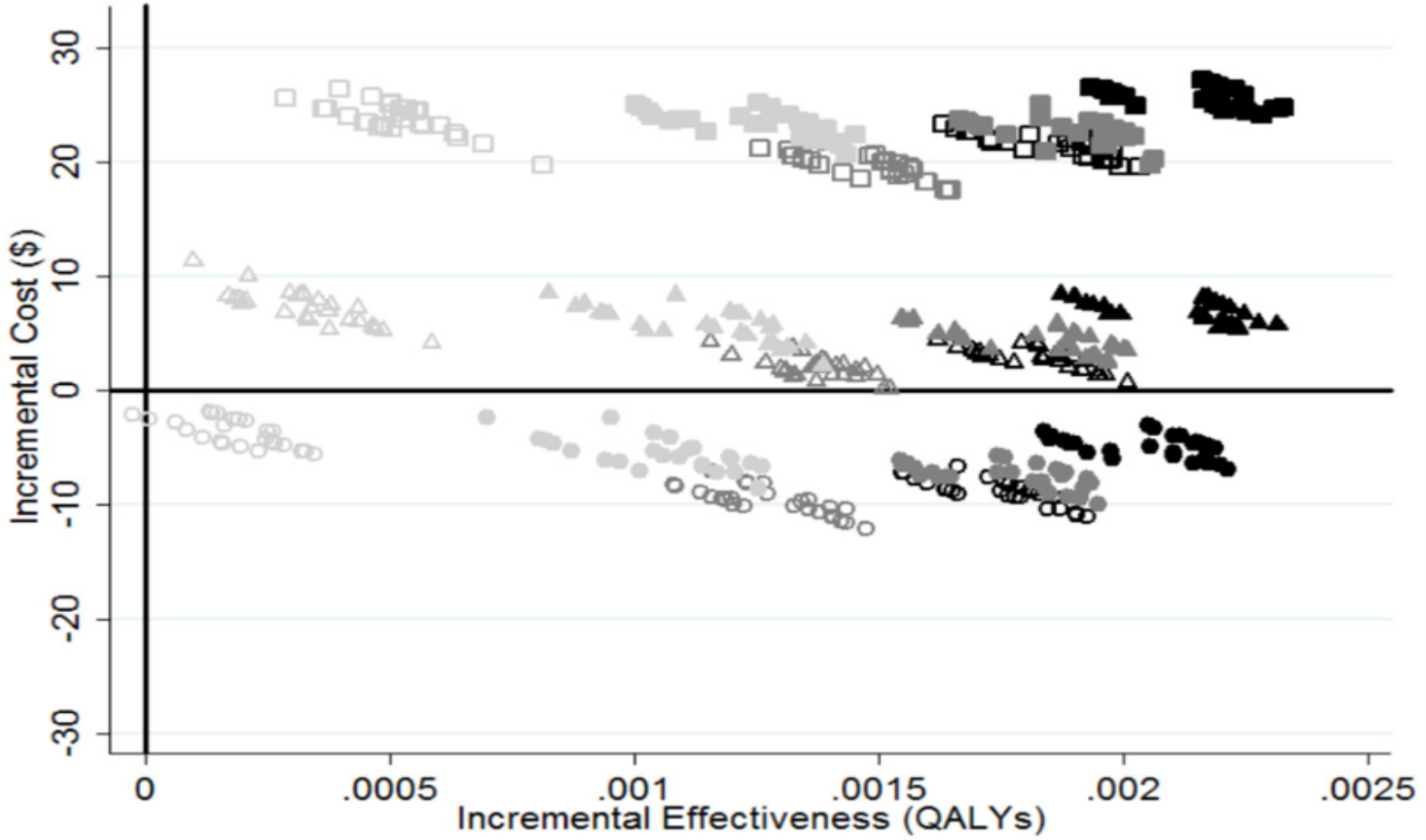
RESEARCH ARTICLE

An Economic Analysis of Strategies to Control *Clostridium Difficile* Transmission and Infection Using an Agent-Based Simulation Model

Richard E. Nelson[1,2]*, Makoto Jones[1,2], Molly Leecaster[1,2], Matthew H. Samore[1,2], William Ray[1,2], Angela Huttner[3], Benedikt Huttner[3], Karim Khader[1,2], Vanessa W. Stevens[1,4], Dale Gerding[5], Marin L. Schweizer[6,7], Michael A. Rubin[1,2]

Table 4. Results from cost-effectiveness analysis.

	Effectiveness measure = infections averted			Effectiveness measure = QALYs[a]		
	Transmission			Transmission		
Importation	Low	Medium	High	Low	Medium	High
Low importation						
BASE	-	-	-	-	-	-
INT	$36,936	$22,114	Dominant	$80,118	$19,892	Dominant
OPT	$434,024	$388,071	$112,865	$923,269	$189,776	$110,952
Medium importation						
BASE	-	-	-	-	-	-
INT	$10,980	$3,115	Dominant	$51,611	$4,272	Dominant
OPT	$95,788	$78,655	$26,176	$211,511	$73,780	$29,473
High importation						
BASE	-	-	-	-	-	-
INT	$6,963	$506	Dominant	$20,389	$616	Dominant
OPT	$56,243	$38,835	$13,978	$197,459	$41,531	$15,628


Incremental Cost ($)
30
20
10
0
-10
-20
-30
0
.0005
.001
.0015
.002
.0025
Incremental Effectiveness (QALYs)

Conclusions

- Economic evaluations can help us decide how to spend our limited resources
- Costs and effectiveness can be challenging to measure accurately, especially in AS research
- The economic evaluation of AS research is a developing field

Questions

Contact me:

vanessa.stevens@hsc.utah.edu

vanessa.stevens@va.gov

References

- Nelson et al. AJPM 2016. http://www.ajpmonline.org/article/S0749-3797(15)00696-0
- Jain et al. NEJM 2011. http://www.nejm.org/doi/full/10.1056/NEJMoa1007474
- Stevens et al. Clin Micro Infect 2013. http://www.clinicalmicrobiologyandinfection.com/article/S1198-743X(14)60095-1/abstract
- Barnett et al. *AJE* 2009.
- Barnett et al. *Value in Health* 2011.
- Rubin MA, Jones M, Leecaster M, Khader K, Ray W, et al. (2013) A Simulation-Based Assessment of Strategies to Control Clostridium Difficile Transmission and Infection. PLOS ONE 8(11): e80671. doi:10.1371/journal.pone.0080671.http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0080671

A cost-effectiveness analysis of two different antimicrobial stewardship programs

Lucas Miyake Okumura[a,*], *Bruno Salgado Riveros*[b], *Monica Maria Gomes-da-Silva*[c], *Izelandia Veroneze*[d]

Table 2 – The base case: outcomes, costs per patient, CER, and ICER.

	Absolute Risk	Direct costs (average value)	CER	ICER
Conventional ASP	0.6209	US$ 18,013.22	US$ 29,011.46	US$ 19,287.54
Bundled ASP	0.7308	US$ 20,132.92	US$ 27,549.15	
Conventional ASP[a]	0.6202 ± 0.08	US$ 18,021.21 ± 5.72	US$ 29,057.10	US$ 19,317.58
Bundled ASP[a]	0.7328 ± 0.11	US$ 20,196.37 ± 6.33	US$ 27,560.55	

ASP, antimicrobial stewardship program; AR, Absolute Risk; CER, Cost-Effectiveness Rate; ICER, Incremental Cost-Effectiveness Ratio.

[a] After 10,000 iterations.

Notes: CER represents the cost per patient that survives 30 days. ICER represents the cost per incremental patient that survives 30 days.

Budget impact analyses

- Analysis of provider's expenditures for a program over a short period of time (often 1-3 years)
  - Costs are not usually adjusted for inflation or discounting
- Uses provider/payer perspective
  - So no patient-incurred costs
  - But should reflect impacts on enrollment and retention that could result from affecting patients
- Complimentary to CEA
  - CEAs often address societal perspective
  - BIAs are influential in implementation decisions
- Drug plans in Canada require BIA

Cost of illness

- Prevalence models
  - Cross sectional
  - Reflect costs in a given period of time – e.g., all annual costs associated with a disease
  - Most common method

- Incidence models
  - Lifetime costs
  - Reflects cost from onset of disease to cure/death – e.g., estimate lifetime costs associated with a new diagnosis
  - Difficult to estimate future costs

Cost-minimization analysis

- Examines only the cost of competing technologies (not the cost of consequences) for the purpose of choosing one with the lowest cost
  - Brand name versus generic
  - Two or more drugs in the same therapeutic class – with similar side effect profiles
  - Assumes equal clinical effectiveness so outcomes are not valued
  - Issue of economic efficiency
  - Cost per patient treated

Cost-benefit analysis

- Resources consumed and health outcomes measured in monetary units
- Decision rule: Choose treatment with the highest net benefit
- Controversy – assigning monetary value to health

Cost-benefit analysis

- Results expressed two ways:
  - Benefits – costs = net benefit or net cost
  - Benefit/cost = benefit cost ratio

- Decision rule:
  - Accept programs with net benefit or benefit:cost ratio > 1
  - When comparing multiple alternatives, choose the treatment with the highest net benefit ratio