# Cost effectiveness Analysis in the Evaluation of Vaccine Programs

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Figure 1—Total Drug Expenditure, Canada, 1985 to 2004

Source: Canadian Institute for Health Information.
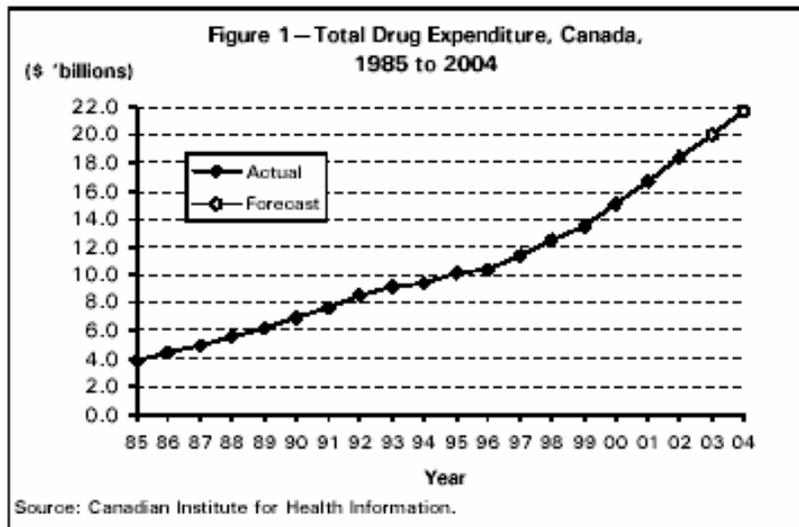
Average growth 1985-1992: 9.7%

"Enter the health economists, holding aloft tables
of various interventions and their comparative
cost-effectiveness ratios…"

Cost-effectiveness analysis: are the outputs worth the inputs?[Editorial]
Naylor, David MD, ACP Journal Club, May-June 1996

Cost effectiveness analysis

- "an area of research that identifies, measures, and compares the costs and consequences of health products and services"

- Synonyms/ related disciplines:
  - Pharmacoeconomics
  - Economic evaluation
  - Health technology assessment

- Bootman et. Al. Principles of Pharmacoeconomics

Growing number of …

- ◆ Academic societies:
  - ▪ ISPOR, iHEA, HTAI, SMDM

- ◆ Journals
  - ▪ Pharmacoeconomics, Value in Health, Int J Tech Ass, Medical Care, Cost Eff Res All, Health Econ
  - ▪
- ◆ Publications
  - ▪ ~500/year 1980-1985
 - ▪ ~3,500/year 1996-2000

Growing number of …

- ◆ Health technology assessment agencies
  - ▪ Canada
    - ● CADTH (Canadian Association for Drugs and Technology in Health)
    - ● Ontario-DQTC, Medical Advisory Secretariat
    - ● IHE, AHFMR, AETMIS, TAU,
    - ● BC, Sask, MB
  - ▪ INAHTA – 19 member countries

Growing number of….

- jurisdictions in which pharmacoeconomic analyses are required for formulary decisions…
  - Australia- (1993)
  - Ontario (1996), NS, NB, PEI, NF (recommended BC, AB, SK)
  - Europe
    - Norway, Sweden, Austria, Belgium, Latvia, Lithuania, Estonia
    - Etc
  - Asia-… developing

Outline

i)… abc of cost effectiveness analysis

ii) How can it help in evaluating vaccine programs?

iii) What are it's limitations?

cost

Vaccine program "A"

health

TIME


cost

Vaccine program "B"
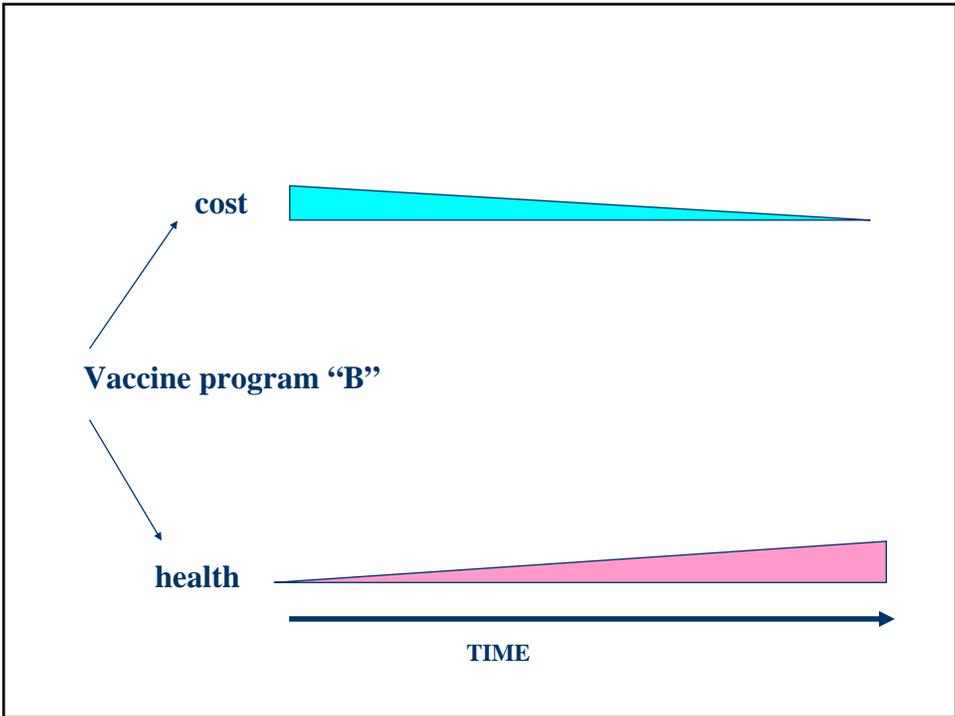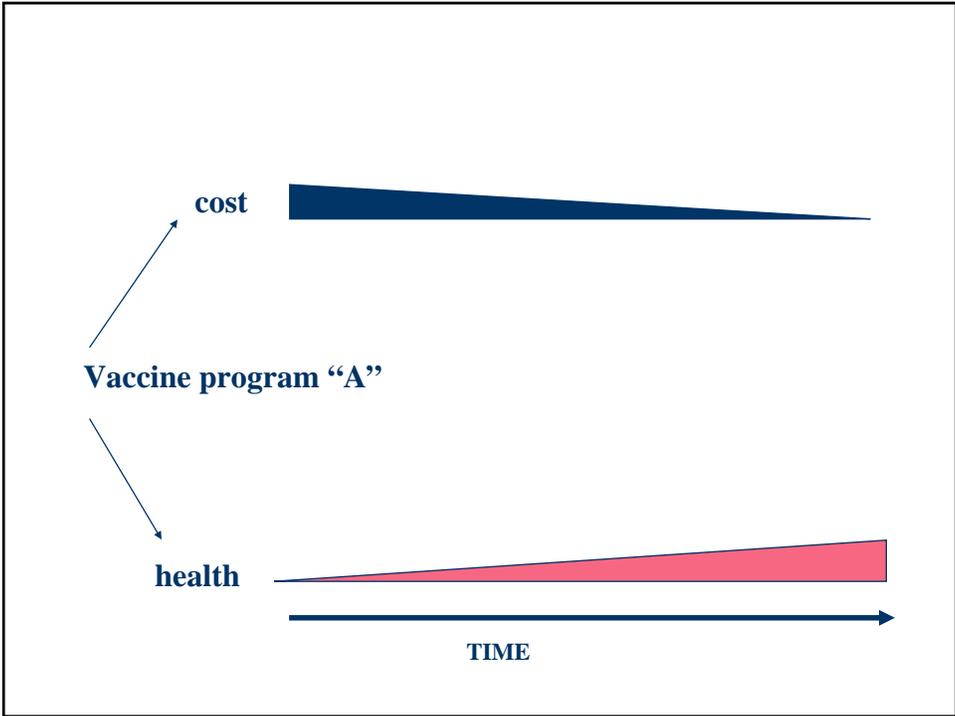
health

TIME

Cost Effectiveness

(Cost A – Cost B)
_____
(Health A – Health B)

Costs

- Drugs (e.g. Vaccines)
- Lab tests
- Physician Services
- Hospitalization
- Home care
- Long term care

- TIME- waiting, traveling, loss of work

Health

- ◆ "Natural units"
  - ▪ Prevented: ← CEA
    - ● HAV infection
    - ● Liver death
    - ● Transplant

- ◆ Index ← CUA
  - ▪ Life years gained
  - ▪ Quality-adjusted life years gained

QALY

- ◆ Health has two dimensions, quality and quantity
- ◆ Utility used to weight length of life
- ◆ Utility - measure of patient preference for standardized health states
- ◆ Expressed on 0-1 scale

eg. QALY's in Hemodialysis

1.0

utility

0.5

0   Life expectancy   5 yrs

LE = 5 years

Utility = 0.5

QALY's = 5 x 0.5 = 2.5
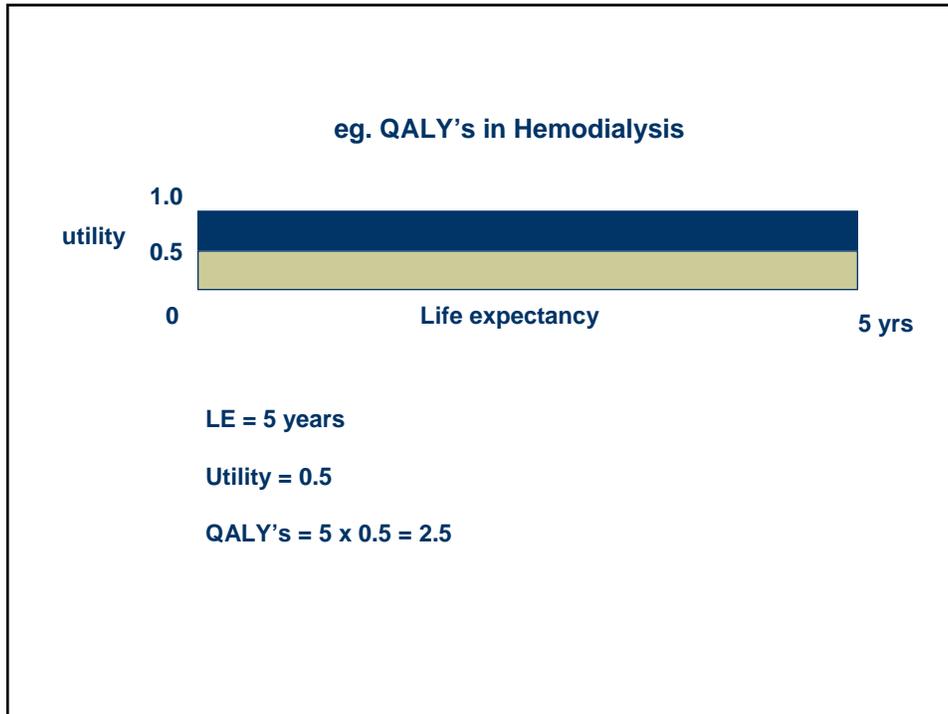
Study design

◆ Cost-consequence

◆ Cost effectiveness (cost per life year gained)

◆ Cost utility (cost per quality adjusted life year gained)

Interpreting the results
Laupacis et. al. (CMAJ 1993)

- <$20,000 / QALY   strong evidence for adoption

- $20,000-$100,000 / QALY   moderate evidence

- >$100,000 / QALY   weak evidence for

                           adoption

Benefits of CEA

## Universal Hepatitis A Vaccination in Canada: A Cost Effectiveness Analysis

◆ Andrea Anonychuk, MSc
◆ Chris Bauch, PhD
◆ Maggie Hong Chen, MSc
◆ Bernard Duval, MD, MPH
◆ Vladimir Gilca, MD
◆ Murray Krahn, MD, MSc
◆ Ba' Pham, MSc
◆ Arni S.R. Srinivasa Rao, PhD
◆ Andrea C. Tricco, MSc

Funded by:

Hepatitis A Epidemiology in Canada
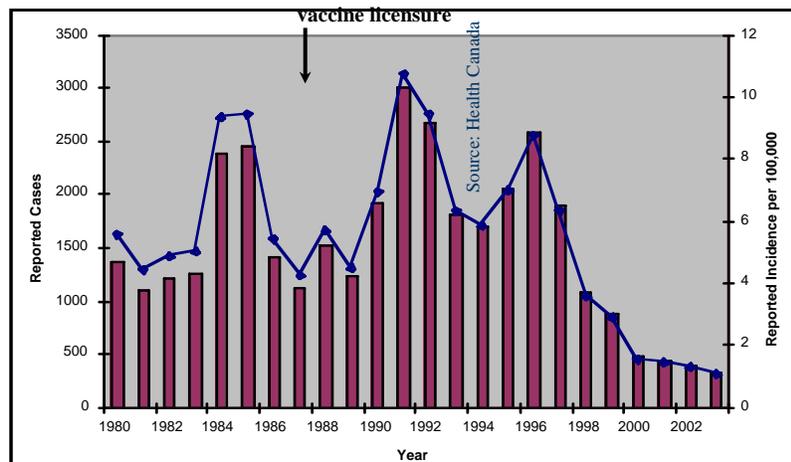
Research rationale

- Yet, vaccine is safe and effective
- Fairly cheap
- Neighbors (US) are vaccinating

Dynamic model description

Aging

Vaccin-
ation

Infection
(travel)

| V | | S | | E | | I | | R |

Waning
immunity
Death

Infection
(domestic)

Becomes
infectious

Recovery/
Death

Aging

V = Vaccinated
S = Susceptible
E = Infected but not yet infectious

I = Infectious
R = Recovered
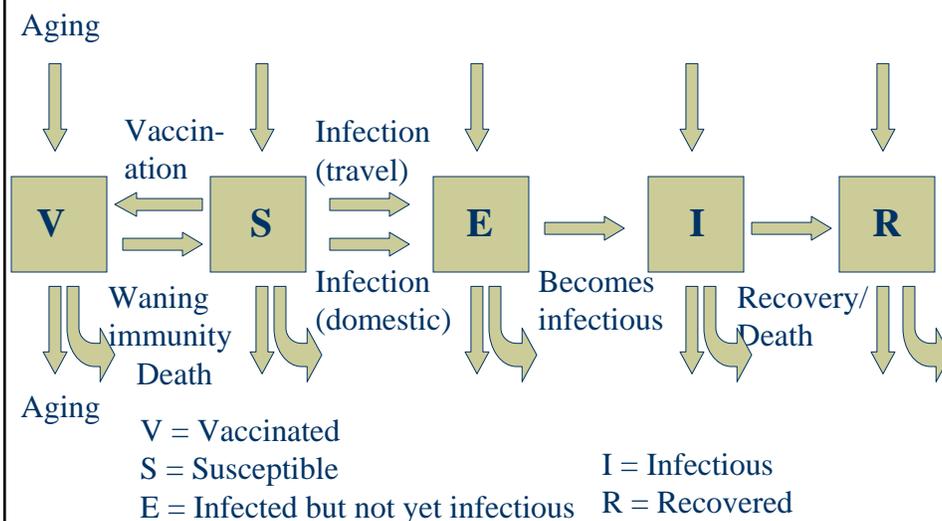
Results: Costs, cases, deaths

red=ministry, black=society

Strategy	Targeted Vaccine Costs, millions $	Universal Vaccine Costs, millions $	Infection Costs, millions $	Total Costs, millions $	Marginal Costs, millions $	Marginal QALYS
Current		0 0	0.4 0.9	7.9 20.3	0	0
4+9	6.0 15.6	3.4 3.4	0.3 0.6	9.6 19.6	1.7 -0.7	7.9
9+9	6.0 15.6	1.6 1.6	0.4 0.8	7.9 18.0	-0.02 -2.2	2.7

Strategy	Reported Cases	Deaths
Current	790	3.6
4+9	440	2.8
9+9	610	3.7

For 1980-1994 population values

Conclusions

- In absolute terms, QALY gains of implementing universal HA vaccination in Canada are small
  - 10-30 QALYs gained per year (undiscounted)

  - However, a strategy which replaces two doses of HB vaccine at age 9 with two doses of combined HA/HB vaccine is cost-saving.

- However uncertainty intervals are large due to marginal effects.
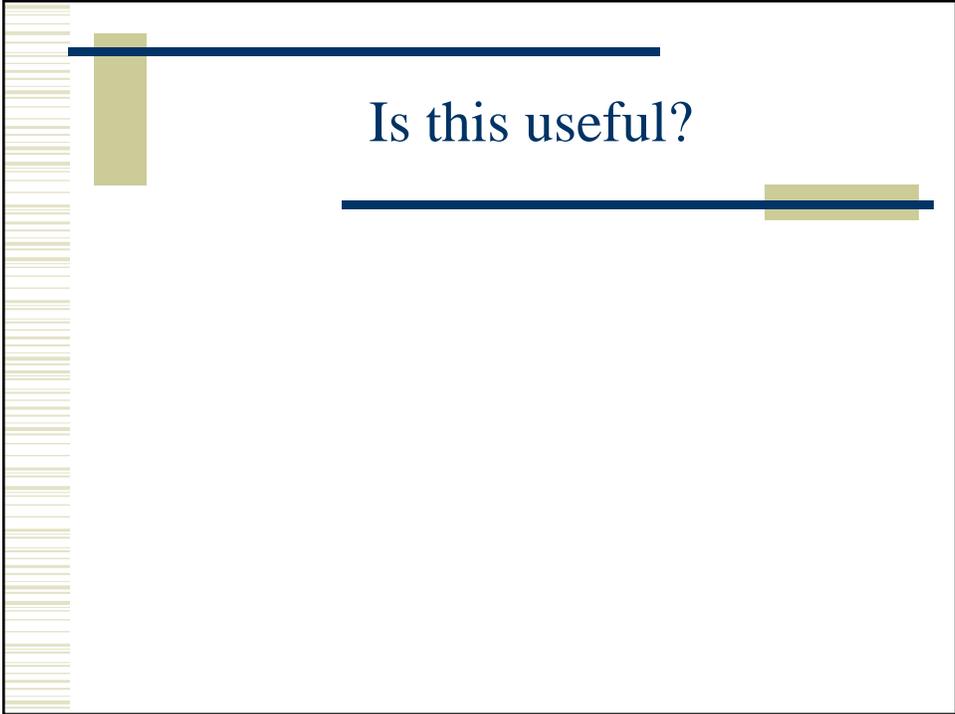
Is this useful?
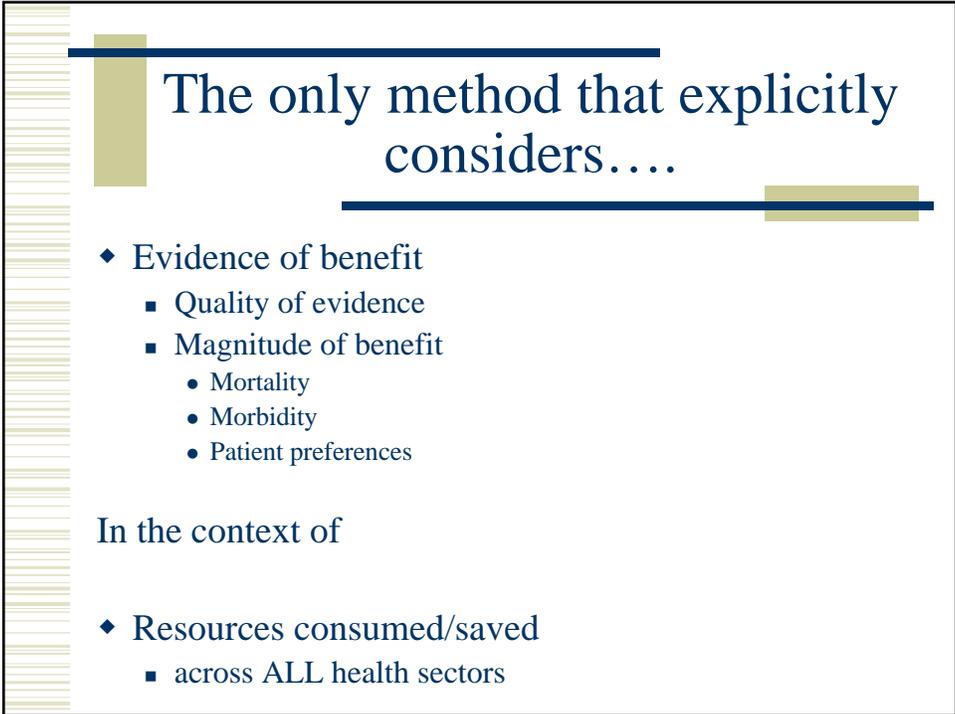
The only method that explicitly considers….

- Evidence of benefit
  - Quality of evidence
  - Magnitude of benefit
    - Mortality
    - Morbidity
    - Patient preferences

In the context of

- Resources consumed/saved
  - across ALL health sectors

BUT……
some caveats…

1. What are your goals…?
Efficiency ?

- 1) what are goals….?
  - Maximize public health
  - Base decisions on "evidence"

  - OR
  - Consider health gain in context of resources used

2. CEA is a measure of value….

- Is it a "good deal"

- Not-
  - Can I afford it…

3. CEA models don't include everything

- They DO include mortality, morbidity, quality of life, cost

- They DON'T include
  - Attitude toward risk, ALL preferences about vaccines, issues of equity, distributional issues,

4. CEA's for vaccine programs are hard to do (well)

- Require dynamic models
- Team that includes epidemiologists, mathematical modelers, content experts, health economists

5. Bias is a problem

- ◆ Bias you can see
- ◆ Bias you can't

Bell et. al. BMJ 2006

Table 2 Characteristics of studies associated with favourable incremental cost effectiveness ratios according to three threshold values. Values are odds ratios (95% confidence intervals)

Study characteristic	Crude OR (95% CI)			Adjusted OR (95% CI)*		
	<$20 000/QALY	<$50 000/QALY	<$100 000/QALY	<$20 000/QALY	<$50 000/QALY	<$100 000/QALY
Publication year						
1976-91	1.6 (0.98 to 2.7)	1.4 (0.80 to 2.4)	1.2 (0.67 to 2.3)	1.6 (0.96 to 2.7)	1.3 (0.76 to 2.3)	1.2 (0.61 to 2.2)
1992-6	1.3 (0.94 to 1.9)	1.4 (0.93 to 2.3)	1.1 (0.68 to 1.6)	1.3 (0.87 to 1.8)	1.3 (0.87 to 1.9)	1.0 (0.64 to 1.6)
1997-2001	1.0	1.0	1.0	1.0	1.0	1.0
Journal impact factor†						
<2	1.0	1.0	1.0	1.0	1.0	1.0
2-4	0.62 (0.42 to 0.91)	0.62 (0.41 to 0.94)	0.59 (0.38 to 0.94)	0.75 (0.50 to 1.1)	0.82 (0.53 to 1.3)	0.77 (0.47 to 1.2)
>4	0.60 (0.42 to 0.86)	0.56 (0.38 to 0.82)	0.83 (0.53 to 1.3)	0.95 (0.63 to 1.4)	0.81 (0.52 to 1.3)	1.1 (0.66 to 1.9)
Disease category						
Cardiovascular	1.0	1.0	1.0	1.0	1.0	1.0
Endocrine	1.3 (0.68 to 2.6)	1.2 (0.58 to 2.5)	1.3 (0.58 to 3.0)	1.2 (0.56 to 2.4)	1.1 (0.52 to 2.3)	1.2 (0.53 to 2.7)
Infectious	1.1 (0.66 to 1.7)	0.79 (0.48 to 1.3)	0.74 (0.43 to 1.3)	1.0 (0.64 to 1.7)	0.75 (0.44 to 1.3)	0.71 (0.39 to 1.3)
Musculoskeletal	1.4 (0.60 to 3.3)	1.3 (0.51 to 3.1)	1.4 (0.50 to 3.7)	1.1 (0.43 to 2.7)	0.89 (0.34 to 2.3)	1.1 (0.37 to 3.1)
Neoplastic	0.91 (0.56 to 1.5)	0.79 (0.46 to 1.3)	0.77 (0.42 to 1.4)	0.78 (0.47 to 1.3)	0.64 (0.37 to 1.1)	0.69 (0.36 to 1.3)
Neurological/psychiatric	0.76 (0.40 to 1.5)	0.78 (0.40 to 1.5))	0.66 (0.31 to 1.4)	0.75 (0.39 to 1.4)	0.70 (0.34 to 1.4)	0.61 (0.27 to 1.4)
Other	1.2 (0.75 to 1.8)	0.67 (0.42 to 1.1)	0.52 (0.31 to 0.88)	1.0 (0.63 to 1.6)	0.53 (0.31 to 0.88)	0.49 (0.27 to 0.86)
Study funding source						
Non-industry	1.0	1.0	1.0	1.0	1.0	1.0
Industry	2.2 (1.4 to 3.4)	3.5 (2.0 to 6.1)	3.4 (1.6 to 7.0)	2.1 (1.3 to 3.3)	3.2 (1.8 to 5.7)	3.3 (1.6 to 6.8)
Not specified	1.3 (0.95 to 1.9)	1.5 (1.1 to 2.2)	1.4 (0.93 to 2.1)	1.3 (0.89 to 1.8)	1.5 (1.0 to 2.1)	1.5 (0.97 to 2.2)
Region of study						
Europe	0.50 (0.28 to 0.89)	0.43 (0.21 to 0.87)	0.46 (0.21 to 1.0)	0.59 (0.33 to 1.1)	0.42 (0.21 to 0.86)	0.43 (0.19 to 0.96)
United States	0.35 (0.21 to 0.57)	0.29 (0.16 to 0.55)	0.33 (0.16 to 0.66)	0.44 (0.26 to 0.76)	0.35 (0.18 to 0.67)	0.33 (0.16 to 0.68)
Other§	1.0	1.0	1.0	1.0	1.0	1.0
Methodological quality¶						
1.0-4.0	1.0	1.0	1.0	1.0	1.0	1.0
4.5-5.0	0.92 (0.64 to 1.3)	0.95 (0.64 to 1.4)	0.96 (0.62 to 1.5)	1.0 (0.70 to 1.5)	1.1 (0.70 to 1.6)	1.0 (0.63 to 1.6)
5.5-7.0	0.48 (0.33 to 0.70)	0.57 (0.39 to 0.83)	0.82 (0.52 to 1.3)	0.58 (0.37 to 0.91)	0.72 (0.45 to 1.2)	0.90 (0.51 to 1.6)

6. CEA is not the (only) answer to rising costs

♦ Funding everything that's cost-effective is a recipe for continued expenditure growth

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Inclusion of drugs in provincial drug benefit programs: should "reasonable decisions" lead to uncontrolled growth in expenditures? Gafni, Birch CMAJ 2003

♦ "funding new technologies that have "acceptable" ICERs … leads to continuous increases in program expenditures because the new, more costly technologies are added without other programs being cut to generate sufficient resources for the new program"

Summary

- CEA is a useful way of putting benefits in the context of costs
- Will likely have an increasing role in evaluation of vaccine programs
- Can be extremely powerful, but use with caution