Economic Evaluation

Bloomberg Philanthropies · DATA FOR HEALTH INITIATIVE · D2P Data to Policy · CDC Foundation Together our impact is greater · Vital Strategies

Review and Preview

- Last lecture:

  Can you afford the intervention?

- This lecture:

  Cost-effectiveness analyses: If you can afford it, is it worth it?

- Next lecture:
  - How sensitive are our results? How much do changes in our input estimates change our output values?

Storyline of a policy brief

Here is **the PROBLEM**

↓

This is / These are **the ROOT CAUSES**

↓

These **INTERVENTIONS / POLICIES** will affect the root causes

↓

Each policy will **COST THIS MUCH** to implement, and **be THIS EFFECTIVE** ← **ECONOMIC EVALUATION**

↓

Therefore, we **RECOMMEND POLICY X**

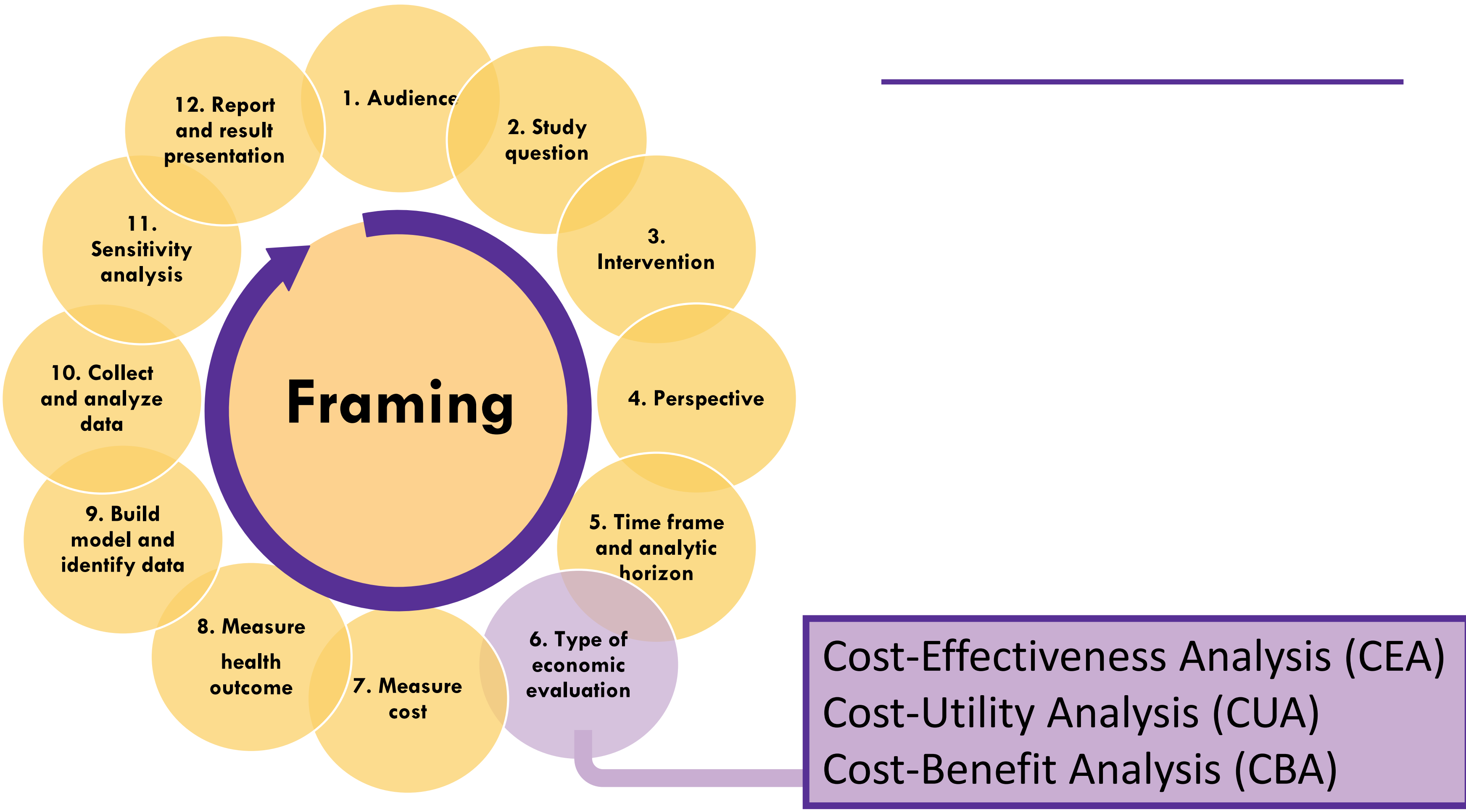
Learning Objectives

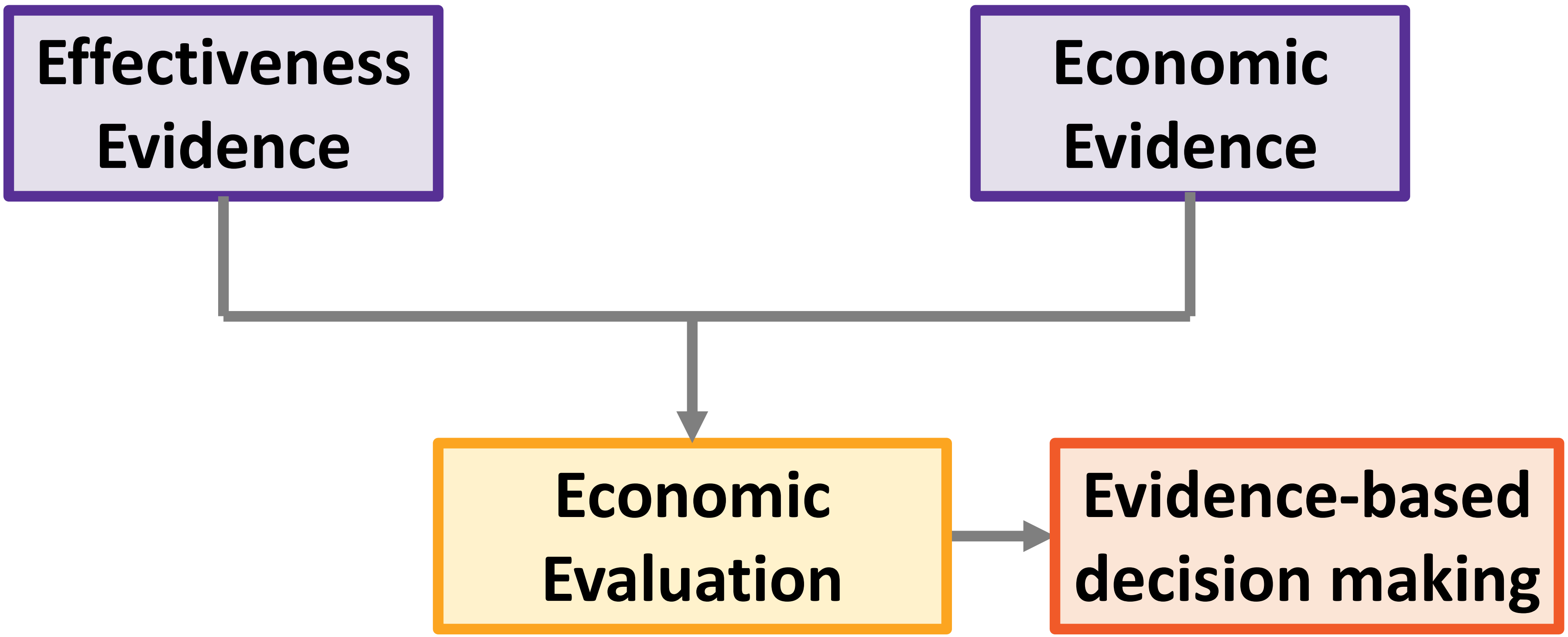
At the end of this module, you will be able to:

- Describe the basics of a full economic evaluation
- List the steps to conduct a full economic evaluation
- Define each type of economic evaluation

  And when to use them use them

- Perform a basic cost-effectiveness analysis


Framing
1. Audience
2. Study question
3. Intervention
4. Perspective
5. Time frame and analytic horizon
6. Type of economic evaluation
7. Measure cost
8. Measure health outcome
9. Build model and identify data
10. Collect and analyze data
11. Sensitivity analysis
12. Report and result presentation
Cost-Effectiveness Analysis (CEA)
Cost-Utility Analysis (CUA)
Cost-Benefit Analysis (CBA)


Effectiveness Evidence
Economic Evidence
Economic Evaluation
Evidence-based decision making

effectiveness, for public health:

the degree to which an intervention successfully produces desired results and outcomes

evidence:

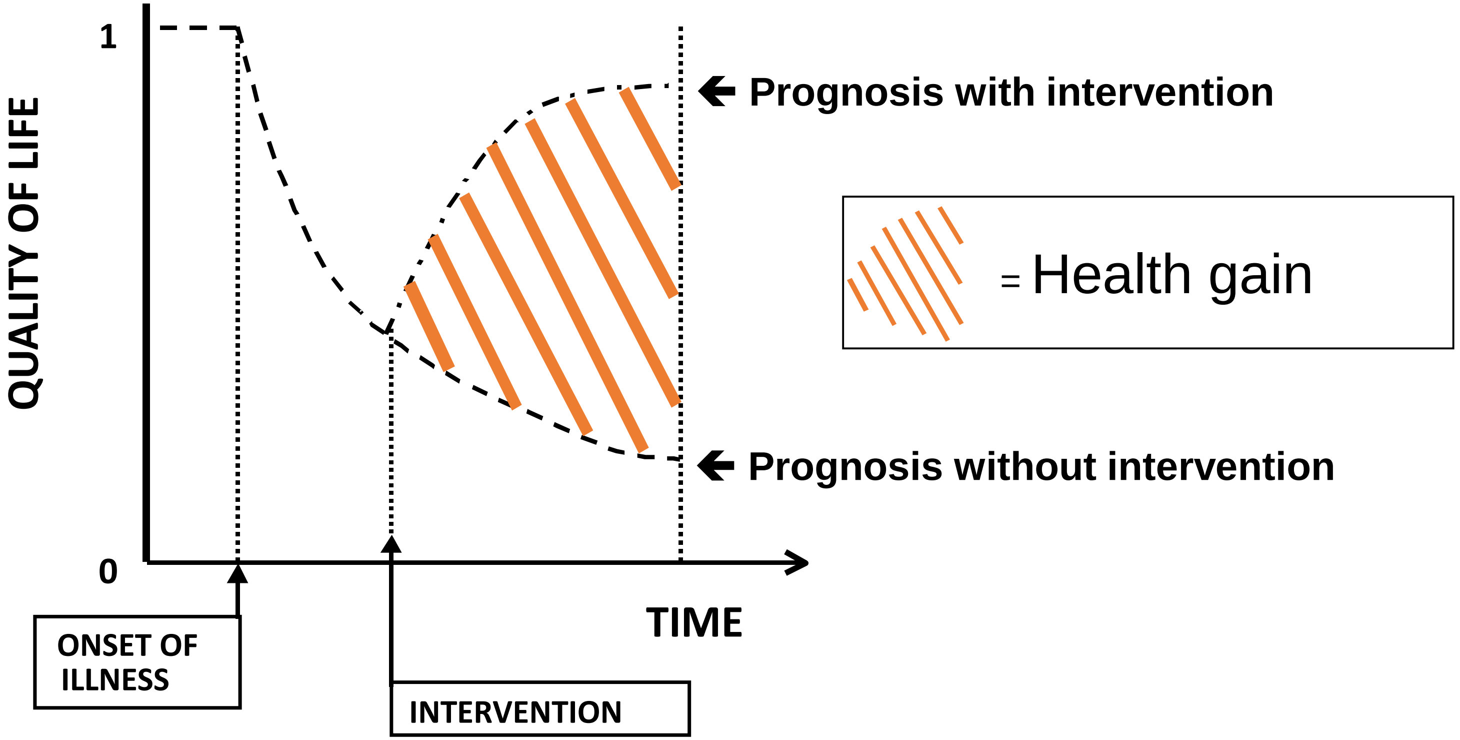
the available body of facts indicating whether an intervention or program is effective

Evidence range and where to find them

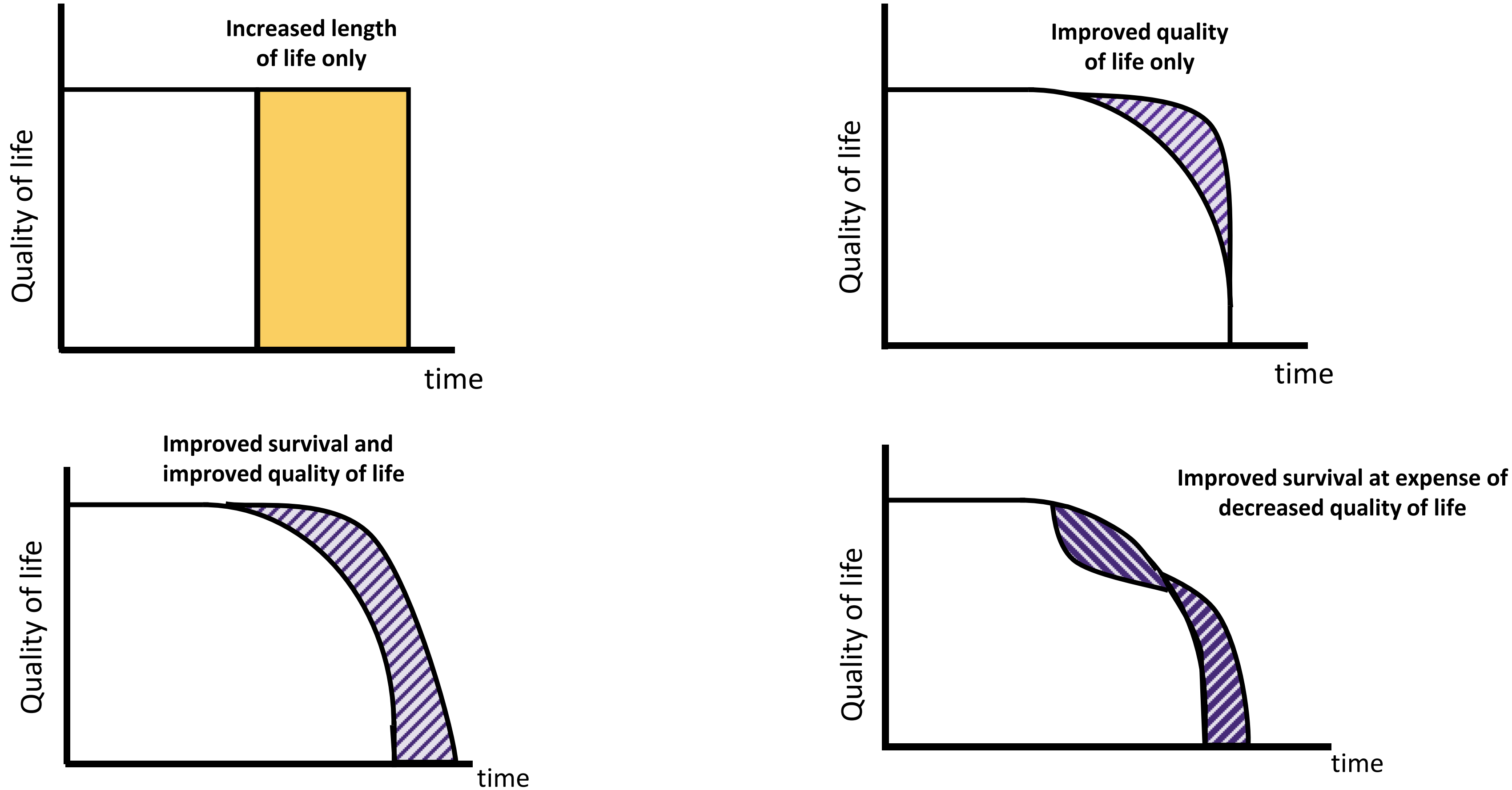
- Systematic reviews (The Community Guide, Cochrane)
- Peer-reviewed journal articles (PubMed)
- Surveillance data (Behavioral Risk Factor Surveillance System)
- Program evaluations
- Qualitative data
  - Community members
  - Other stakeholders
- Media/marketing data
- Expert opinion
- Word of mouth
- Personal experience

Brownson RC, Fielding JE, Maylahn CM. Evidence-based public health: a fundamental concept for public health practice. Annu Rev Public Health, 2009.

How to measure intervention health gain



Impact of health interventions



Types of Economic Evaluation

Economic Evaluation Methods: Partial vs. Full

Partial – costs only

- Cost of illness analysis
- Program cost analysis

Covered in the previous lecture
Lecture 10 – Cost Analysis

Full – costs & outcomes

- Cost-effectiveness analysis (CEA)
- Cost-utility analysis (CUA)
- Cost-benefit analysis (CBA)

Most likely to be used

Review Question:

- **Which of these involves a full economic evaluation?**
  - ☐ A program officer develops an HIV prevention budget
  - ☐ A program manager estimates the costs of providing HIV counseling and testing for one client
  - ☑ A planning officer tries to decide on funding allocations and if programs could treat more people with mobile care clinics or at a hospital

Cost-Effectiveness Analysis (CEA)

Cost-Effectiveness Analysis (CEA)

- To identify most cost-effective interventions from options that produce same health outcome
- Outcomes are in **NATURAL HEALTH UNITS**
  - Lives saved
  - Years of life saved / gained
  - Cases or hospitalizations prevented

CE ratio

- **Consider 2 options:**
  - With intervention
  - Without intervention (Status Quo)

$$\text{CE ratio} = \frac{\text{Costs with intervention} - \text{Costs without intervention}}{\text{Outcome with intervention} - \text{Outcome without intervention}}$$

- **CE ratio is expressed as $ per outcome (natural health outcome)**
  - $ per life saved
  - $ per case averted
  - $ per hospitalization averted

Average, marginal, and incremental CE ratios

Average CE ratio (ACER)

- Ratio of costs to outcomes for a single program
- Example outcome: Cost per patient treated

Marginal CE ratio (MCER)

- Ratio of additional costs to outcomes obtained from one additional unit of an intervention
- Example outcome: Cost to avert one extra death

Incremental CE ratio (ICER)

- Ratio of additional costs to outcomes obtained when one program is compared with the next least effective program
- Additional cost per life year saved

CEA outcomes

Intermediate

- Increased physical activity
- Decreased blood pressure
- Increased test scores

Final

- Heart disease cases prevented
- Lives or life years saved
- Increased HS graduation rate

FINAL OUTCOMES ARE BEST!

Challenges with CEA

- Identifying suitable health outcome measure… “apples-to-apples”
- A cost-effective intervention …
  - Does not imply it is cost saving
  - Does not mean it is affordable

The intervention is cost-effective, relative to what?

- One or more alternative options
- Do nothing

  Have own stream of costs and benefits
- Status Quo
  - Can be "do nothing"
  - Current program

Cost-Utility Analysis (CUA)

Cost-Utility Analysis (CUA)

- Variation of CEA
- Measures outcomes in terms of the value (utility) placed on the outcome, not the outcome itself
- Can be used to compare interventions with different natural health outcomes – which are transformed into utility measures
  - A way to compare ”Apples to Oranges” – after natural health outcomes are converted to utilities

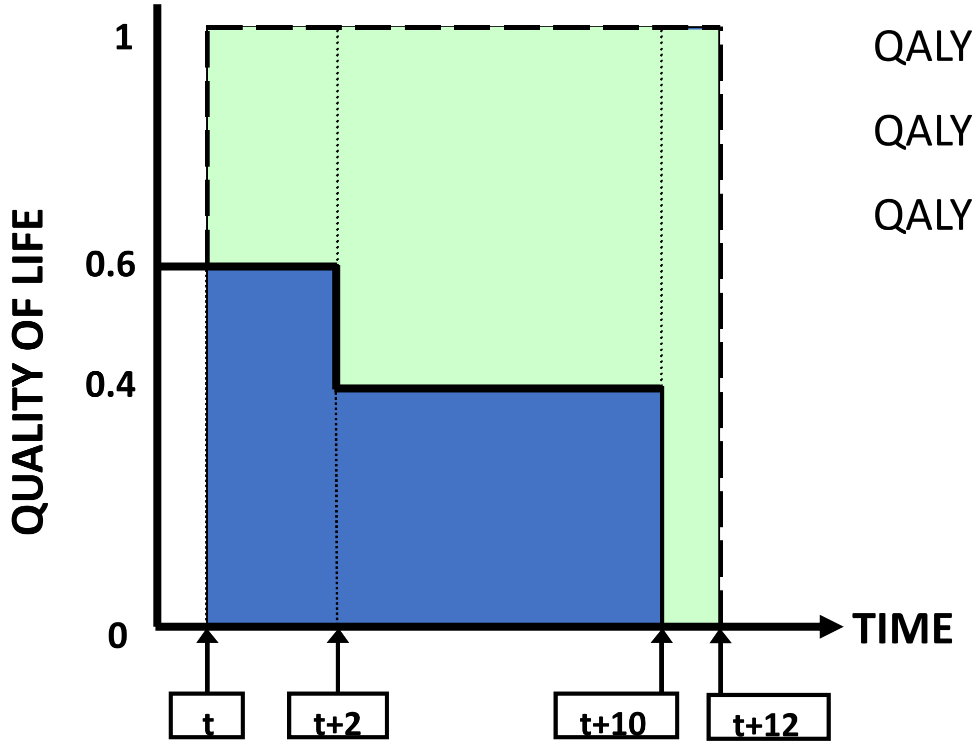
CUA Measures

- Combines
  - Length of life (survival), and
  - Quality of life
- Compares disparate outcomes as utility
  - Quality-adjusted life years (QALYs)
  - Disability-adjusted life year (DALYs)
- CU Ratio: cost per utility
  - $ per QALY
  - $ per DALY

Quality-Adjusted Life Year – QALY

- **Combination of life expectancy and quality of remaining life-years**
  - Quantity of life: people are either alive or not
  - Quality of life: relates to both physical and mental capacity
- **QALY places a weight on time in different health states**
  - A year of perfect life = 1; a year of less than perfect health is < 1
  - Death is equivalent to 0
  - Some health states may be considered worse than death and have negative values

QALY calculation



QALY without = 2x0.6 +8x0.4 = 4.4

QALY with = 12x1 = 12

QALY gain = 12 – 4.4 = 7.6

QALY gain = 2x0.4
+ 8 x 0.6
+ 2 x 1.0
= 7.6

(From, Morris et al 2012)

Disability Adjusted Life Year – DALY

- Total burden of disease: morbidity and mortality

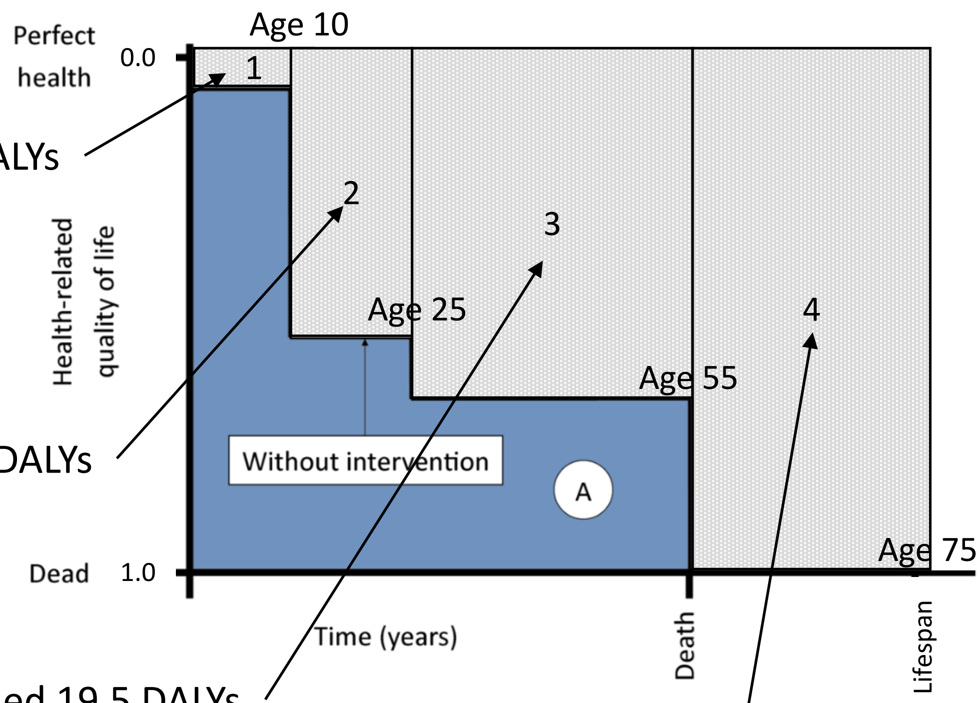
DALY = YLL + YLD

- Years lost due to disability (YLD):
  - Weighted count of years lived with disability
  - Year lived in less than perfect health is worth < 1 year
  - The more severe the disease/disability, the less year lived is worth
- Years of life lost (YLL)

DALYs

10 years at 5% ability lost = 0.5 DALYs
15 years at 55% ability lost = 8.25 DALYs
30 years at 65% ability lost = 19.5 DALYs
20 years at 100% ability lost =20.0 DALYs

Total lifetime DALY = 48.25 DALYs



Gained 0.05 DALYs

Gained 8.25 DALYs

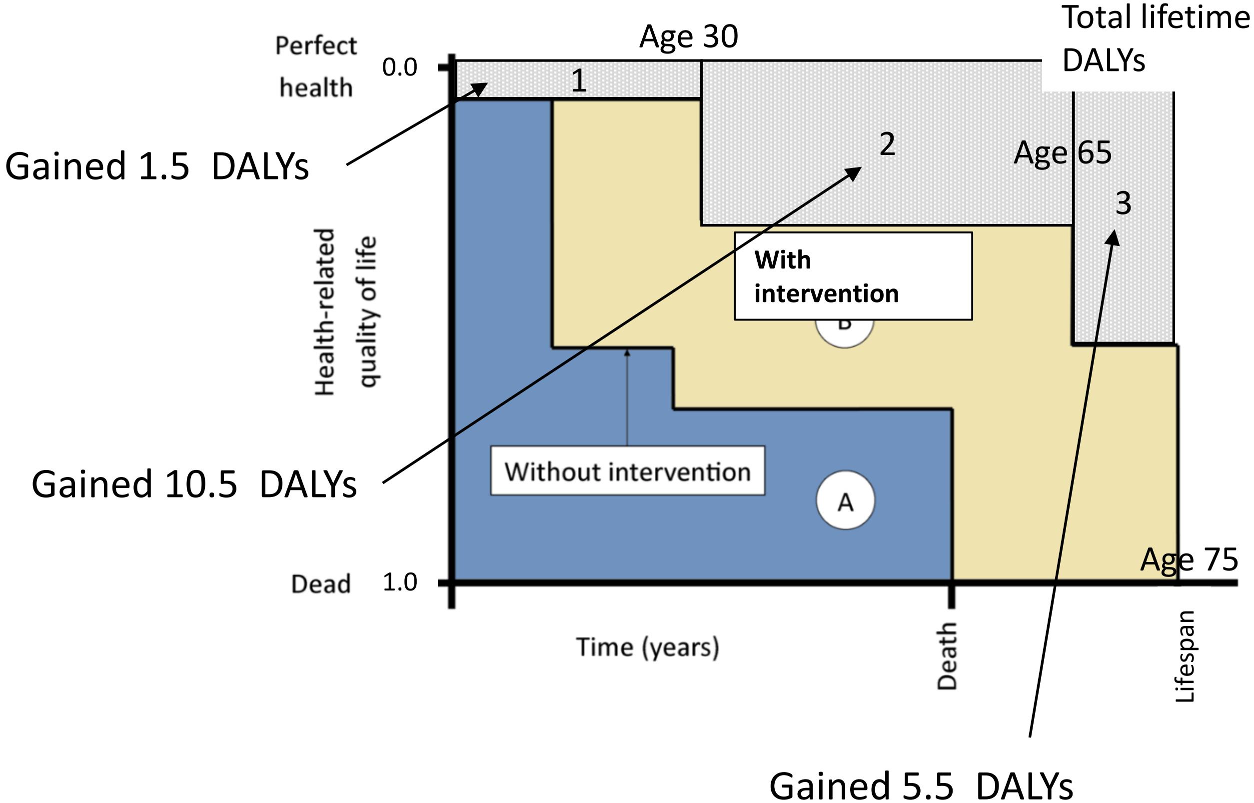
Gained 19.5 DALYs

Gained 20 DALYs

DALYs

30 years at 5% ability lost = 1.5 DALYs
35 years at 30% ability lost = 10.5 DALYs
10 years at 55% ability lost = 5.5 DALYs

Total lifetime DALYs = 17.5 DALYs



Total gain of 30.75 DALYs

Cost-Benefit Analysis (CBA)

Cost-Benefit Analysis (CBA)

- Considered gold standard of economic evaluation
- Estimates both inputs and outcomes in monetary value

  i.e. all costs and outcomes are converted to monetary values

- Compares benefit of different strategies to produce best possible outcome
- Challenge: **WHAT IS THE VALUE OF LIFE?**

CBA and net present value (NPV)

- **Convert all future costs and benefits to present value**

  For more accurate CBA results

- **NPV = $ present value of all benefits - $ present value of all costs**
  - **+NPV:** benefits outweigh the costs
  - **-NPV:** costs outweigh benefit i.e. money-losing intervention

CBA Example

Economic Evaluation of the Routine Childhood Immunization Program in the United States, 2009

AUTHORS: Fangjun Zhou, PhD,[a] Abigail Shefer, MD,[a] Jay Wenger, MD,[a] Mark Messonnier, PhD,[a] Li Yan Wang, MBA,[b] Adriana Lopez, MHS,[a] Matthew Moore, MD, MPH,[a] Trudy V. Murphy, MD,[b] Margaret Cortese, MD,[a] and Lance Rodewald, MD[a]

WHAT'S KNOWN ON THIS SUBJECT: The first evaluation of the economic impact of all vaccines in the routine US childhood immunization schedule assessed the 2001 schedule (excluding pneumococcal conjugate and influenza vaccines) and documented substantial cost savings over the lifetimes of the cohort of

* Zhou et al. Pediatrics. 2014;133:577-85.

Results: Routine childhood immunization

Health outcomes

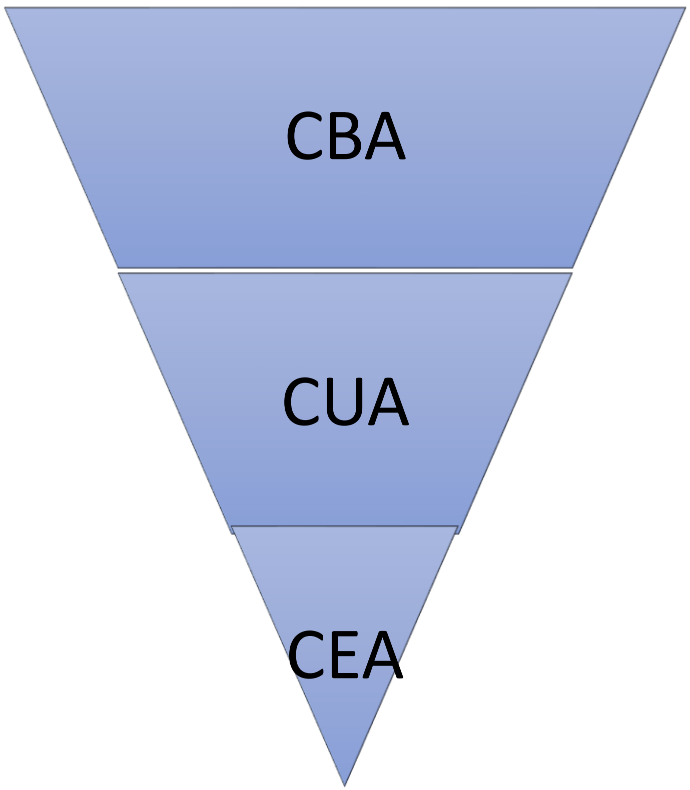
- prevented about 42,000 early deaths
- 20 million cases of disease

Net savings

- $13.5 billion in direct costs
- $68.8 billion in societal costs

WHAT IS THE POLICY IMPLICATION?

CEA, CUA, CBA and Tier of Decision Making



Methods use in the following cases

Case 1:

Allocation of resources to interventions in two sectors of the economy, such as education and health, the outcomes can be converted to common units ($) to make the outcomes comparable (federal level)

CBA

Case 2:

Allocation of limited funds to address public health issues with different outcomes with respect to survival and quality of life (ministry level)

CUA

Case 3:

Decision between two interventions that affect the same health outcome (program level)

CEA

If cost and benefits occur over time

$$\text{Net Present Value} = \sum_{t=0}^{n} \frac{(\text{Benefits - Costs})_t}{(1 + r)^t}$$

where:

r = discount rate

t = year

n = analytic horizon (in years)

Applies to monetary and health outcome results

Syphilis program CEA example

Syphilis intervention example

- In rural Philippines, syphilis in pregnant women accounts for many adverse pregnancy outcomes

- Group of antenatal clinics (n=5) in a high-burden rural area are trying to decide if they should screen and treat pregnant women for syphilis
  - Option 1. Not screen or treat pregnant women (status quo)
  - Option 2. To screen and treat and require $3 from patient
  - Option 3. Treat without screening & require $3 from patient

CEA

- Which option to choose?

Decision tree steps

1. Identify and describe decision problem
2. Identify interventions
3. Identify events/choices within each intervention
4. Fill in each node probability

LECTURE 9

5. Calculate expected value of interventi
6. Choose intervention with best expected value

THIS LECTURE

Framing the Study

1. **Identify the audience(s)**

   Clinic directors, Ministry of Health, public

2. **Define the study question**

   Should antenatal clinics start screening / treating pregnant women for syphilis?

3. **Identify the intervention options**
   - No services (status quo)
   - Screen and treat (more than one way to screen and treat)

4. **Define the perspective**

   Clinic managers i.e. provider perspective

5. **Define time frame and analytic horizon**
   - Time frame: costs incurred throughout a year
   - Analytic horizon: evaluate program over a year

Next steps:

6. **Choose appropriate economic evaluation method**

   Cost-effectiveness analysis

7. **Measure costs (Lecture 10)**

   Cost analysis

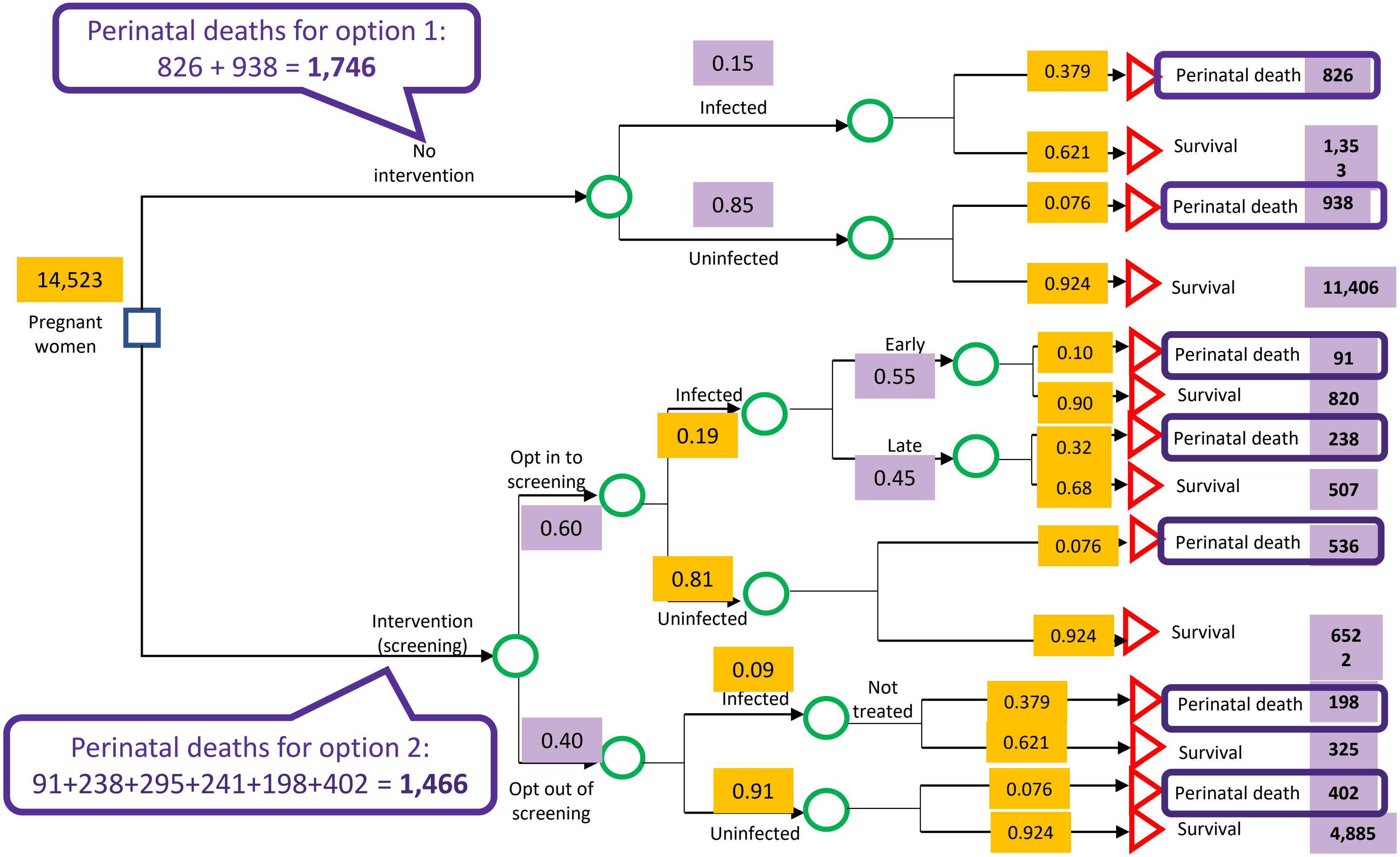
8. **Measure health outcomes (Lecture 8 and 9)**

   Perinatal deaths averted (stillbirths, fetal loss, or neonatal/early infant deaths)

9. **Build model and identify data (Lecture 9)**
10. **Collect and analyze data (Lecture 10)**
11. **Conduct a sensitivity analysis (Lecture 12)**
12. **Write policy brief and present results**

Cost-effectiveness ratio steps

$$\text{CE ratio} = \frac{\text{Costs with intervention} - \text{Costs without intervention}}{\text{Outcome with intervention} - \text{Outcome without intervention}}$$


Perinatal deaths for option 1:
826 + 938 = **1,746**
Perinatal deaths for option 2:
91+238+295+241+198+402 = **1,466**
14,523
Pregnant women
No intervention
0.15
Infected
0.85
Uninfected
0.379
Perinatal death 826
0.621
Survival 1,35 3
0.076
Perinatal death 938
0.924
Survival 11,406
Intervention (screening)
Opt in to screening
0.60
Infected
0.19
Early
0.55
0.10
Perinatal death 91
0.90
Survival 820
Late
0.45
0.32
Perinatal death 238
0.68
Survival 507
0.81
Uninfected
0.076
Perinatal death 536
0.924
Survival 652 2
0.40
Opt out of screening
0.09
Infected
Not treated
0.379
Perinatal death 198
0.621
Survival 325
0.91
Uninfected
0.076
Perinatal death 402
0.924
Survival 4,885

Syphilis program cost, clinic perspective

Total yearly fixed cost: $60,000
Cost per screened patient: $3.65
Cost per treated patient: $2.00

Number of screened patients: 8,714
Number of treated patients: 1,656

Total yearly expense = fixed costs + variable costs
$95,118 = ($60,000) + ($3.65 * 8,714) + ($2.00 * 1,656)

Total clinic revenue = income from patient * number screened
$26,142 = $3.00 * 8,714

Total syphilis program cost = expense - revenue
$68,976 = **$95,118** - **$26,142**

Total cost per patient screened = Total program cost / number of screened patients
$7.92 = **$68,976** / 8,714

Collect and analyze data

Intervention options	Cost	Outcome
Option 1: no intervention	$0	1764
Option 2: screen and treat	$68,976	1466
Difference	**$68,976**	**- 298***

*** means 298 perinatal deaths averted**

$$\textbf{CE ratio} = \frac{\text{Costs with intervention} - \text{Costs without intervention}}{\text{Outcome with intervention} - \text{Outcome without intervention}} = \frac{\$68{,}976 - \$0}{-298} = -231.46$$

CE ratio of screen and treat is $231.46 per perinatal death averted

We are not done yet!

- This is one way to calculate the CE
- Although simple, it can has disadvantages
  - Not systematic
    - Requires you to look throughout the tree
    - More prone to errors, especially in large trees
  - Cannot identify or quantify where major costs or disease burden occur in the intervention
  - Not how researchers calculate it

Syphilis program expected value CE ratio

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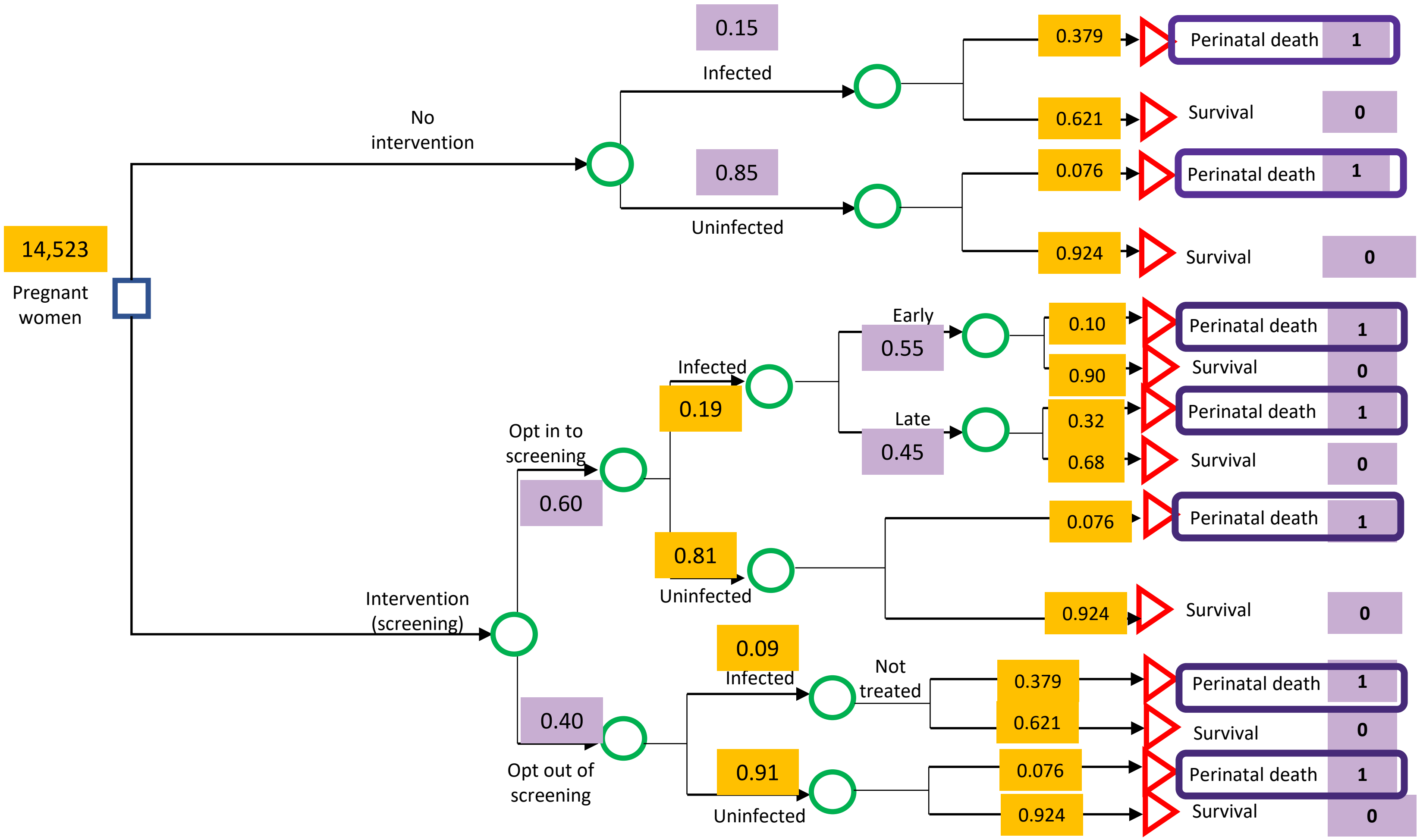
Cost and outcome expected value calculation

1. **Assign 0 to 1 values to outcomes**
   - life v. death outcomes, values can be: life = 1 & death = 0, or death = 1 & life = 0
   - Syphilis example: perinatal death = 1 & survive = 0
2. **Assign monetary values (ex: dollar values) to outcome group**

   Based on cost tables (see example)
3. **Calculate expected outcome and cost values**

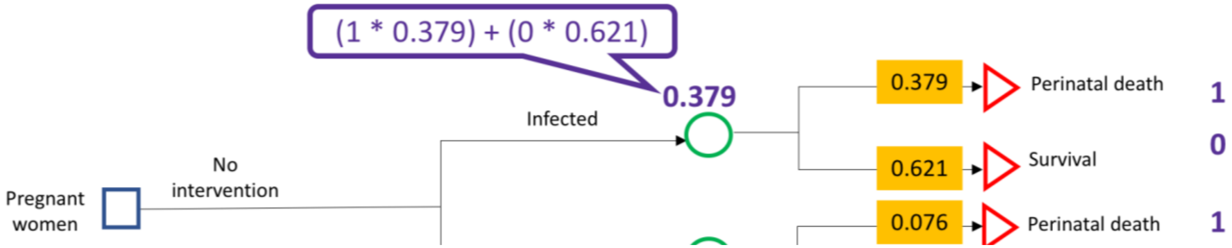
   We will do this step by step later with the decision tree
4. **Divide expected cost value by expected outcome value to get expected CE ratio**



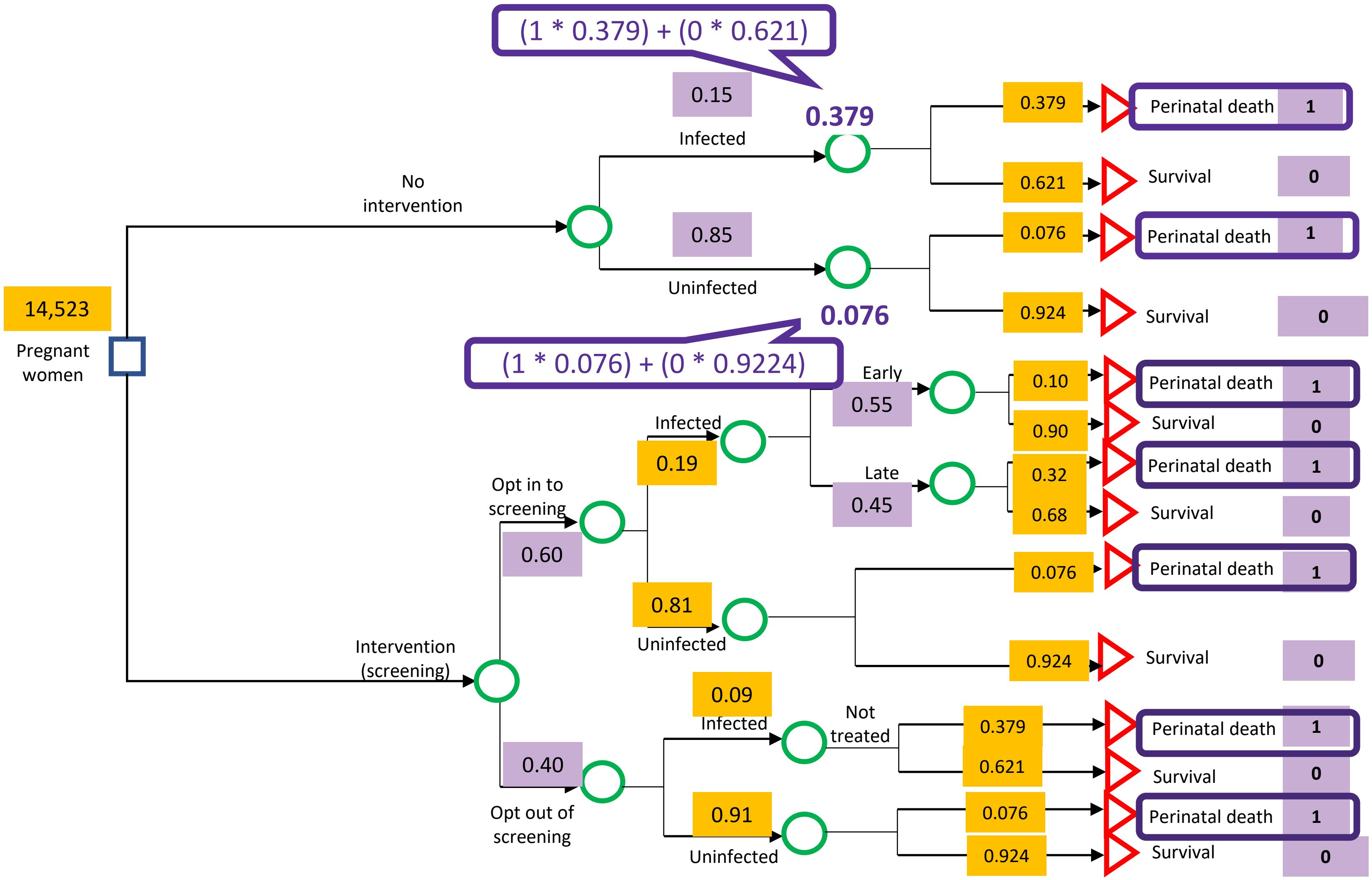
14,523
Pregnant women
No intervention
0.15
Infected
0.85
Uninfected
0.379
Perinatal death 1
0.621
Survival 0
0.076
Perinatal death 1
0.924
Survival 0
Intervention (screening)
Opt in to screening
0.60
0.19
Infected
Early
0.55
0.10
Perinatal death 1
0.90
Survival 0
Late
0.45
0.32
Perinatal death 1
0.68
Survival 0
0.81
Uninfected
0.076
Perinatal death 1
0.924
Survival 0
0.40
Opt out of screening
0.09
Infected
Not treated
0.379
Perinatal death 1
0.621
Survival 0
0.91
Uninfected
0.076
Perinatal death 1
0.924
Survival 0

Calculate expected outcomes

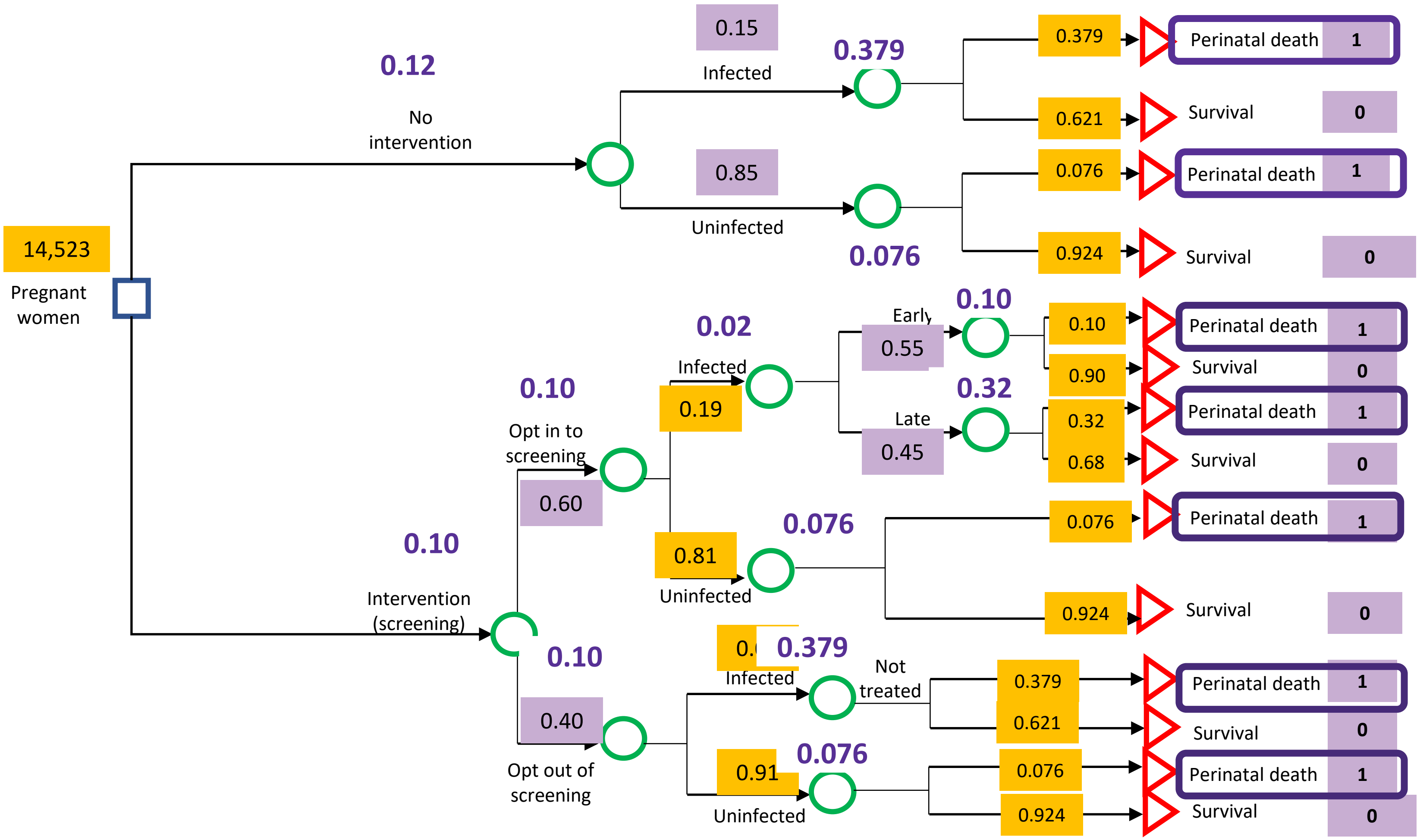
- **Start from terminal node**
  Right end of decision tree
- **Calculate expected average at node to the left**
  Multiply outcome value (1 or 0) with the probability of the outcome occurring



- **Repeat calculation concept until the left end of the tree** (i.e. intervention choice node)



(1 * 0.379) + (0 * 0.621)
0.15
0.379
Infected
No intervention
0.85
Uninfected
0.076
(1 * 0.076) + (0 * 0.9224)
14,523
Pregnant women
0.379
Perinatal death 1
0.621
Survival 0
0.076
Perinatal death 1
0.924
Survival 0
Early
0.55
Infected
0.19
Late
0.45
Opt in to screening
0.60
0.81
Uninfected
Intervention (screening)
0.10
Perinatal death 1
0.90
Survival 0
0.32
Perinatal death 1
0.68
Survival 0
0.076
Perinatal death 1
0.924
Survival 0
0.09
Infected
Not treated
0.40
Opt out of screening
0.91
Uninfected
0.379
Perinatal death 1
0.621
Survival 0
0.076
Perinatal death 1
0.924
Survival 0


14,523
Pregnant women
0.12
No intervention
0.15
Infected
0.379
0.379
Perinatal death
1
0.621
Survival
0
0.85
Uninfected
0.076
0.076
Perinatal death
1
0.924
Survival
0
0.10
Intervention (screening)
0.10
Opt in to screening
0.60
0.02
Infected
0.19
Early
0.55
0.10
0.10
Perinatal death
1
0.90
Survival
0
Late
0.45
0.32
0.32
Perinatal death
1
0.68
Survival
0
0.81
Uninfected
0.076
0.076
Perinatal death
1
0.924
Survival
0
0.10
0.40
Opt out of screening
0.379
Infected
Not treated
0.379
Perinatal death
1
0.621
Survival
0
0.91
Uninfected
0.076
0.076
Perinatal death
1
0.924
Survival
0

Average outcomes v. expected outcomes

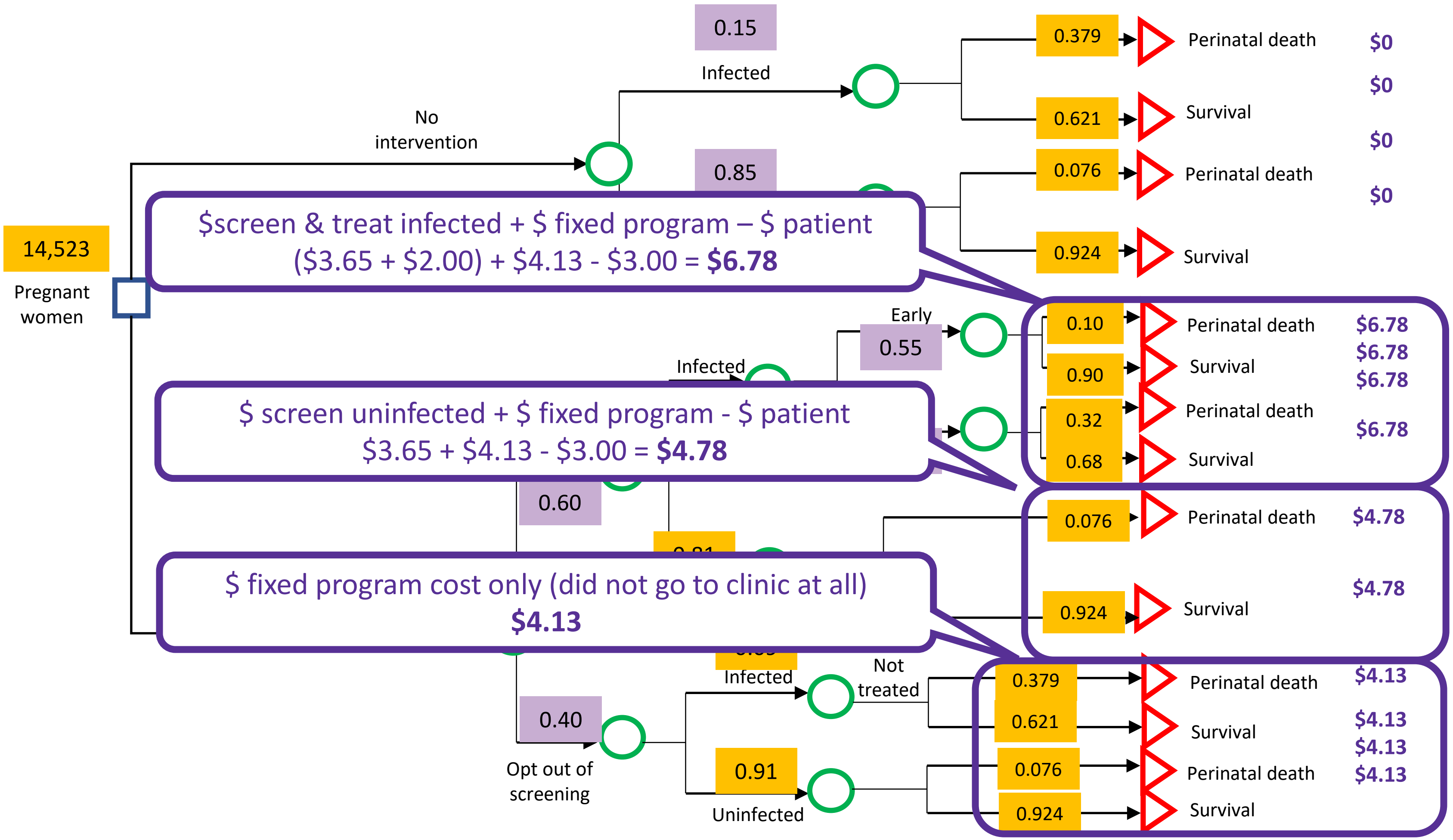
Intervention options	unweighted	weighted
Option 1: no intervention	1,764/14,523 = 0.12 or 12 per 100	0.12 or 12 per 100
Option 2: screen and treat	1,466/14,523 = 0.10 or 10 per 100	0.10 or 10 per 100

- **The average and expected outcomes are the same**
  Because outcome values are 1 or 0
- **Expected outcomes required when outcome values are not 1 or 0**
  e.g. CUA with DALYs: different average and expected outcomes

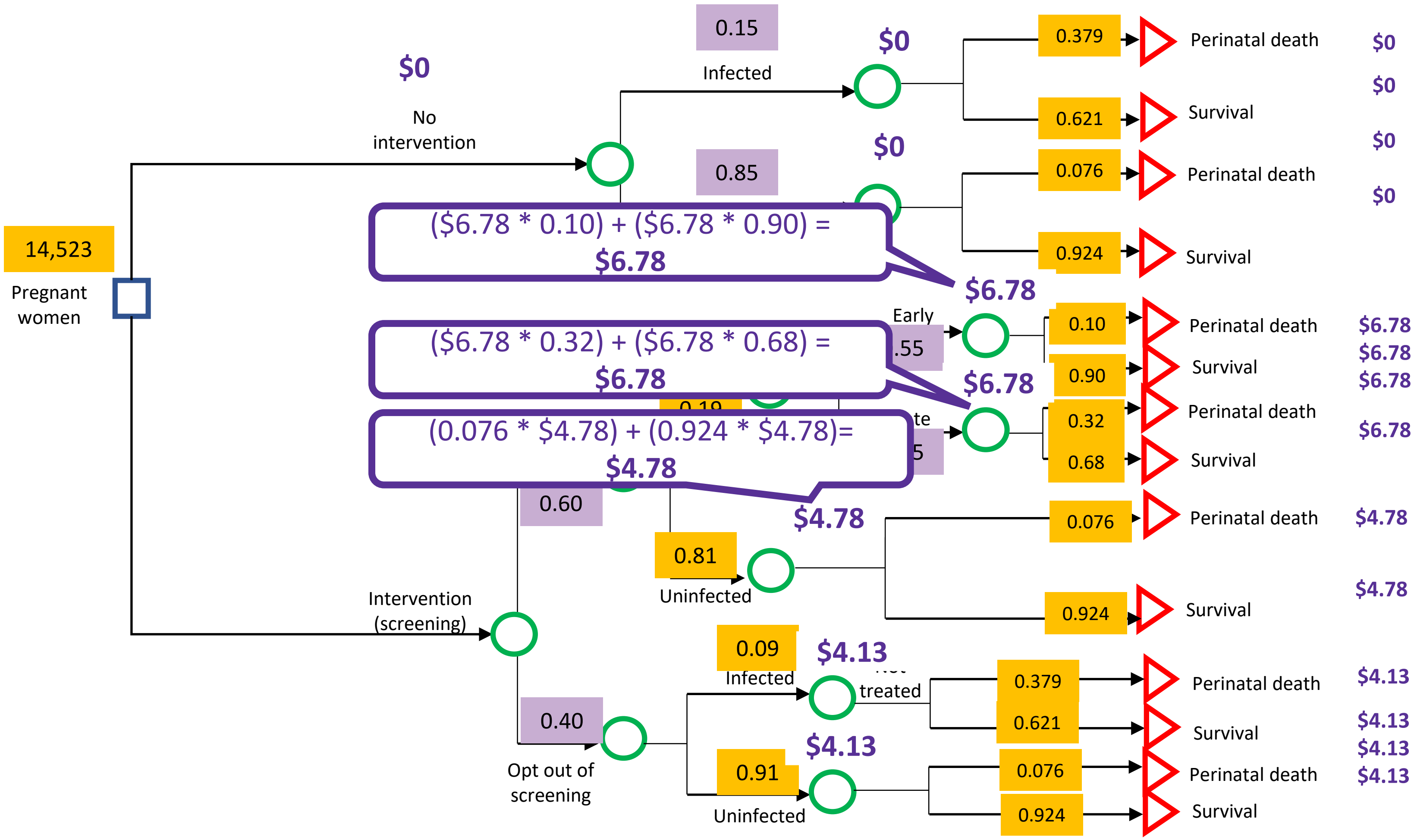
Expected cost calculation

Costs	**No Intervention**	**Screen & Treat**
Cost to clinic to screen an uninfected person	$0	$3.65
Cost to clinic to screen & treat an infected person	$0	$5.65
Fixed cost of program/target population person ($)	$0	$4.13
Paid by patient ($)	$0	($3.00)

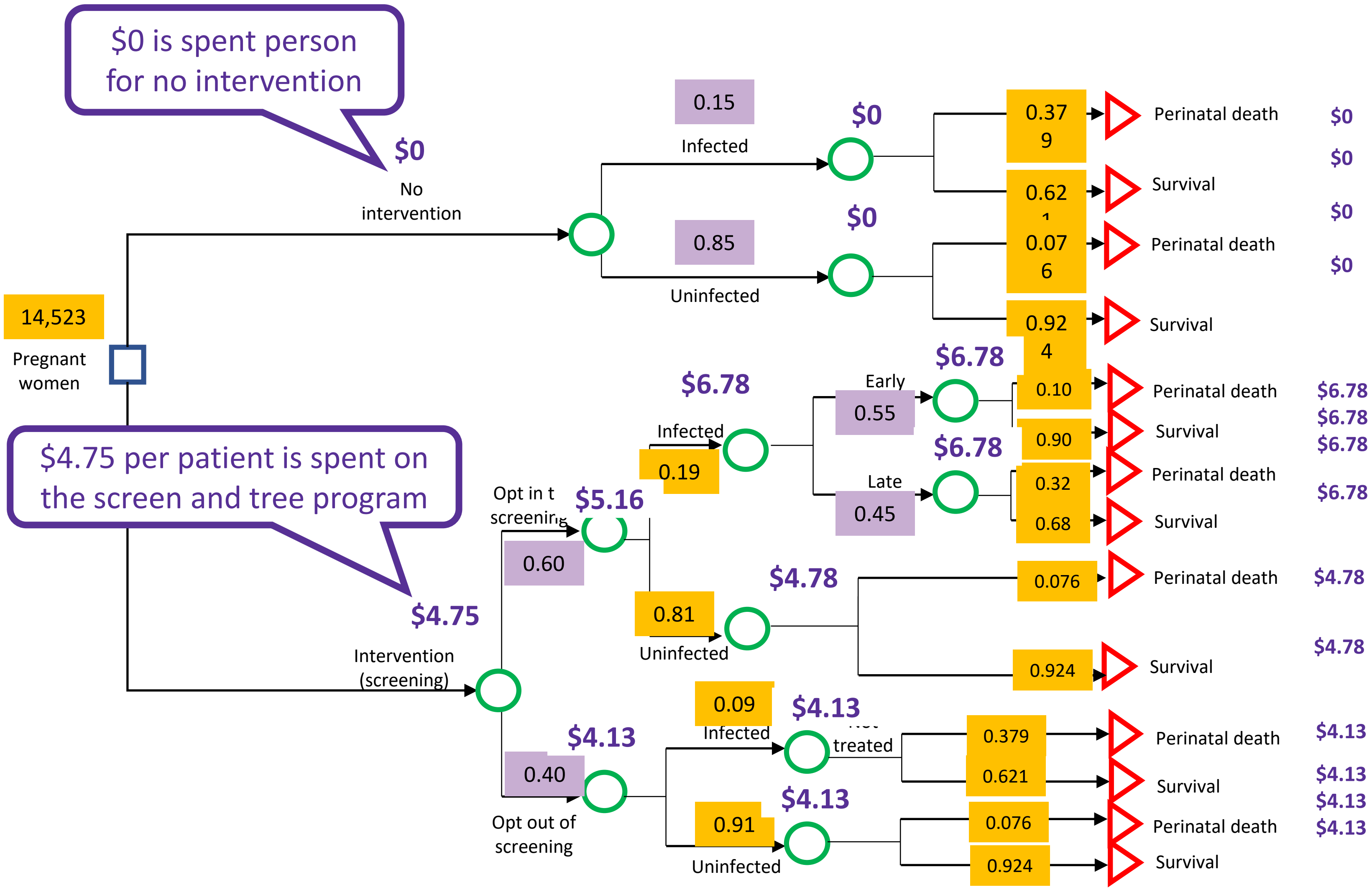
- **Look at each branch individually**
- **Determine the per person cost for each final outcome**
  At the right end of the decision tree
- **Multiply each per person cost with the outcome's probability**
- **Add the per person cost for each node**



14,523
Pregnant women
No intervention
0.15
Infected
0.85
0.379
Perinatal death
0.621
Survival
0.076
Perinatal death
0.924
Survival
$0
$0
$0
$0
$screen & treat infected + $ fixed program – $ patient
($3.65 + $2.00) + $4.13 - $3.00 = $6.78
Early
0.55
Infected
0.10
Perinatal death
0.90
Survival
0.32
Perinatal death
0.68
Survival
$6.78
$6.78
$6.78
$6.78
$ screen uninfected + $ fixed program - $ patient
$3.65 + $4.13 - $3.00 = $4.78
0.60
0.076
Perinatal death
0.924
Survival
$4.78
$4.78
$ fixed program cost only (did not go to clinic at all)
$4.13
0.40
Opt out of screening
Infected
Not treated
0.91
Uninfected
0.379
Perinatal death
0.621
Survival
0.076
Perinatal death
0.924
Survival
$4.13
$4.13
$4.13
$4.13



14,523
Pregnant women
$0
No intervention
0.15
Infected
$0
0.379
Perinatal death
$0
0.621
Survival
$0
0.85
$0
0.076
Perinatal death
$0
0.924
Survival
$0
($6.78 * 0.10) + ($6.78 * 0.90) = $6.78
$6.78
Early
.55
0.10
Perinatal death
$6.78
0.90
Survival
$6.78
($6.78 * 0.32) + ($6.78 * 0.68) = $6.78
$6.78
0.32
Perinatal death
$6.78
0.68
Survival
$6.78
(0.076 * $4.78) + (0.924 * $4.78)= $4.78
0.60
$4.78
0.076
Perinatal death
$4.78
0.81
Uninfected
0.924
Survival
$4.78
Intervention (screening)
0.09
Infected
$4.13
treated
0.379
Perinatal death
$4.13
0.621
Survival
$4.13
0.40
Opt out of screening
0.91
Uninfected
$4.13
0.076
Perinatal death
$4.13
0.924
Survival
$4.13



$0 is spent person for no intervention
$4.75 per patient is spent on the screen and tree program
14,523
Pregnant women
$0
No intervention
$4.75
Intervention (screening)
0.15
Infected
$0
0.85
Uninfected
$0
0.379
0.621
0.076
0.924
Perinatal death
Survival
Perinatal death
Survival
$0
$0
$0
$0
Opt in t screening
$5.16
0.60
0.19
Infected
$6.78
Early
0.55
$6.78
Late
0.45
$6.78
0.10
0.90
0.32
0.68
Perinatal death
Survival
Perinatal death
Survival
$6.78
$6.78
$6.78
$6.78
0.81
Uninfected
$4.78
0.076
0.924
Perinatal death
Survival
$4.78
$4.78
0.40
Opt out of screening
$4.13
0.09
Infected
$4.13
treated
0.91
Uninfected
$4.13
0.379
0.621
0.076
0.924
Perinatal death
Survival
Perinatal death
Survival
$4.13
$4.13
$4.13
$4.13

Choose intervention with best expected value

Intervention options	Cost	Outcome
Option 1: no intervention	$0	12 perinatal death per 100 women
Option 2: screen and treat	$4.75	10 perinatal death per 100 women

$$\textbf{Expected CE ratio} = \frac{\$4.75 - \$0}{0.10 - 0.12} = -237.50$$

Expected CE ratio of screen & treat is $237.50 per perinatal death averted

$$\textbf{Average CE ratio} = \frac{\$68{,}976 - \$0}{1466 - 1764} \quad -231.46$$

Ave CE ratio of screen & treat is $231.46 per perinatal death averted

Why difference in ratio? Rounding errors. Expected value in Excel is -$231.46

Is “screen & treat” worth it?

- Is an infant’s life worth $237.50?
- Screen and treat will cost $68,976 for a year implementation
  - Is this within our budget?
- Do we have enough information to make a decision?

What if $237.50 per death averted is too much?

- **Aim to increase the % of women who opt to screen**
  - $ incentives?
  - Reduced screening cost?
- **Aim to increase the % of women who present early for treatment**
  - Media campaign?
  - Community engagement of childbearing women?
  - How much more $?
- **Conduct additional or alternative analysis**
  - Years of Life Lost …
  - Evaluate morbidity outcomes in addition to mortality outcomes and conduct a CUA

Years of life gained

- **Years of life lost = Age of death – Average life expectancy**
  - Age of death is approximately 0 because outcome is perinatal death
  - Life expectancy in rural Philippines is 69 years
  - You lose 69 years of life for each infant who dies
- **Screen & treat results in 298 perinatal deaths averted**
- **Screen & treat implementation results in 20,562 years of life gained**

  Years of life gained = 298 death averted * 69 years
- **Screen and treat costs $3.35 per year of life gained**

  Cost per year of life gained = $68,976 / 20,562

END

Bloomberg Philanthropies DATA FOR HEALTH INITIATIVE D2P Data to Policy CDC Foundation Together our impact is greater Vital Strategies