

Economic Evaluation

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



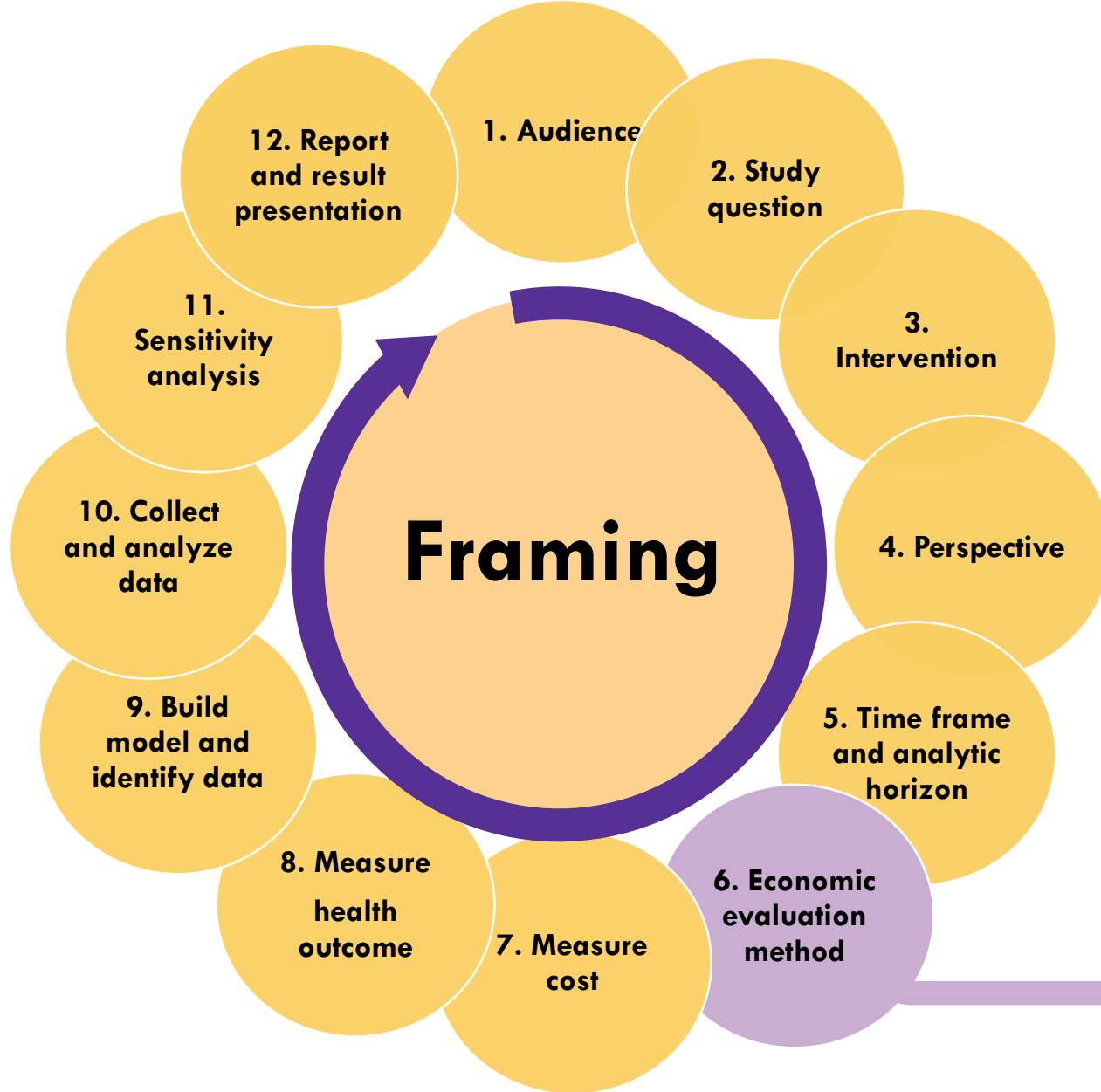
Therefore, we **RECOMMEND POLICY X**

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
- Perform a basic cost-effectiveness analysis







*“The dissemination of **accurate information** on **costs** and **benefits** may be the best way to **reduce** opposition and implement **effective** public health actions.”*

- Dr. Thomas Frieden, NEJM, 2013

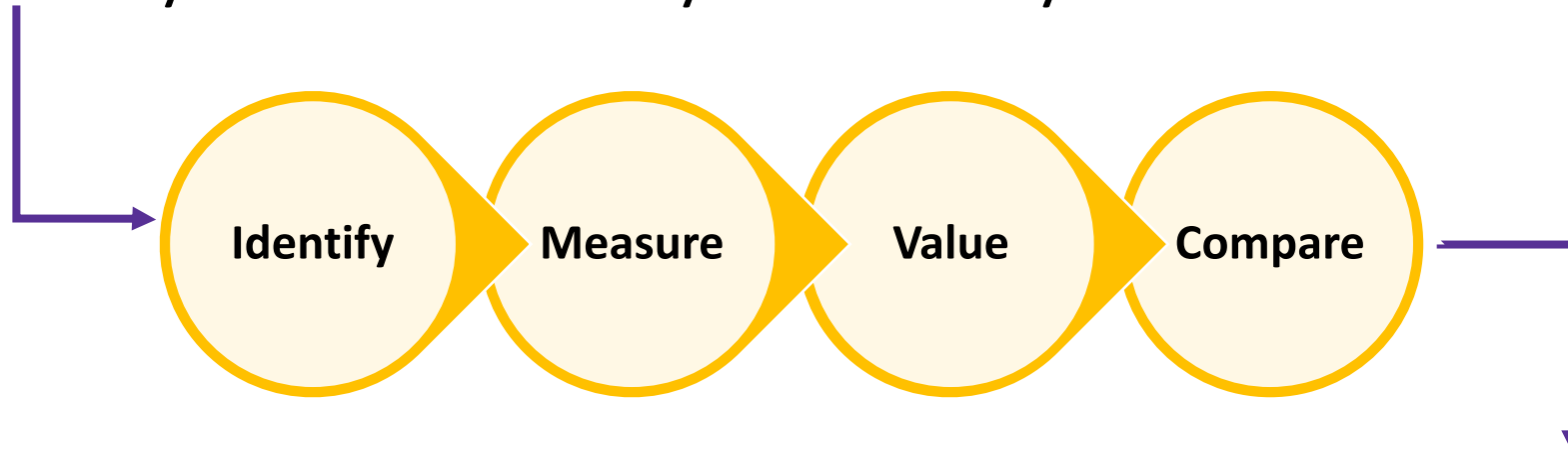
WHAT IS ECONOMICS?



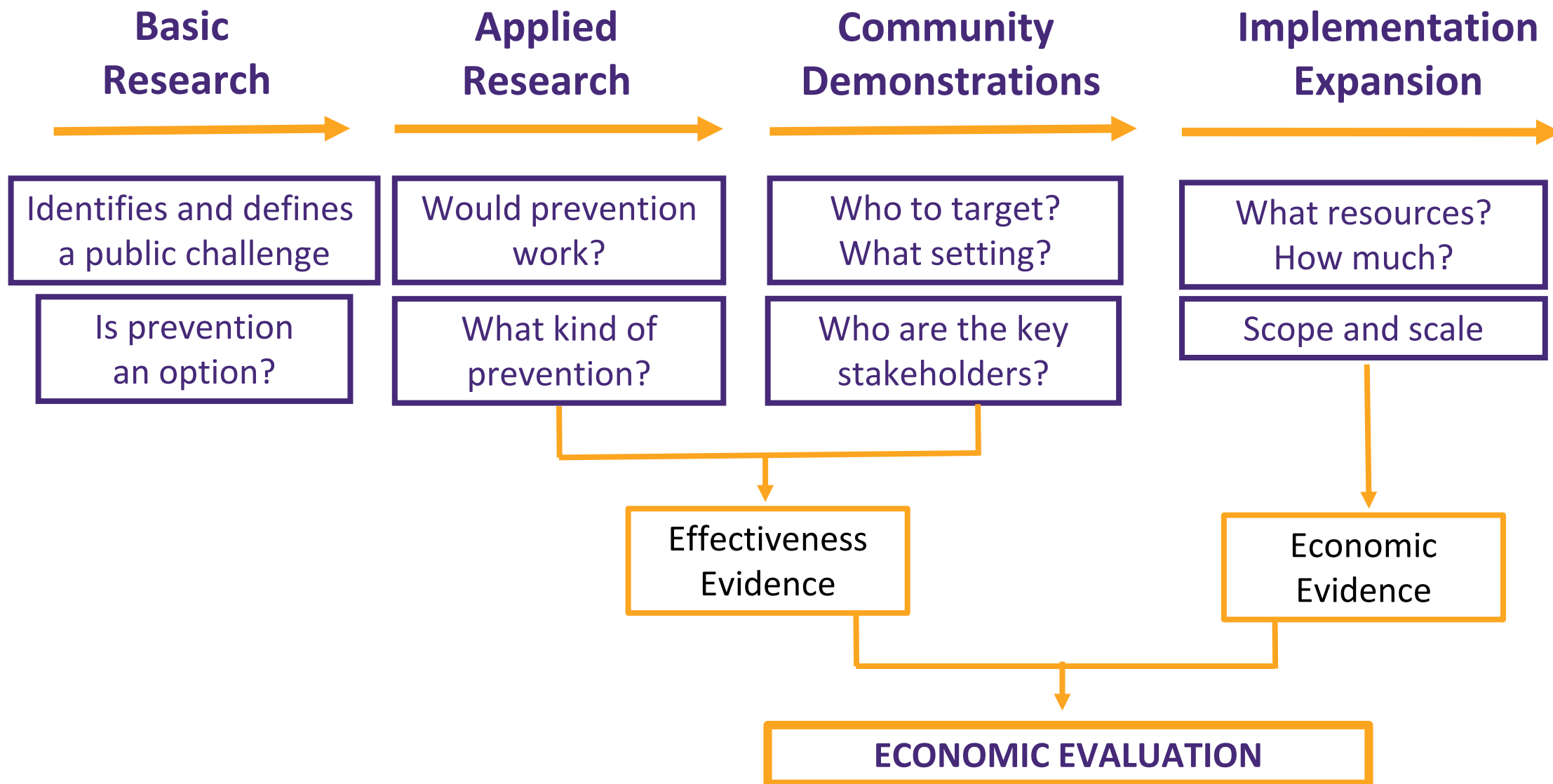
- It is **NOT** about money
- It is the study of decisions

Brief review – economic evaluation

Applied analytic methods to systematically:

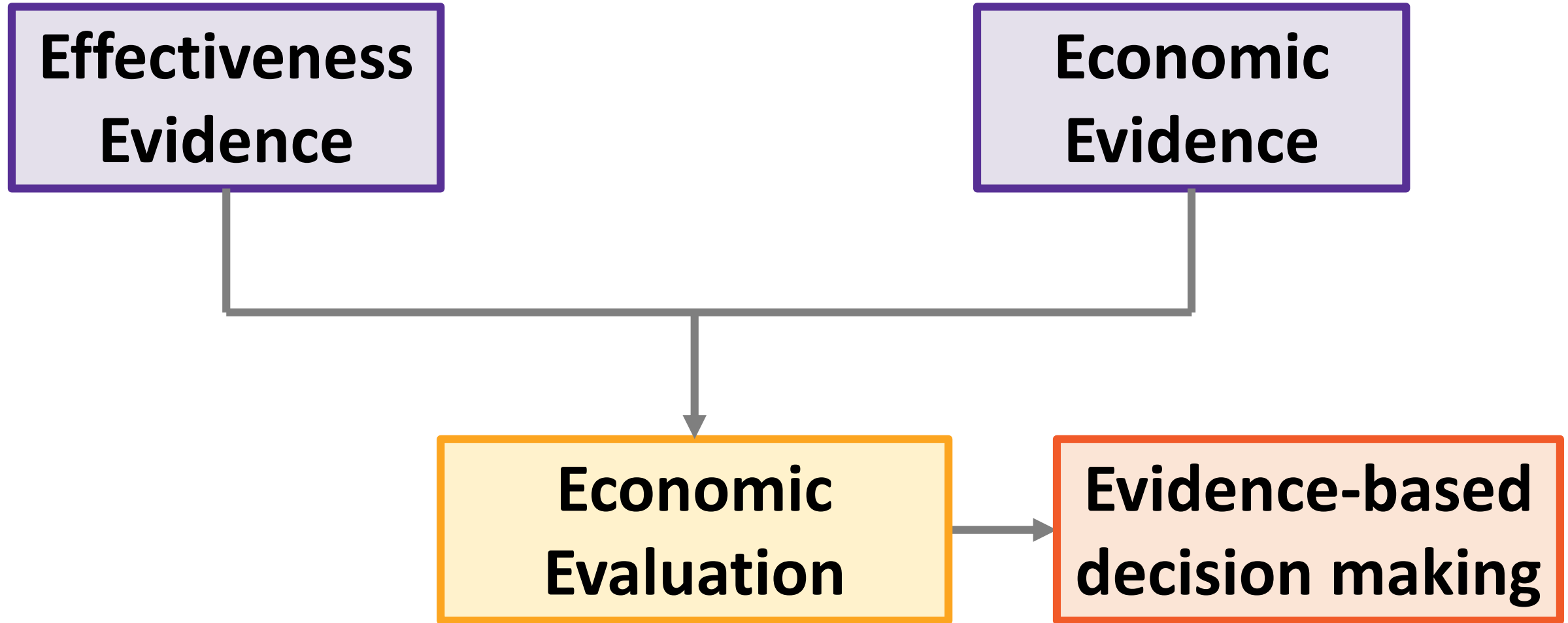


The **costs and consequences** of public health interventions, programs, etc.



Why effectiveness in economic evaluation?

“To establish **an effective intervention package**, it is critical to understand the full range of available evidence-based strategies, the **size and characteristics of the population to be reached, the projected impact of each intervention,** and the estimated cost.” - Frieden (AJPH, 2013)



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

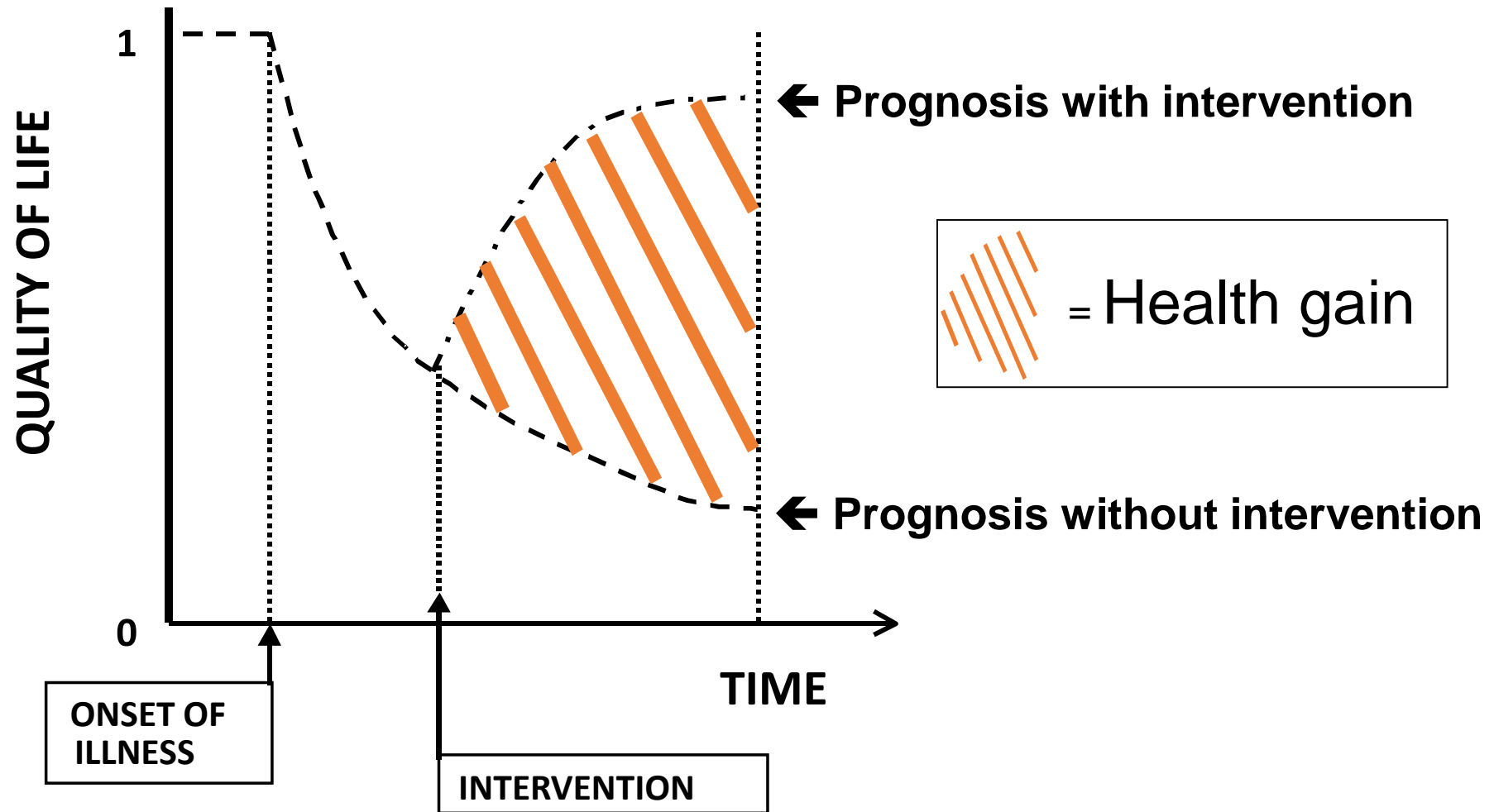
- Systematic reviews (The Community Guide, Cochrane)
- Peer-reviewed journal articles (PubMed)
- Surveillance data (Behavioral Risk Factor Surveillance System)
- Program evaluations
- Qualitative data
 - Community members
 - Other stakeholders
- Media/marketing data
- Expert opinion
- Word of mouth
-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

OBJECTIVE

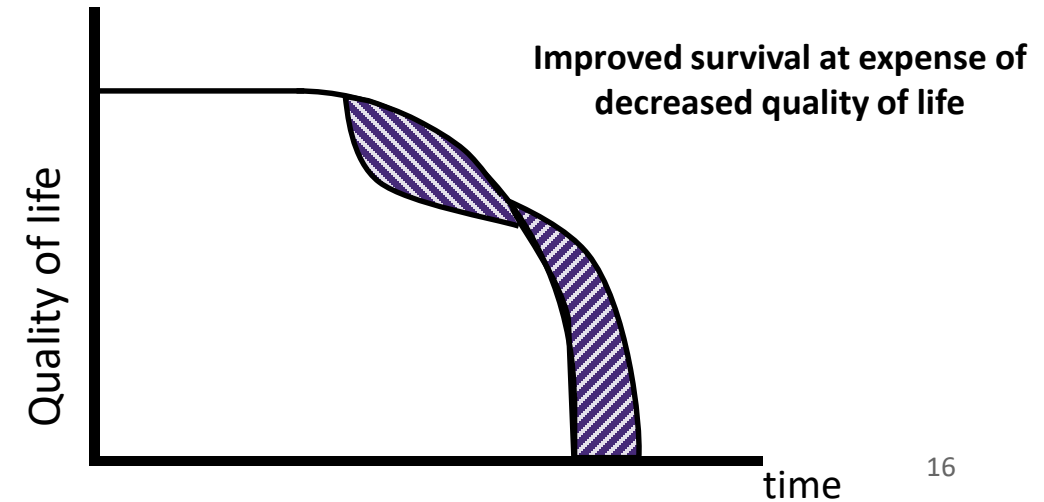
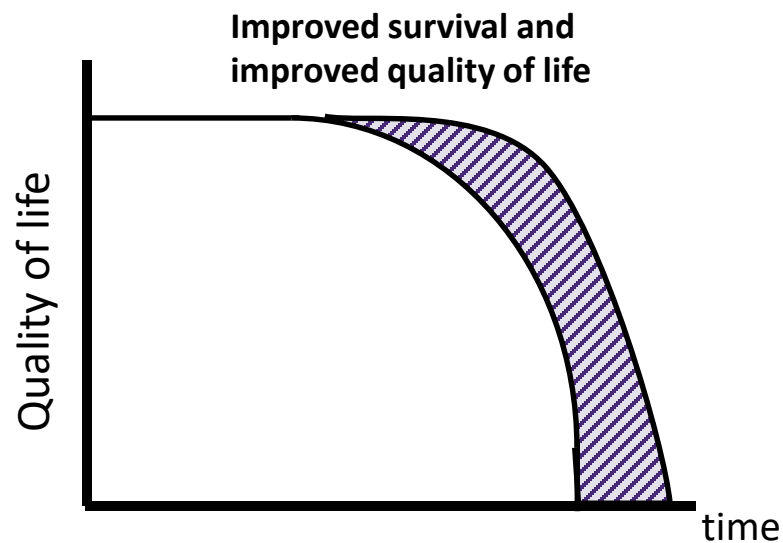
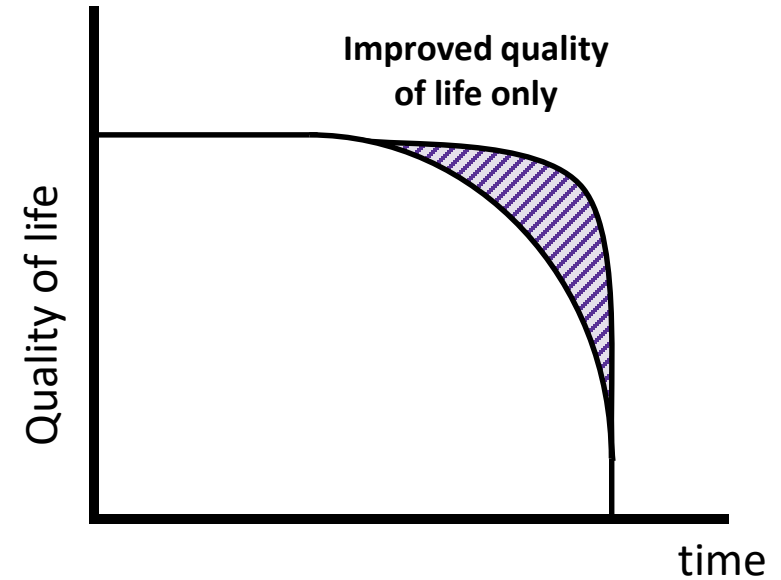
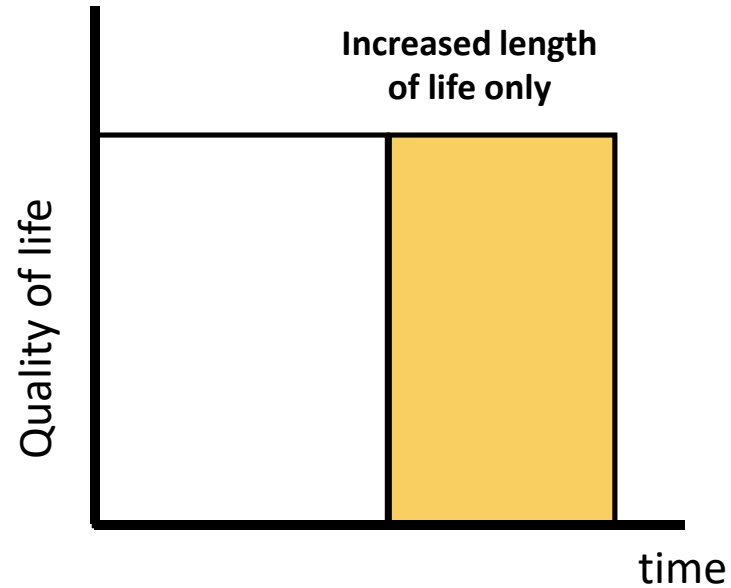


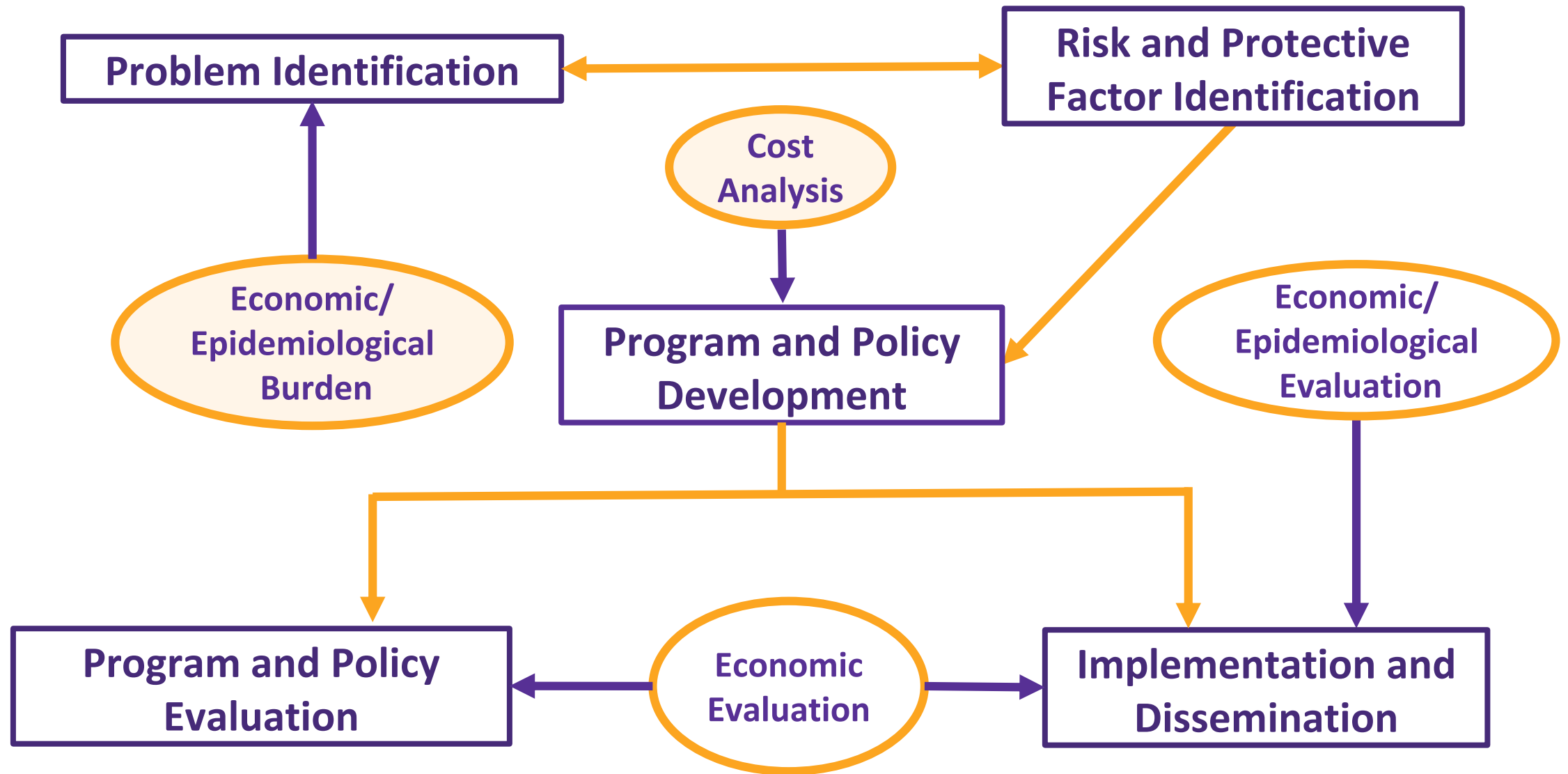
SUBJECTIVE

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)

Most likely to be used

Type	Description	Measures	Decision level
PARTIAL ECONOMIC EVALUATION			
Cost of illness analysis	Disease economic burden	Net cost (\$)	Public health decision-makers at the local, state, and national levels
Program cost analysis	Net program cost	Net cost (\$)	Public health decision-makers at the local, state, and national levels First step to CEA, CUA, and CBA
FULL ECONOMIC EVALUATION			
Cost-benefit analysis (CBA)	Compares different programs with different outcomes (e.g., health vs. other area)	Benefit-cost ratio (\$benefit: \$cost)	National level and broader perspective, such as the President and Congress (e.g.,: Congress needs to decide between investments in health or investments for another program)
Cost-effectiveness analysis (CEA)	Compares interventions with the same outcomes (ex: between two cervical cancer interventions)	Cost-effectiveness ratio (\$per case averted)	Program level (ex: a cancer program director decides to fund one of two possible cervical cancer prevention interventions)
Cost utility analysis (CUA)	Compares interventions with different health outcomes (ex: cervical cancer vs. Alzheimer's disease)	Cost-utility ratio (\$per QALY saved)	Agency level (ex: the CDC or a local health agency director decides between funding cervical cancer or Alzheimer's disease interventions)

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

Marginal CE ratio (MCER)

- Ratio of additional costs to outcomes obtained from one additional unit of an intervention

Incremental CE ratio (ICER)

- Ratio of additional costs to outcomes obtained when one program is compared with the next least effective program

Weighted CE ratio

$$\text{CE ratio} = \frac{\text{Net cost}}{\text{Net outcome}}$$

- "Weighted" cost-effectiveness ratio
 - Like crude odds ratio
 - Previous calculation of the CE ratio was simple
 - Calculating the **expected costs and outcomes** provides the same answer, but:
 - More systematic
 - Less room for error
 - More exact
 - Easier for more complicated analyses

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

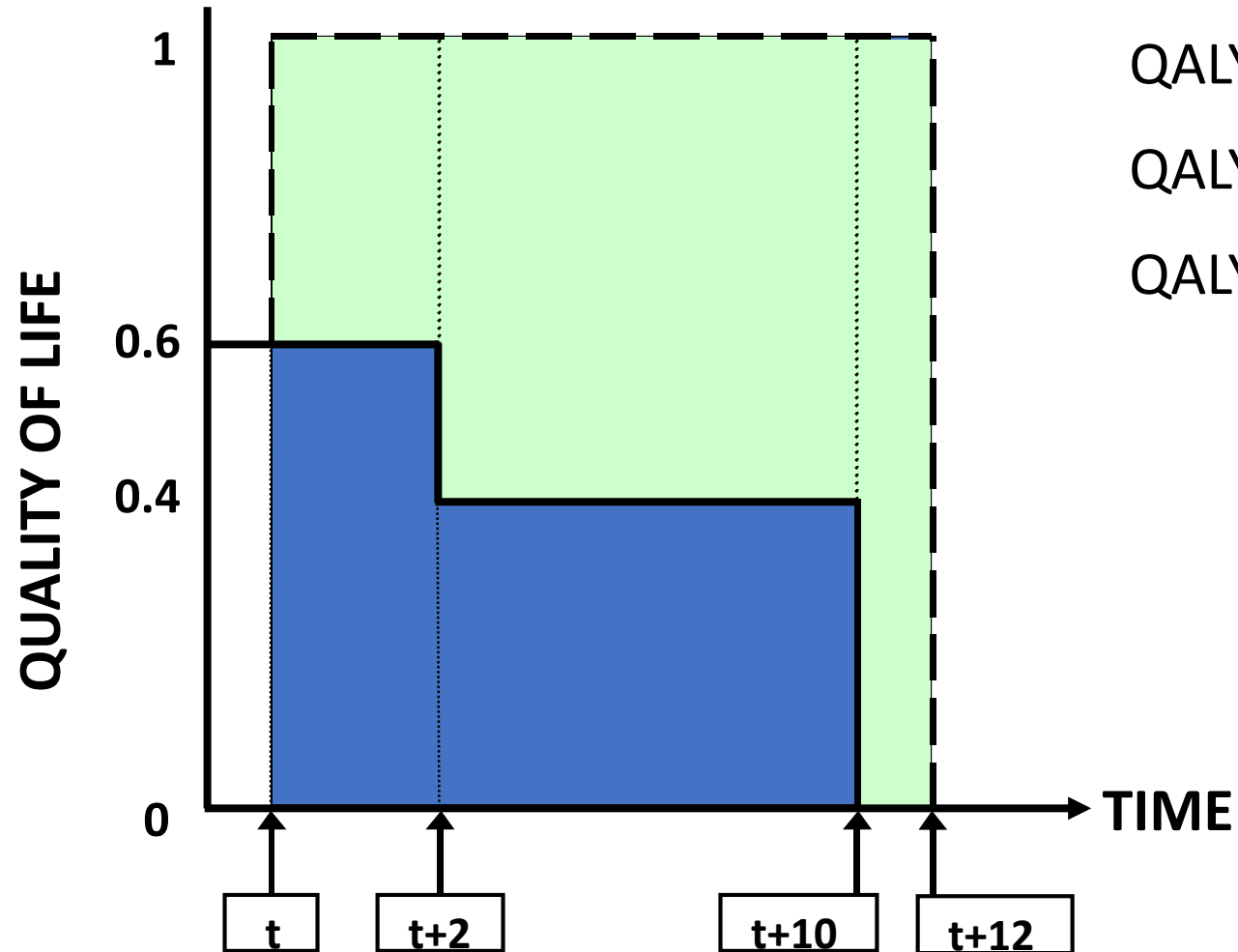
CUA Measures

- **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 (briefly)

- **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



$$\text{QALY without} = 2 \times 0.6 + 8 \times 0.4 = 4.4$$

$$\text{QALY with} = 12 \times 1 = 12$$

$$\text{QALY gain} = 12 - 4.4 = 7.6$$

$$\begin{aligned} \text{QALY gain} &= 2 \times 0.4 \\ &+ 8 \times 0.6 \\ &+ 2 \times 1.0 \\ &= 7.6 \end{aligned}$$

Disability Adjusted Life Year – DALY (briefly)

- Total burden of disease: morbidity and mortality
- 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

$$\text{DALY} = \text{YLL} + \text{YLD}$$

- YLL: Years of Life Lost
- YLD: Years lost due to disability

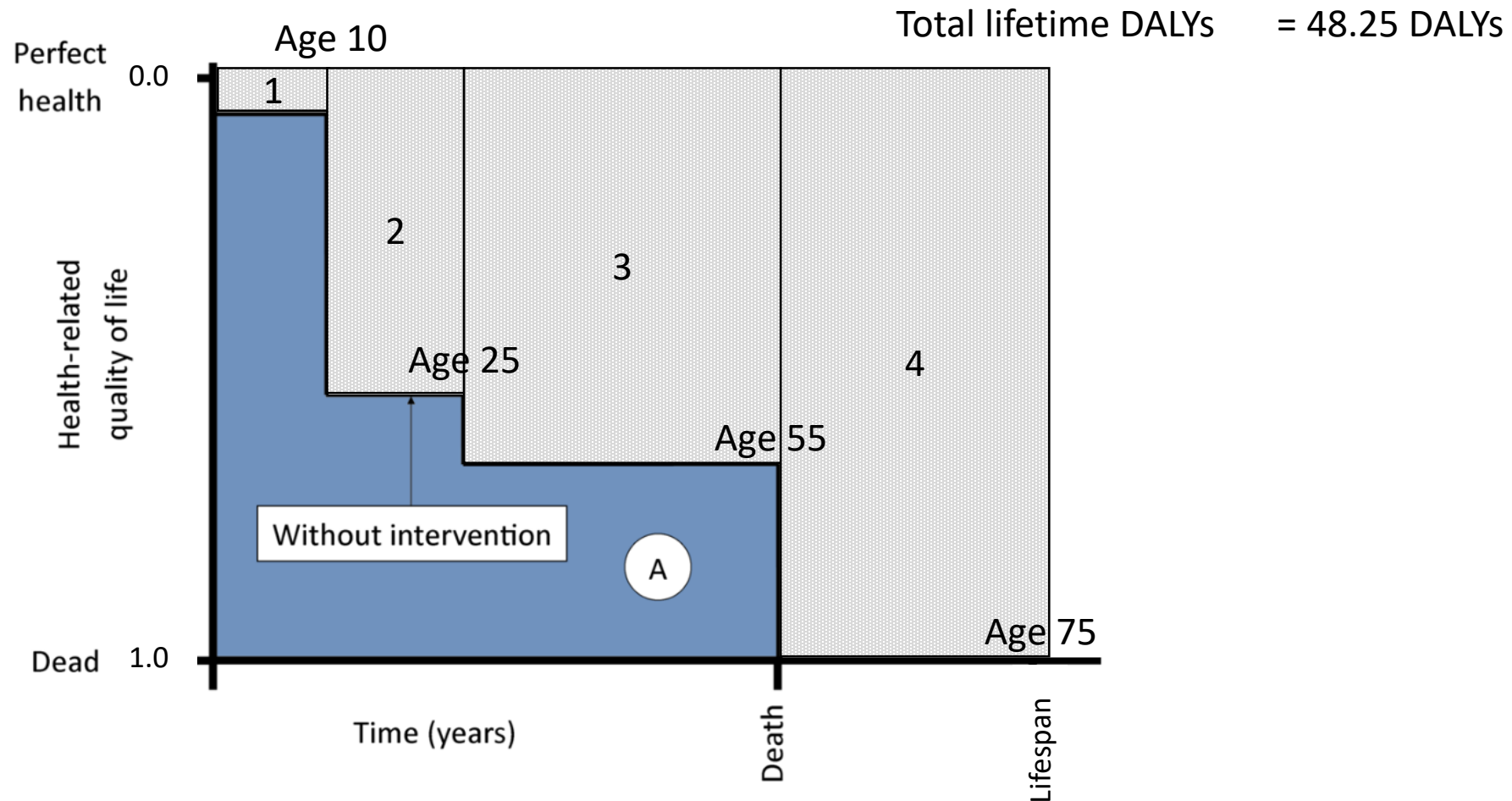
DALYs

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



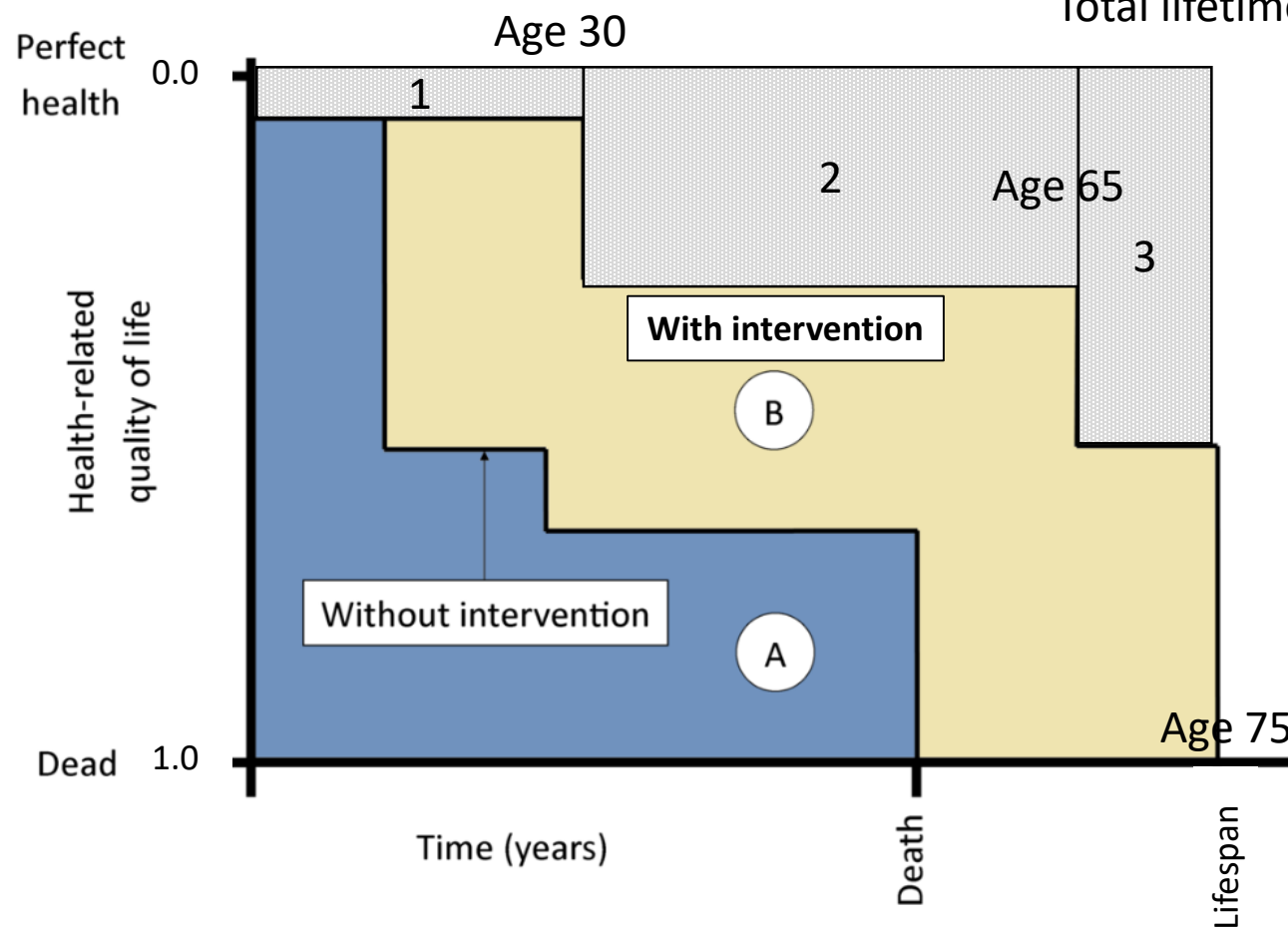
DALYs

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 (BCA)

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

CBA formula

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

where:

r = discount rate

t = year

n = analytic horizon (in years)

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



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?

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
- Which option to choose?

CEA

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

LECTURE 9

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)

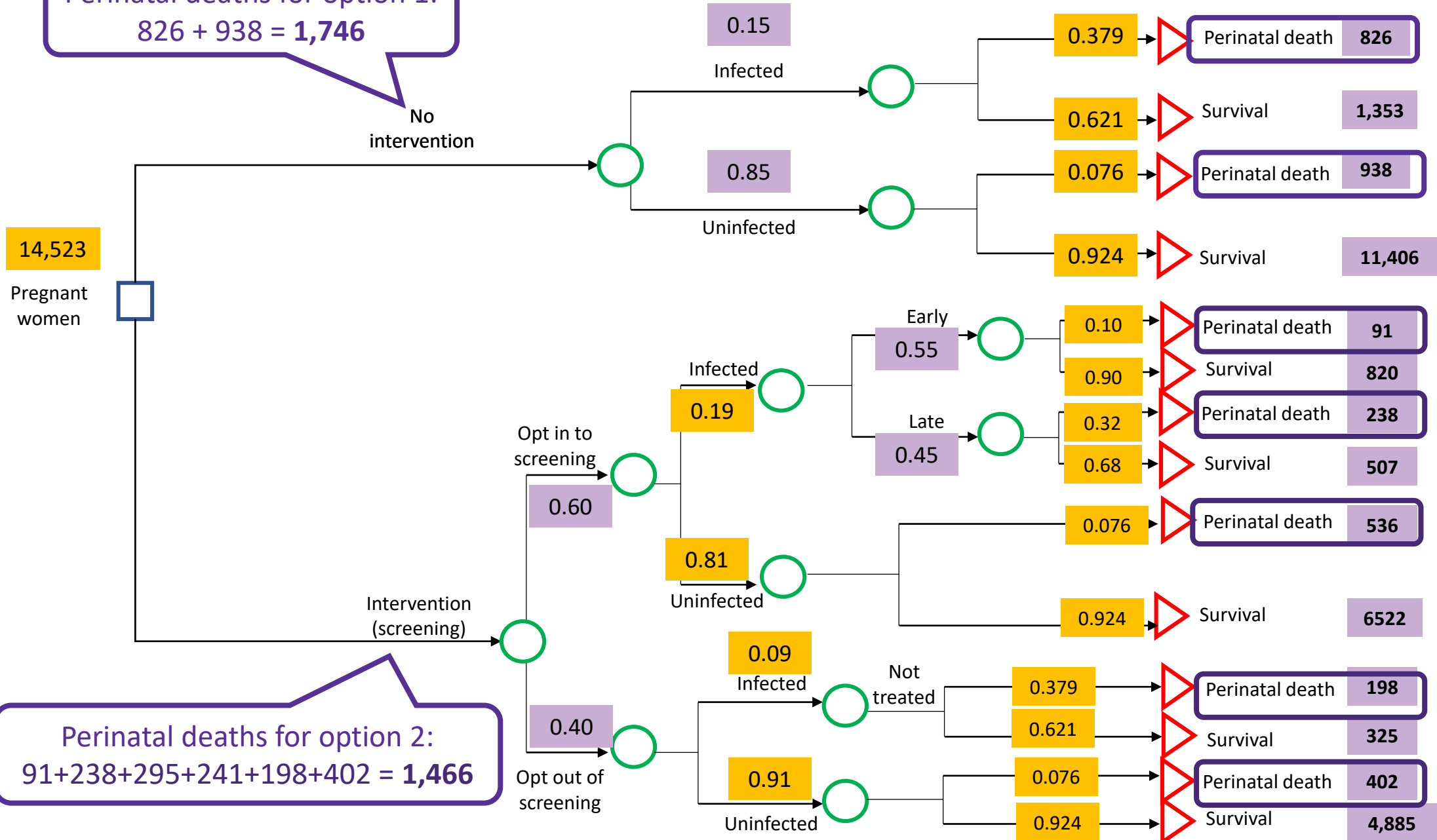
11. Conduct a sensitivity analysis (Lecture 12)

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**



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**

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

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

We are not done yet!

- **Crude CE ratio v. weighted CE ratio**
 - \$231.46 per perinatal death averted is a crude CE ratio
- **Need to calculate population level weighted value i.e. *expected value***
 - Need an *expected* cost per person
 - Need a total *expected* outcomes per population and sub population

Syphilis program weighted CE ratio

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

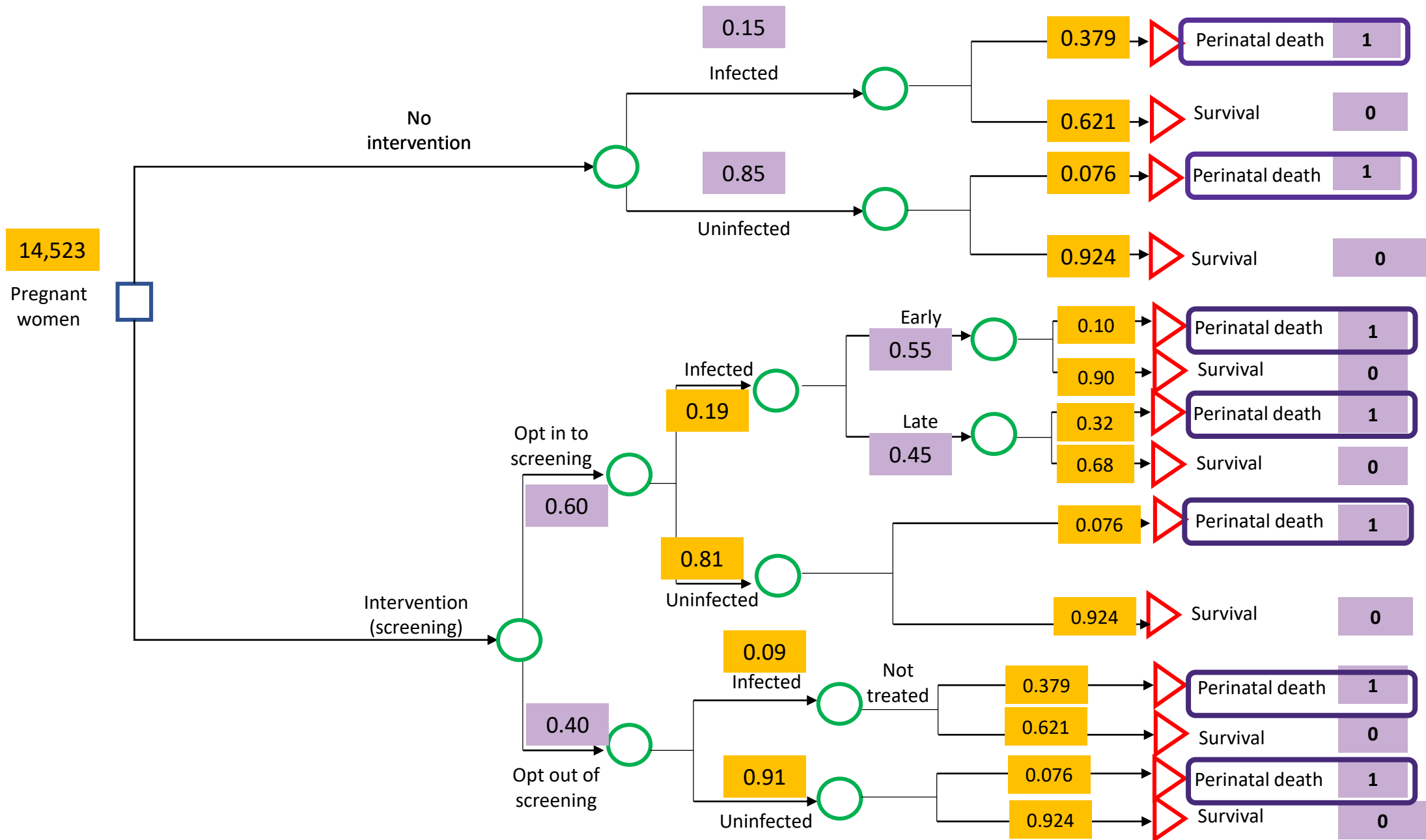
2. Assign monetary values (ex: dollar values) to outcome group

- Based on cost tables (see example)

3. Calculate weighted outcome and cost values

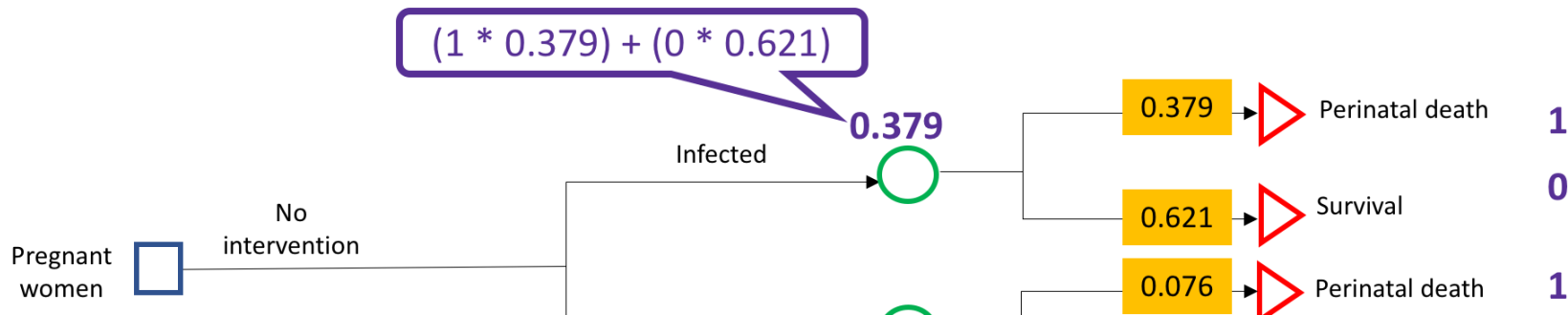
- We will do this step by step later with the decision tree

4. Divide weighted cost value by weighted outcome value to get weighted or expected cost per outcome

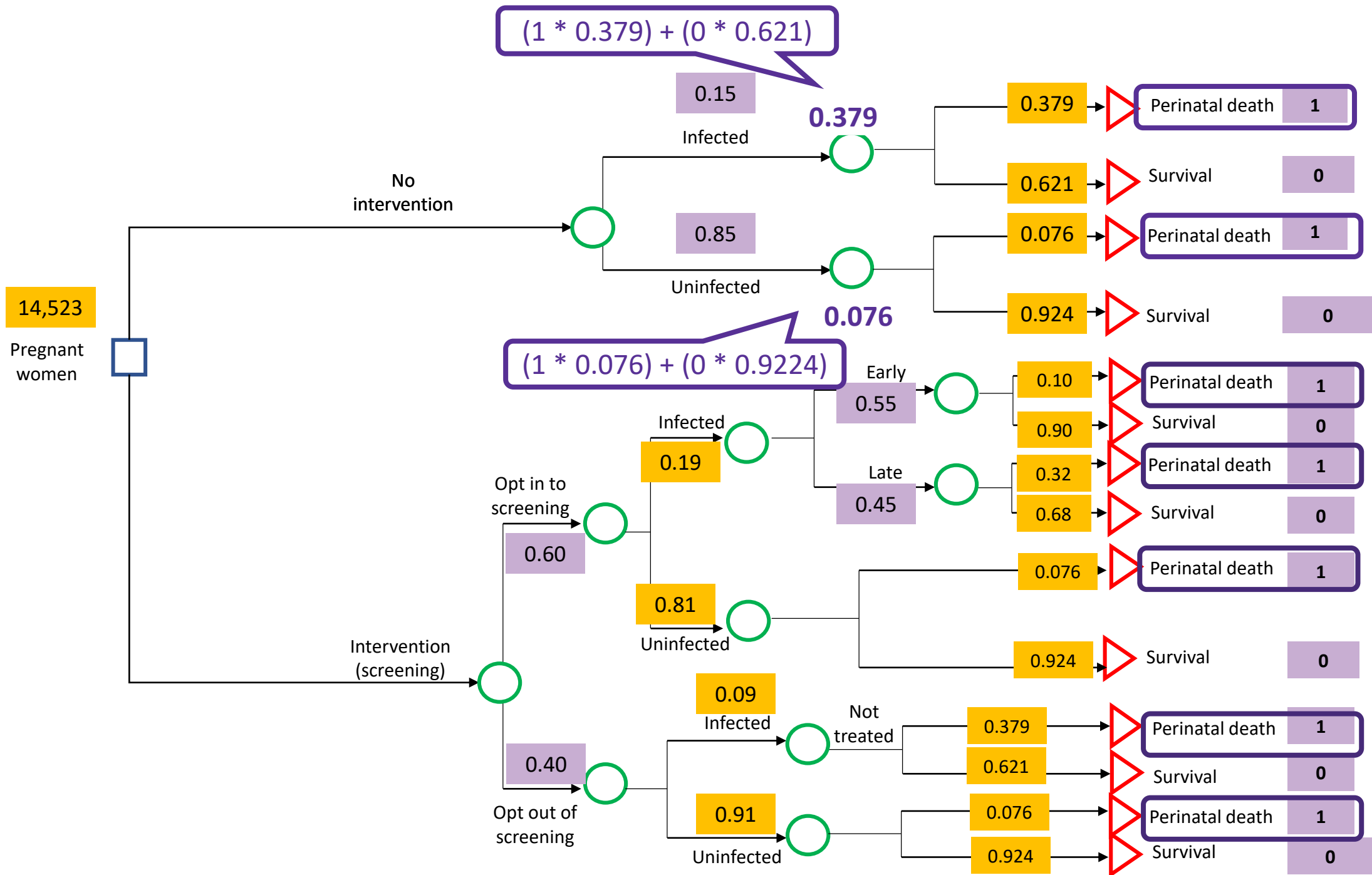


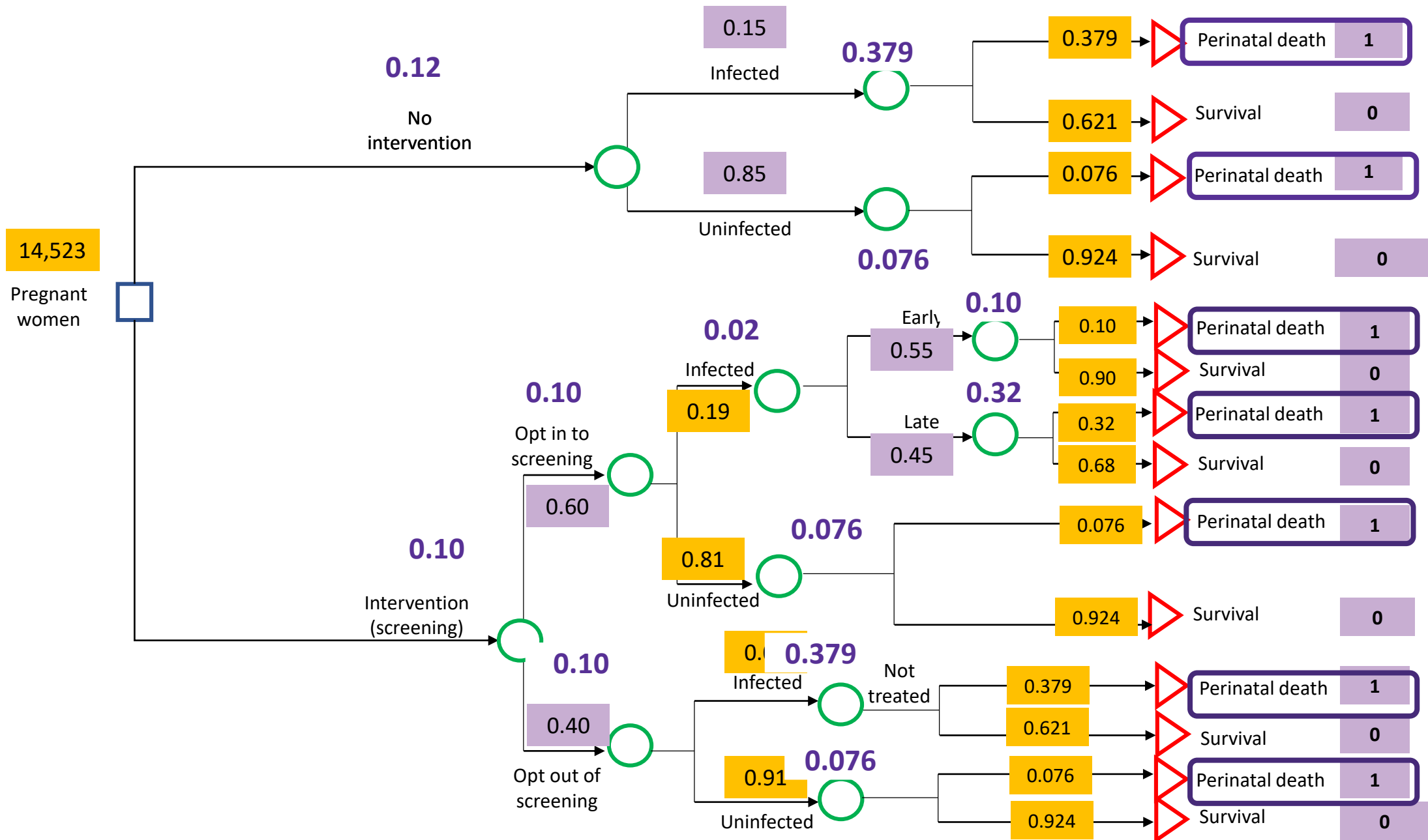
Calculate expected outcomes

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



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





Unweighted outcomes v. weighted outcomes

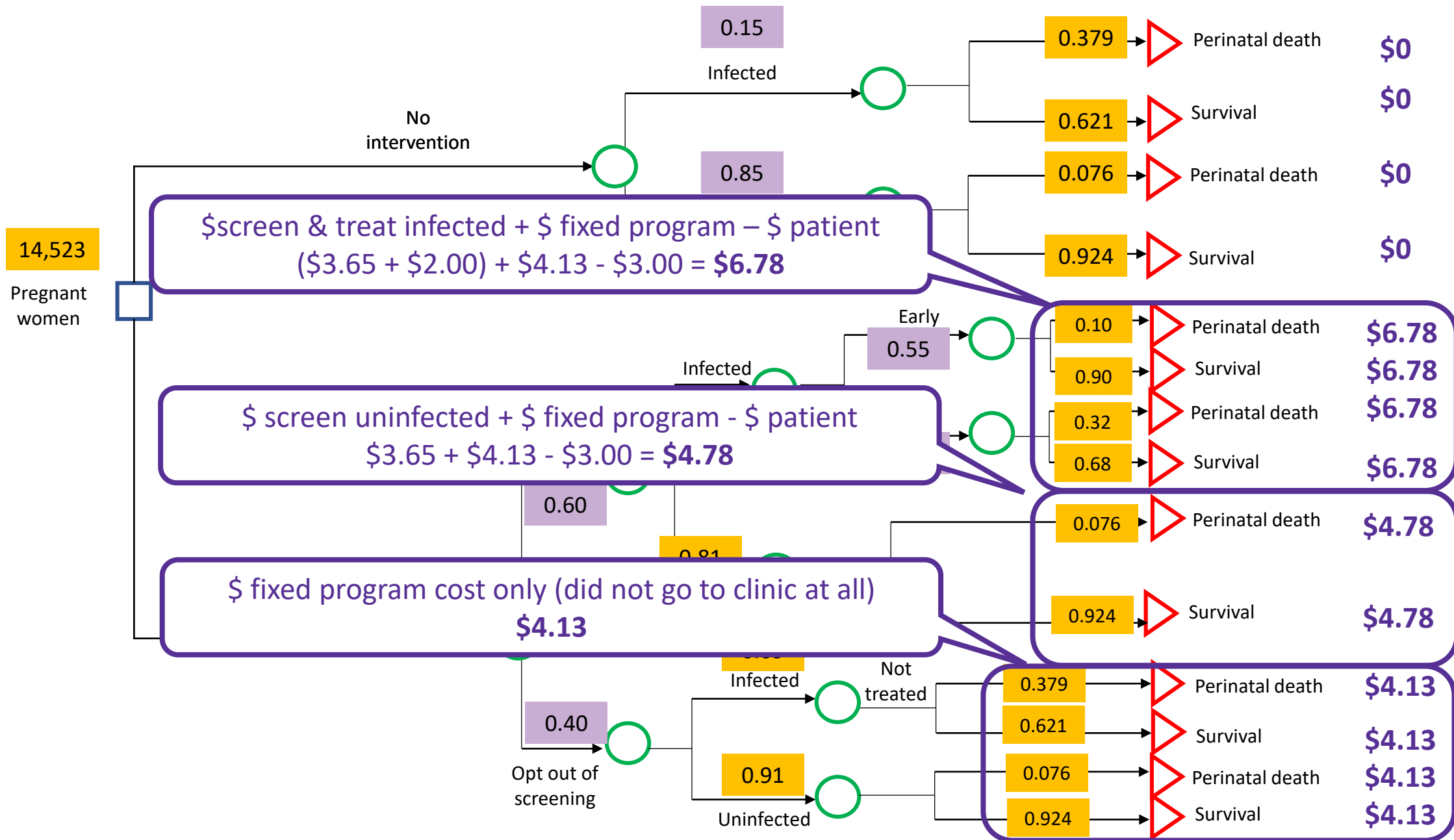
Intervention options	unweighted	weighted
Option 1: no intervention	$1,764/14,523 = 0.12$ or 12 per 100	0.12 or 12 per 100
Option 2: screen and treat	$1,466/14,523 = 0.10$ or 10 per 100	0.10 or 10 per 100

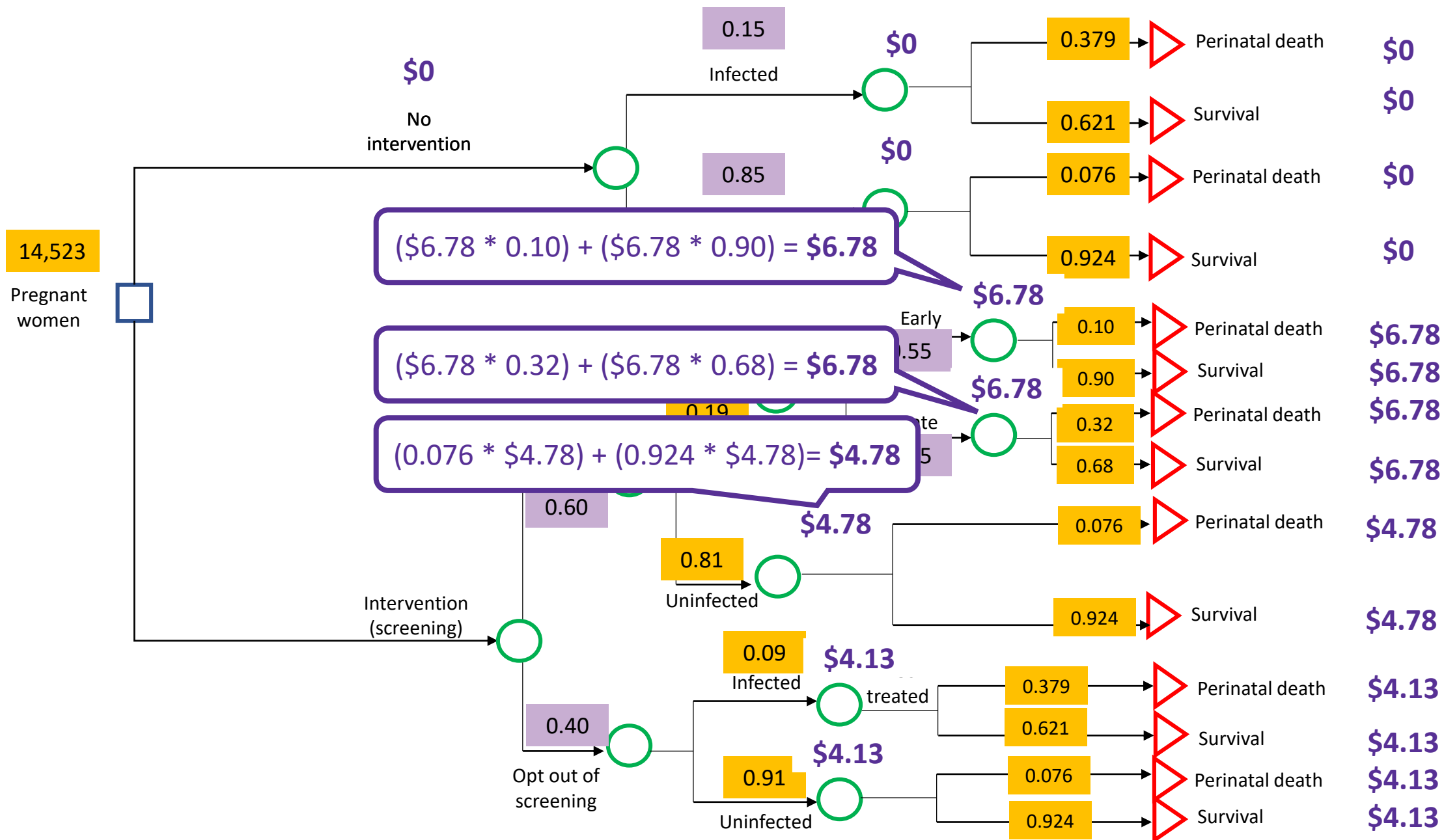
- **The unweighted and weighted outcomes are the same**
 - Because outcome values are 1 or 0
- **Weighted outcomes required when outcome values are not 1 or 0**
 - e.g. CUA with DALYs: different unweighted and weighted outcomes

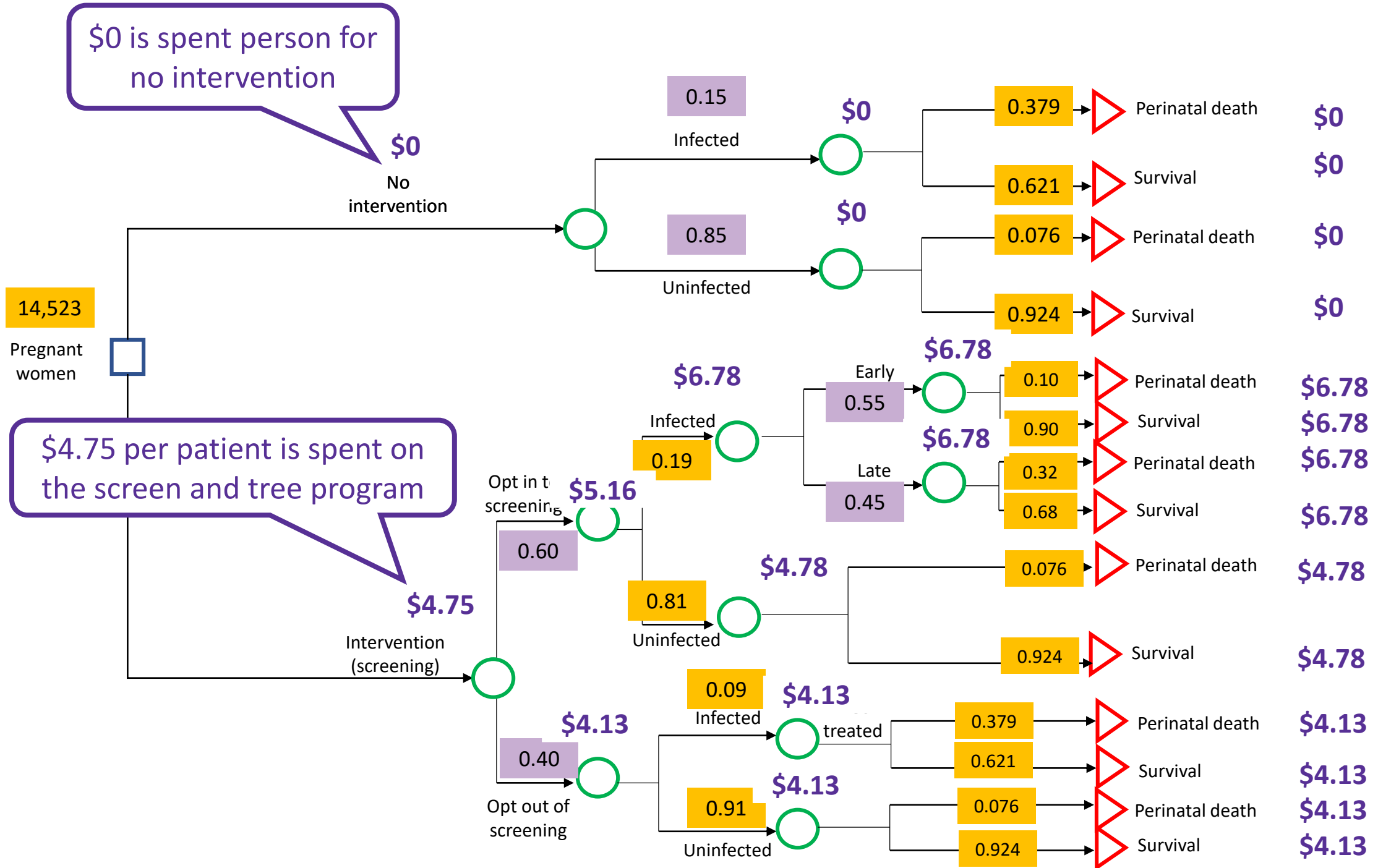
Weighted cost calculation

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**







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

$$\text{Weighted CE ratio} = \frac{(\$4.75 - \$0)}{(0.10 - 0.12)} = -237.50$$

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

$$\text{Crude CE ratio} = \frac{\$68,976 - \$0}{-298} = -231.46$$

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

Is “screen & treat” worth it?

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

- 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
