Role of Economic Epidemiology: With Special Reference to HIV/AIDS

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Outline of presentation

- Definitions
- Trend/Aim/Benefit
- Prevalence dependence
- Effects of individual behaviour
- Economic impact of HIV/AIDS
- Concepts from mathematical epidemiological models
- Measuring economic impact

Outline…….

- Economic evaluation concepts
- Conclusion

What is Economic Epidemiology?

- **Economic epidemiology** is a field at the intersection of epidemiology and economics
- Its premise is to incorporate
  - principles of individual behavior
  - incentives for healthy behavior **(Wikipedia)**
  - resource optimization
  - simple economics

into epidemiological models and

- the dynamics of infectious diseases

into health economics

Epidemiology

- It is the basic science of **public health**

  which is the science and art of
  - preventing diseases
  - prolonging life
  - promoting health

  through organised efforts and informed choices of governments, individuals, communities, societies and organisations (both private and public) (Winslow, 1920)

Epidemiology

- **DEFINITION:-** The **study** of the **distribution**, **frequency** and **determinants** of health problems and disease in human population
- **PURPOSE:- To obtain, interpret and use health information to promote health and reduce disease (that's public health)**
- **Public health** means **public policy**

Economics

- **Economics** is the social science that studies the production, distribution, and consumption of goods and services.
- Economics aims to explain how economies work and how economic agents interact. (Wikipedia)
- Economics plays a big role in **public policy** while epidemiology says a lot about **the dynamics of infectious diseases**

What is the trend?

- Epidemiological models do not real take account of economic constraints or incentives faced by individuals and policy makers
- Economic models mostly do not incorporate the dynamics of disease.
- Biological and economic epidemiology make different predictions of disease occurrence because of their different predictions about the relationship between prevention and prevalence (Philipson, 1999)

- Hazard rate into infection is an **increasing function** of prevalence in epidemiological analysis while it is a **decreasing function of prevalence** in economical analysis
- More people infected in the population leads to more susceptibles infected later
- Susceptibles face a larger risk of infection and therefore their demand for prevention becomes high and thus reduce infection hazard
- No real collaborative work between biologists, economists and mathematical epidemiologists (Klein et al 2007)

Aim

- Have an interdisciplinary approach to manage the complex interaction of mathematical, economical, epidemiological and biological considerations in the emergence, persistence and spread of infectious diseases

Benefits: Epidemiological models

- Provide a foundation for public policy models of disease treatment and prevention programs
- Estimate disease incidence and prevalence (number of individuals per unit time who are infected)
- Identify groups of the population which are most at risk of contacting the disease
- Estimate parameters defining strategies to counteract the epidemic

Benefits: Policy makers

- Require to make **informed decisions** to determine the best way of allocating scarce resources for the different programs of prevention and treatment
- Need to know the **benefit and cost of each program** that produces the greatest reduction in infections, morbidity and mortality given resource constraints

Benefits contd….

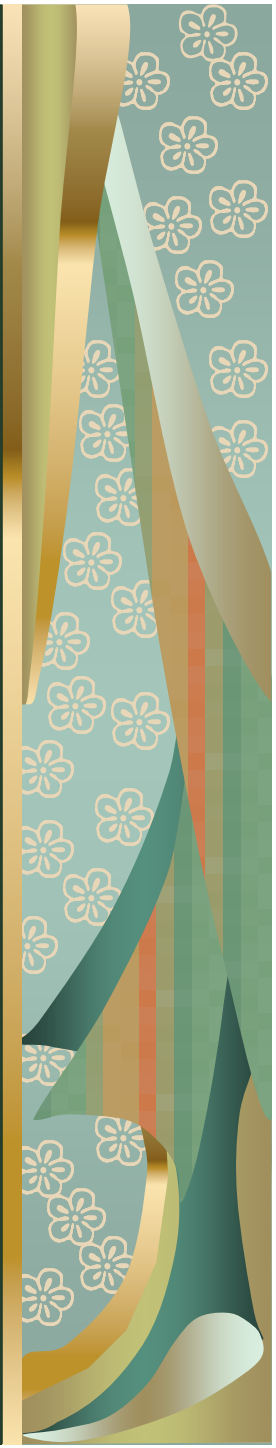
- Reasonable assessments of program costs and benefits are required to make rational policy decisions
- Improves policy responses to epidemic diseases by providing clear tools for thinking about how certain actions can influence the spread of disease transmission.

Benefits contd….

- Optimal strategies and policies are needed to control the spread of diseases
- **Economic evaluation** concepts are therefore required to help to identify, measure, compare costs and consequences of alternate strategies

So what?

- Economic epidemiology strives to incorporate different types of behavior responses (individual, policy maker) into epidemiological models to enhance a model's utility in evaluating control measures.
- Need understand what is involved and how it can be done to make sure that this '**marriage**' between economics and epidemiology can work



Principle of Individual Behaviour

- The field is dependent on the idea of prevalence
- Epidemiological analysis discusses how various patterns of behaviour affect the progression and occurrence of the disease but does not analyse the implications and effects of this behaviour change
- Limiting the spread of a disease at the population level requires changing individual behavior,

- This depends on what information (general and specific) individuals have about the level of risk because individuals change their behavior as the prevalence of a disease changes
- Decisions affecting health also dependant on objectives and constraints – not normal taken care of in health policy formulation – economics of the home

  - other things to take care

"Wellbee" says

BE WELL!

take

ORAL

POLIO

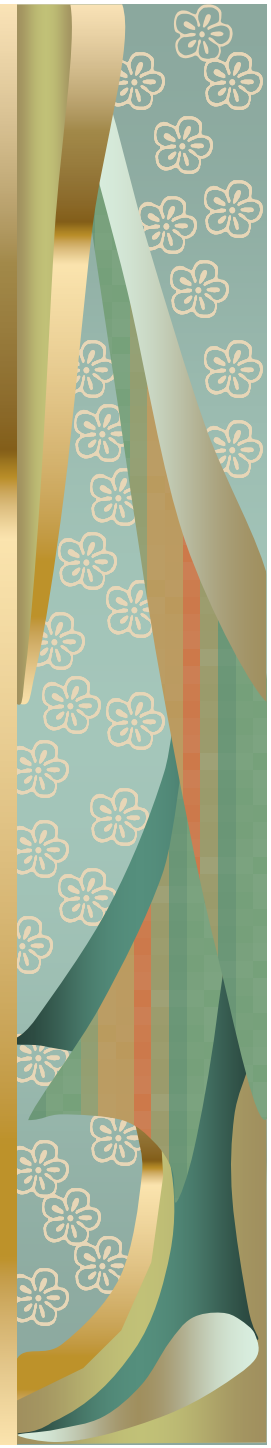
VACCINE

- tastes good
- works fast
- prevents polio

- When disease disappears the demand for vaccines also does so
- Decline in vaccination then allows the disease to return
- Supply side is also affected since demand for the supplier is also eradicated

Example

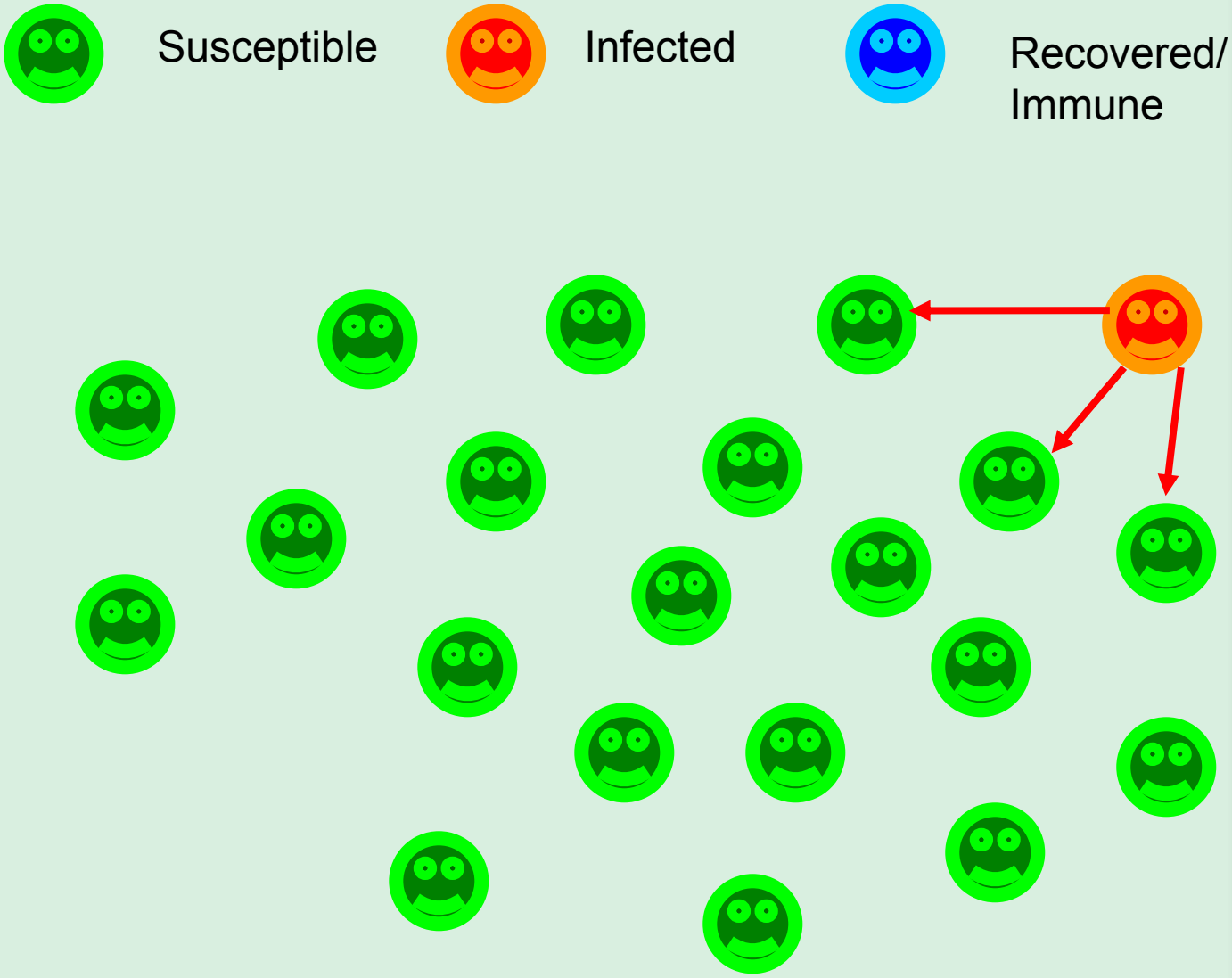
- Massive campaigns of boiling drinking water, wash your hands before you eat, don’t shake hands, etc to reduce cholera transmission can reduce the effects of the epidemic and this might lead to relaxation of the above campaigns



- People tend to ignore a disease if risk is low, but if the risk of infection is higher, individuals are more likely to take preventive action.
- If the pathogen is more transmissible, like HIV, the greater the incentive is to make personal investments for control.
- Similarly if there is a lowered risk of disease, either through some interventions like vaccination or because of lowered prevalence, individuals may increase their risk-taking behavior.

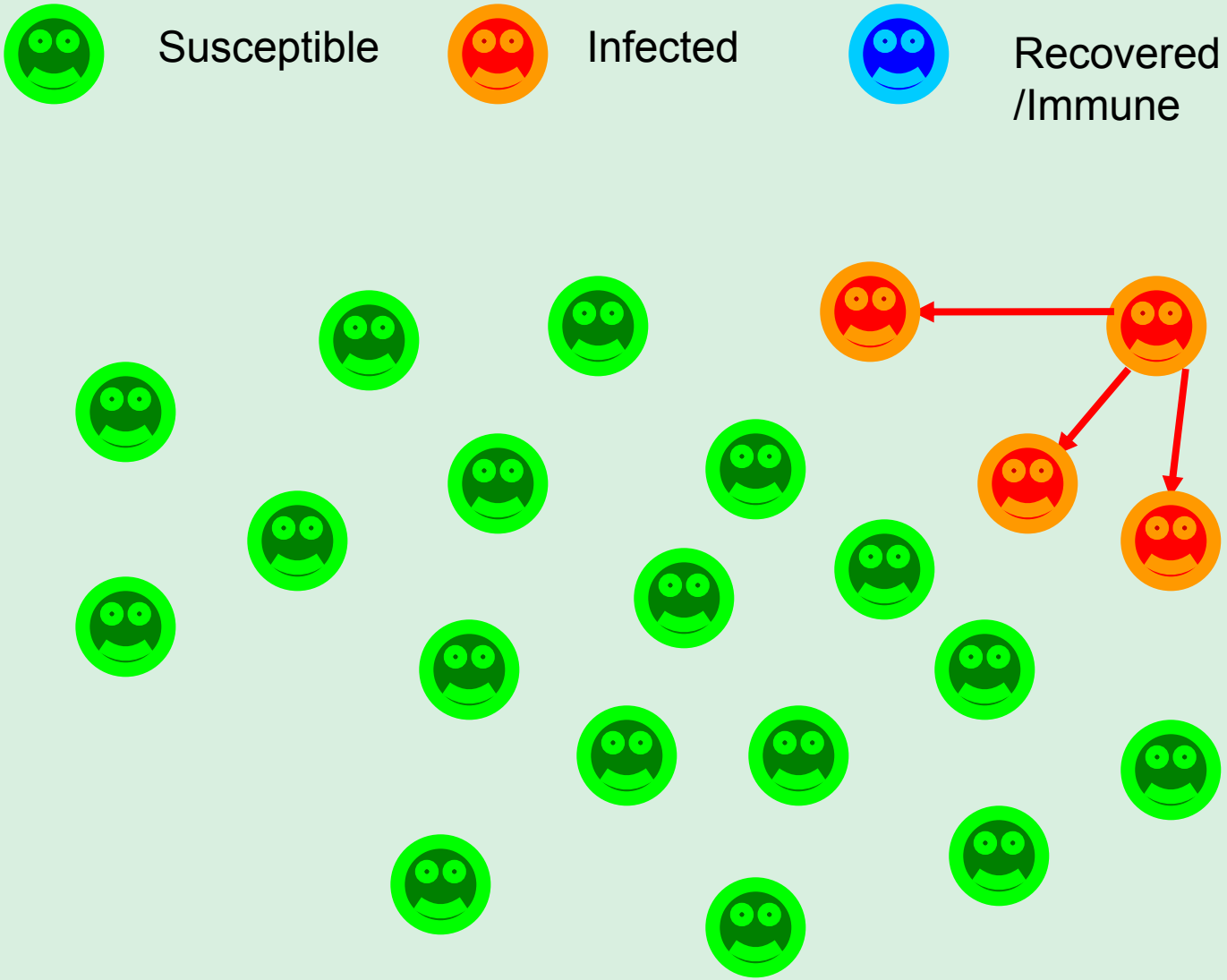
- Models suggested that the introduction of highly active antiretroviral therapy (ART), which significantly reduced the morbidity and mortality associated with HIV/AIDS, may lead to increases in the incidence of HIV as the perceived risk of HIV/AIDS decreased (Blower SM et al, 2000)

Transmission process (a)



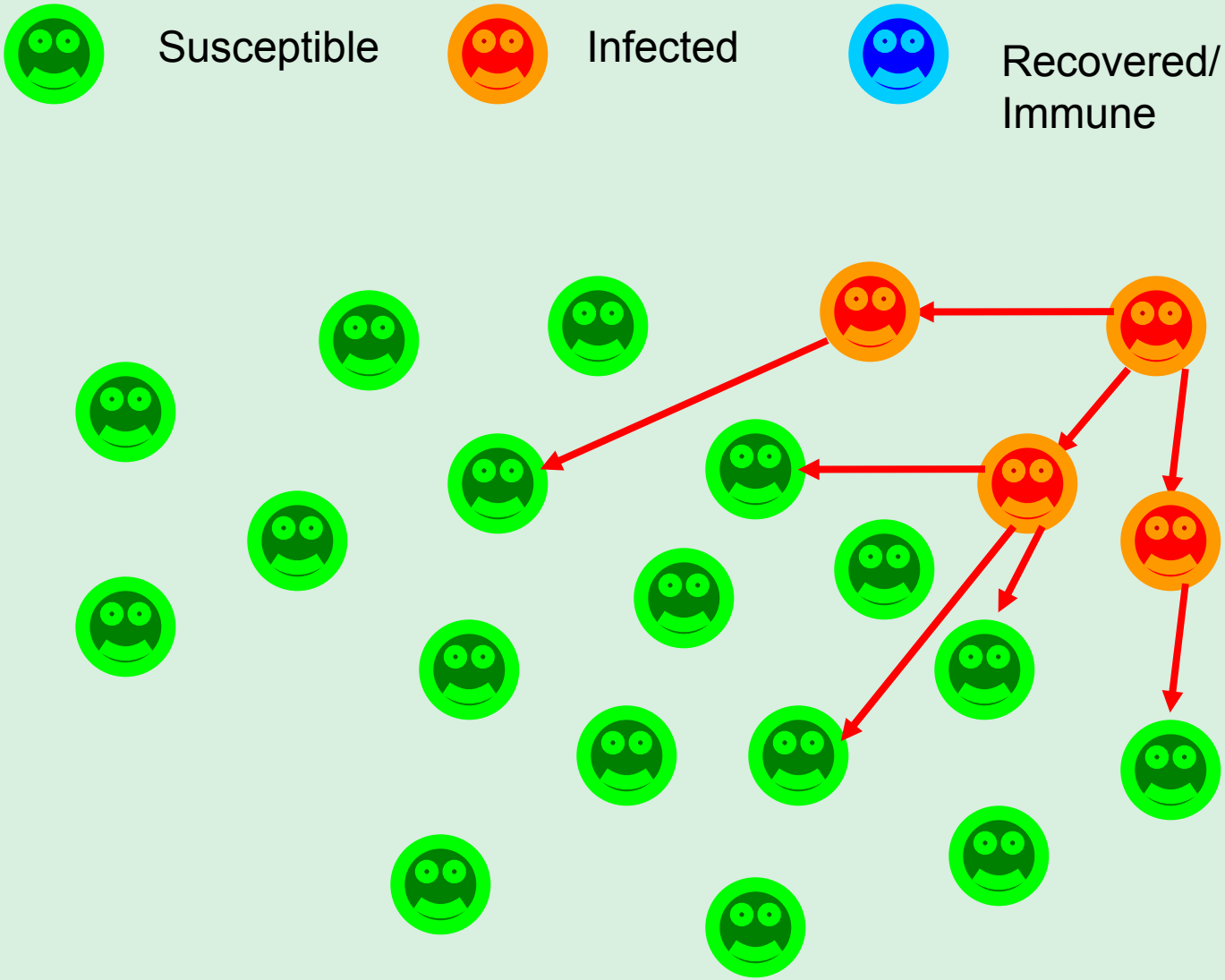
One person acquires infection in the community and transmits to three neighbours

Transmission process (b)



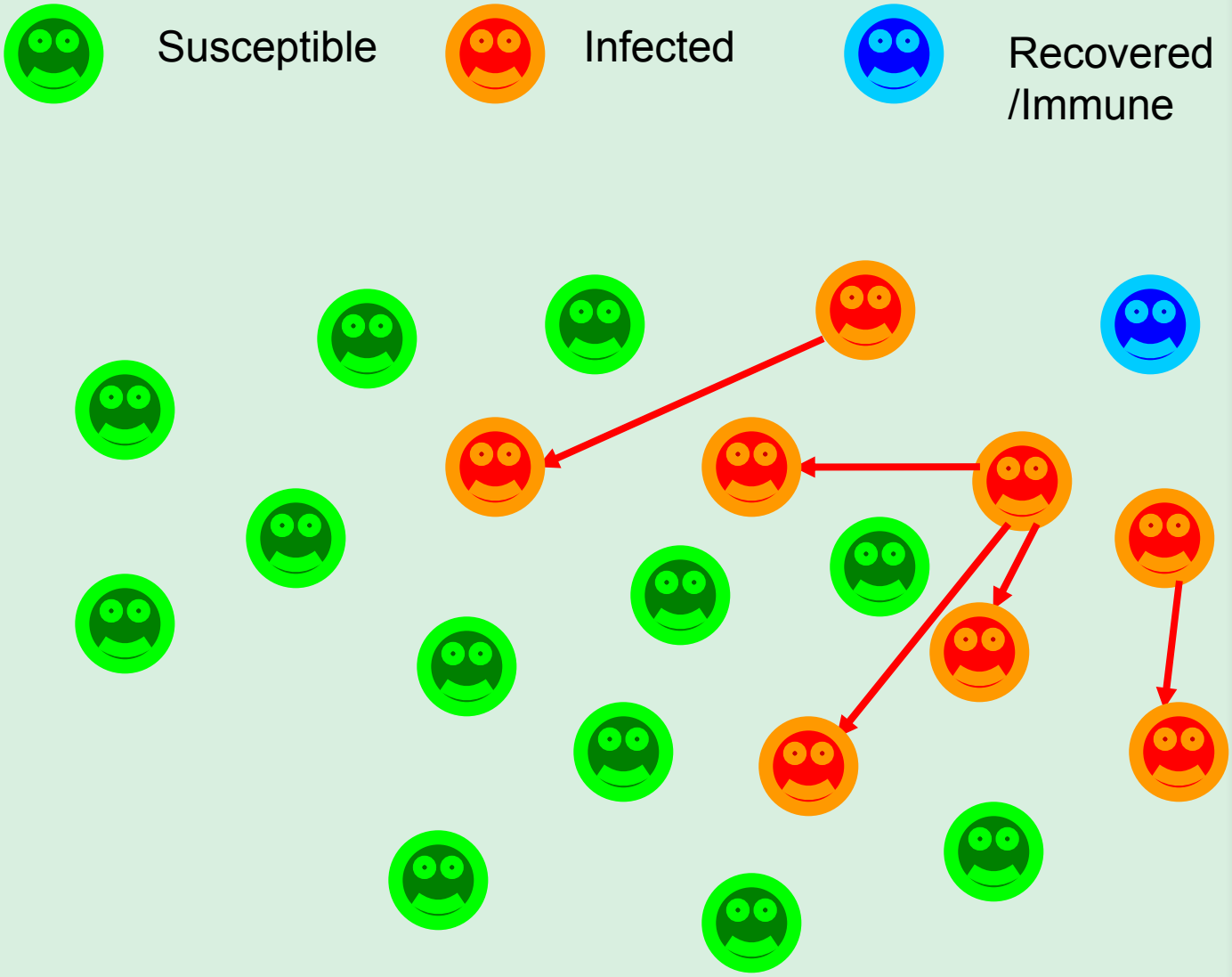
Three persons infected by one

Transmission process (c)



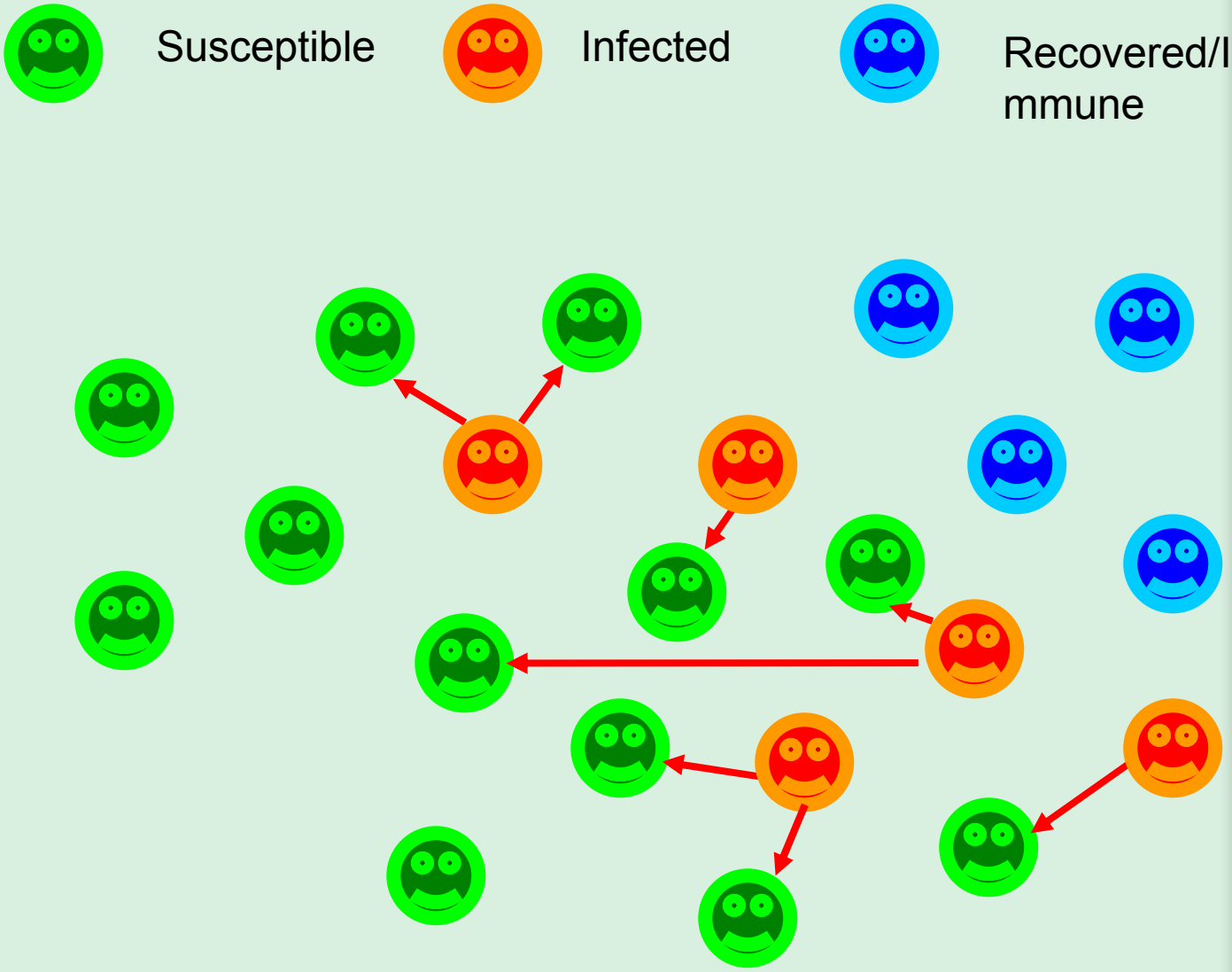
Transmission continues

Transmission process (d)



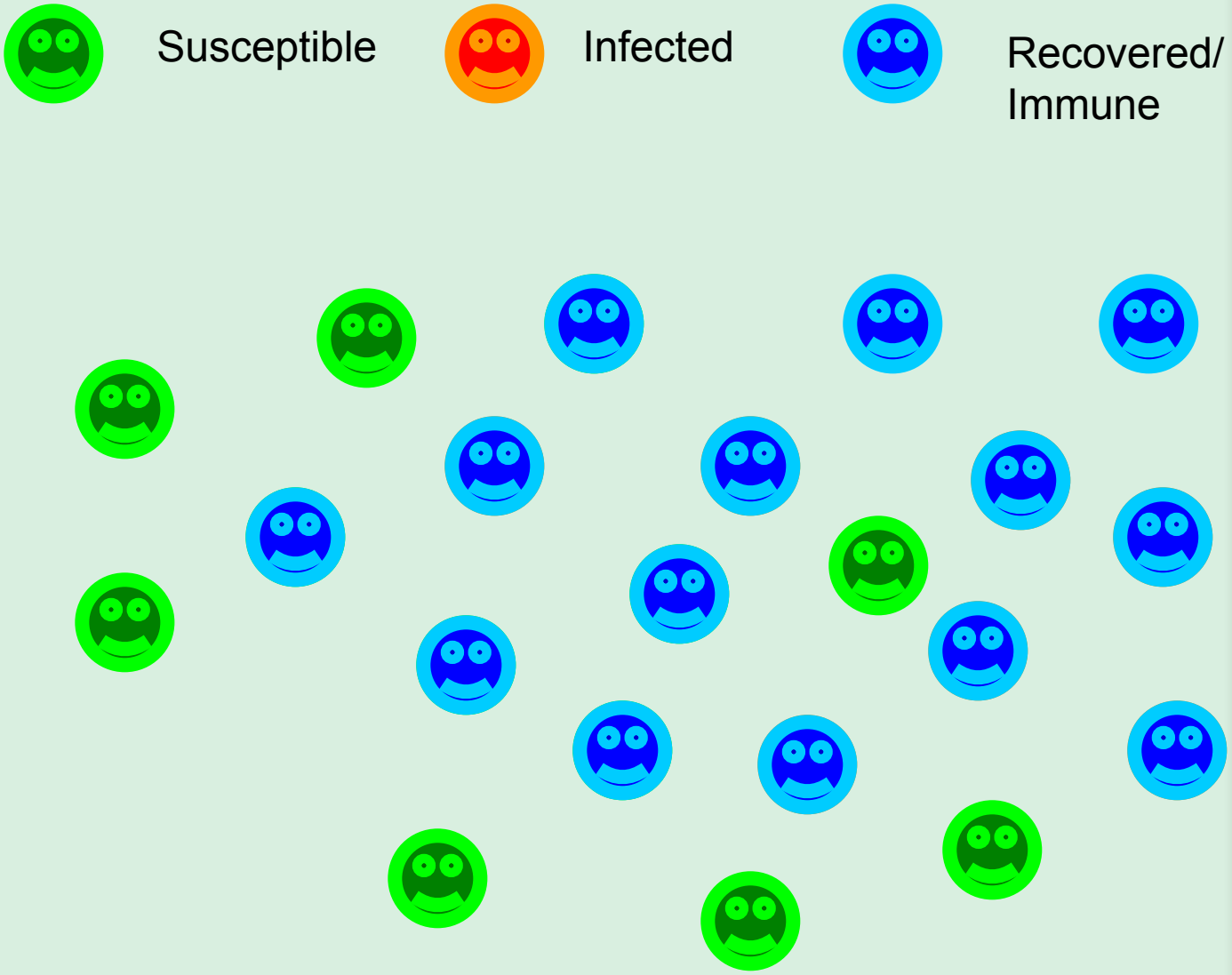
Transmission continues (Index case recovers)

Transmission process (e)



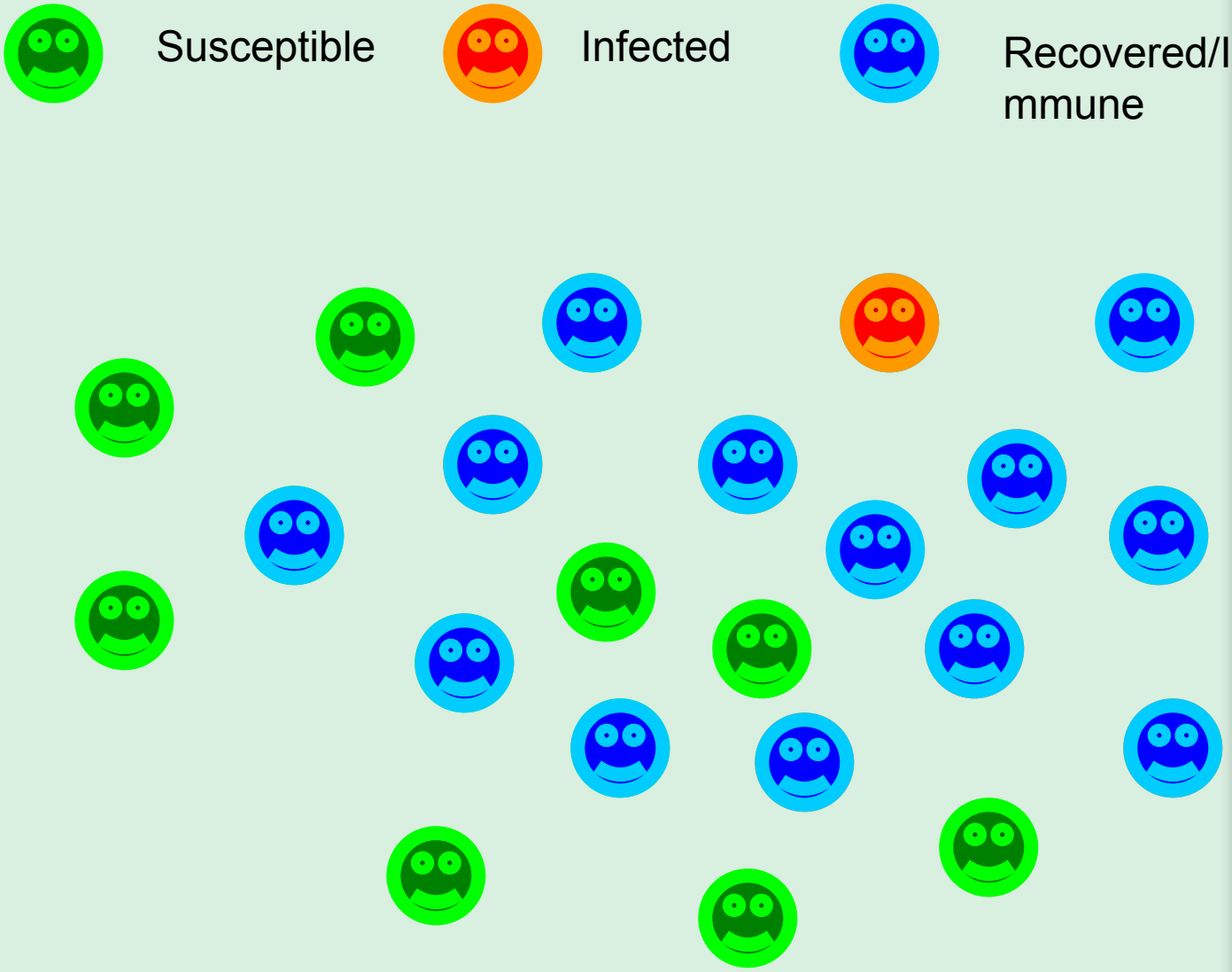
Transmission continues (more recoveries)

Transmission process (f)



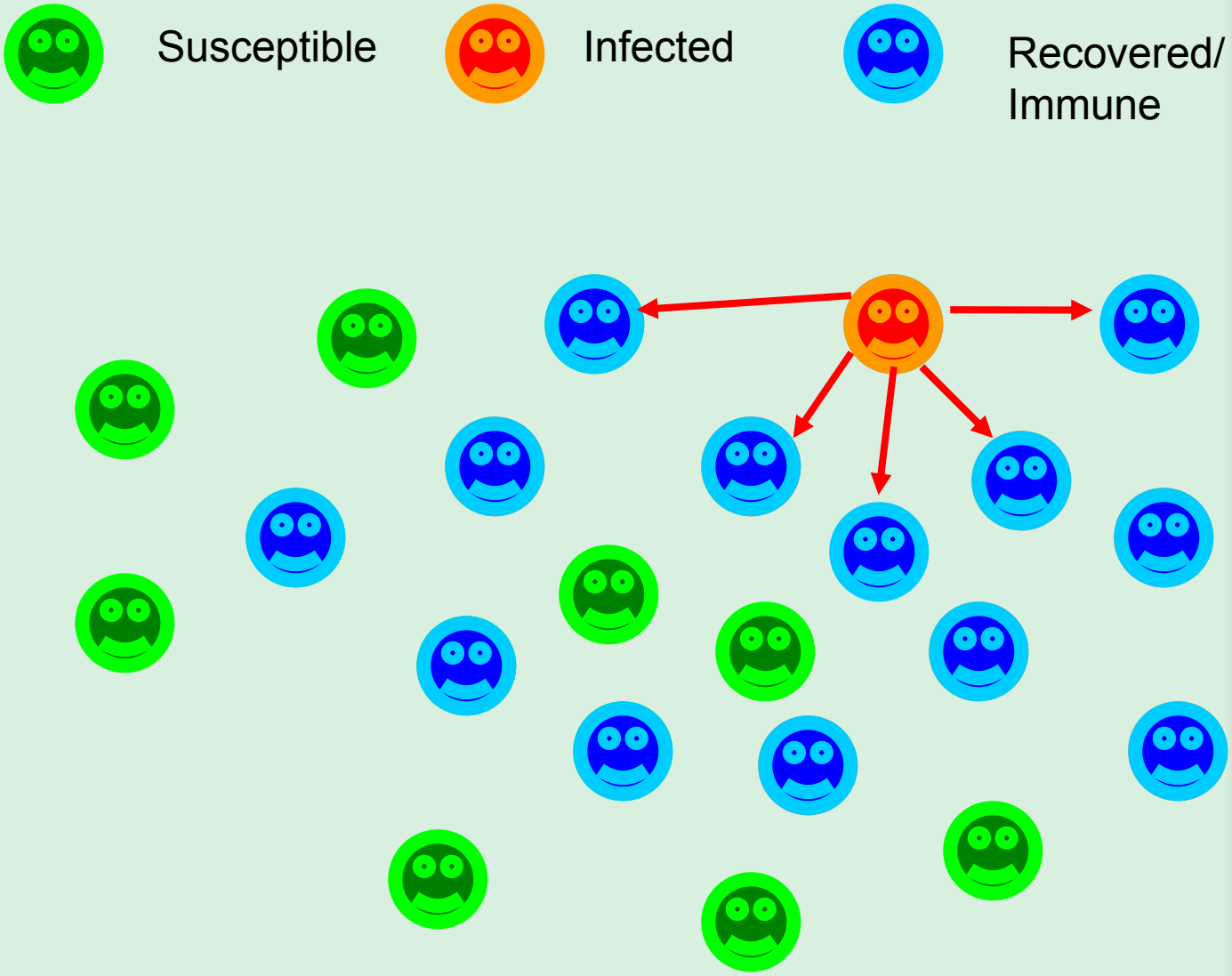
The disease clears from the community

Transmission process (g)



Suppose in infective sets in the community from elsewhere

Transmission process (h)



No infection will occur due to herd immunity

Effects of individual behaviour

- Positive or negative
- Government intervention “to align the private costs and benefits with the social costs and benefits of decisions” (Gersvitz and Hammer,2003) in the form of subsidies for preventives and treatment

Public interventions:

- Behavioral response have important implications for the timing of public interventions, because prevalence and public subsidies may compete to induce protective behavior (Geoffard, et al 1996).
- Price subsidies and mandatory vaccination- limited since higher vaccination coverage of individuals in the program might lower the incentive of those outside the program to be vaccinated

- Demand rises for those who are subsidized and demand falls for those not covered.
- Prevalence competes with public intervention in inducing protective activity

- If prevalence induces the same sort of protective behavior as public subsidies, the subsidies become irrelevant because people will choose to protect themselves when prevalence is high, regardless of the subsidy, and subsidies may not be helpful at the times when they are typically applied.

Externalities

- Individual's action results in benefits or costs to others
- Prevention and therapy involve externalities eg mass spraying reduces mosquito but is it good for the neighbour's health or environment
- Are individual and social incentives for prevention and treatment the same?
- What are their objectives and constraints

  (economics of the home, other important objectives – life goes on)
- Is it to avoid infecting others eg your spouse, the public, etc or for selfish reasons

Prevention in times of love

Prevention in business

Factors influencing behaviour responses

- Environmental factors- services and policies
- Social factors – peers, family, role models
- Personal factors – knowledge, self-efficacy, risk, risk perception

Economic Impact of HIV/AIDS

- Economic impact of HIV/AIDS is based on the direct monetary values that are incurred as the epidemic runs its course.
- Costs involved affects the patient, the worker, family, the government

- A decline in savings and investment (from the relocation of expenditures towards medical care),
- Consequently, there is net effect on the growth rate of per-capita GDP

- The long-run economic costs of AIDS are almost certain to be much higher and possibly devastating if we emphasize the importance of human capital and transmission mechanism across generations in any economy.

- The formation of human capital, which should be thought of as the entire stock of knowledge and abilities embodied in the population, plays a leading role in promoting economic growth.
- AIDS can severely retard economic growth even to the point of leading to an economic collapse since AIDS is primarily a disease of young adults.

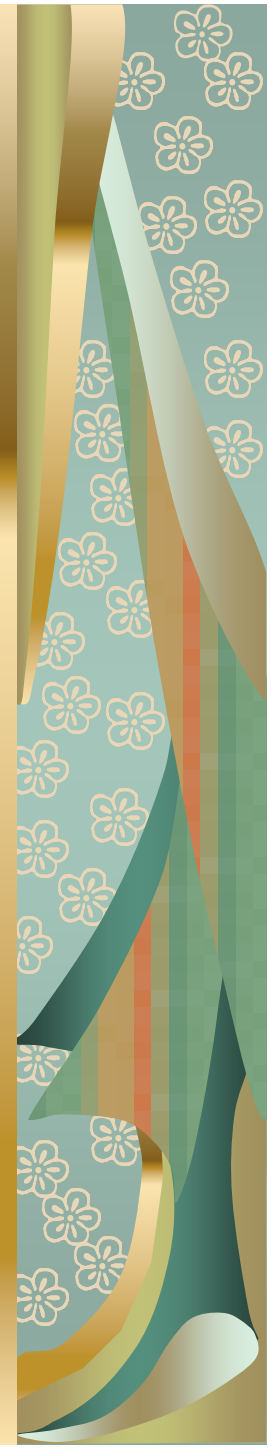
- In terms of the economic policy, AIDS has particularly two important implications.

➢ By killing off mainly young adults, AIDS also seriously weakens the tax base, and so reduces the resources available to meet the demands for public expenditures, including those aimed at accumulating human capital, such as education and health services not related to AIDS - pressure on economy.

- Slower growth of the economy means slower growth of the tax base, an effect that will be reinforced if there are growing expenditures on treating the sick and caring for orphans.
- As a result, the state's finances will come under increasing pressure.

Measuring the Economic Impact

- Base all our analysis on a mathematical model, where prevention and treatment have been augmented in the fight against the pandemic.
- Develop the cost function model which captures all costs of therapy and progression to AIDS for all those who are infected at the beginning of treatment



The Costs

- Types: - direct, indirect, intangible
- Loss of productivity due to
  - premature death of infected individuals
  - sickness of infected individuals
  - time lost to the care giver
- Strengthening the health care system to prevent spread

Costs

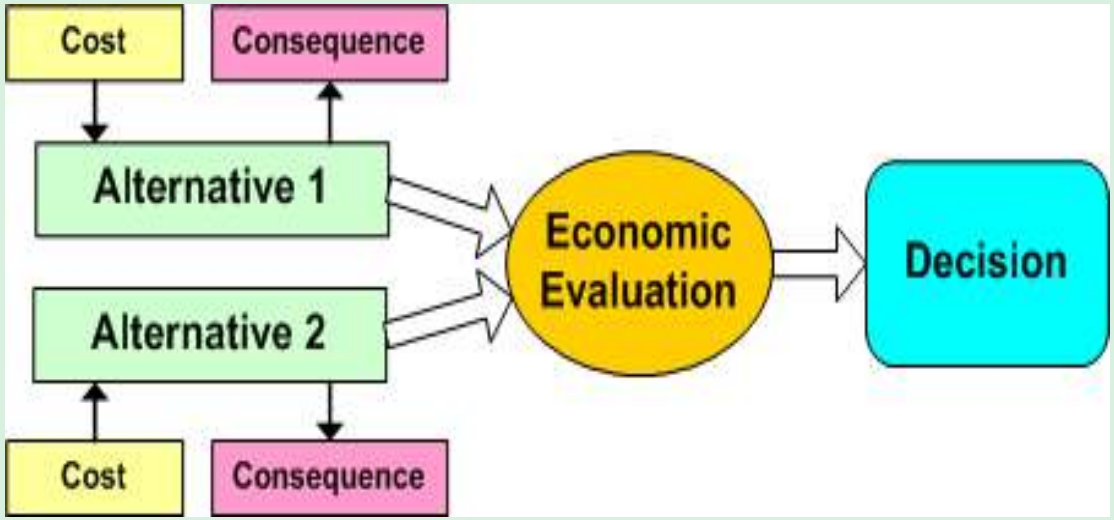
- Loss of skilled work force
- Retraining a new work force
- Screening people for the infection
- Screening of blood products
- Preventions eg vertical transmission, educational campaigns
- Hospitalization
- Pain of suffering to the patients and their families - intangible

Costs

- Post infection counseling,
- Training peer educators, printing booklets and other related material.
- Home based care
- Running the clinic and other related administrative issues such as follow up of defaulters by phoning
- Research and development
- **Measuring the Economic Impact + Economical epidemiology ???**

The Economic evaluation

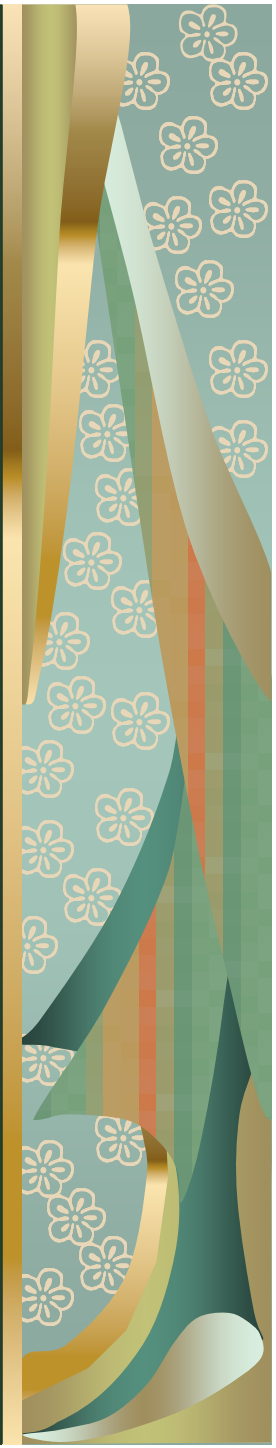
- " The comparative analysis of alternative courses of action in terms of both their costs and consequences in order to assist policy decisions" (Drummond et al,1997)



- Economic evaluation is ***not*** "choosing the cheapest".

Main concepts

- Identify, measure, compare costs and consequences of alternative strategies, policy interventions and allocate limited resources as efficiently as possible
- **Technical efficiency**: meeting a given objective at least cost
- **Allocation efficiency**: producing exactly what society wants or expects

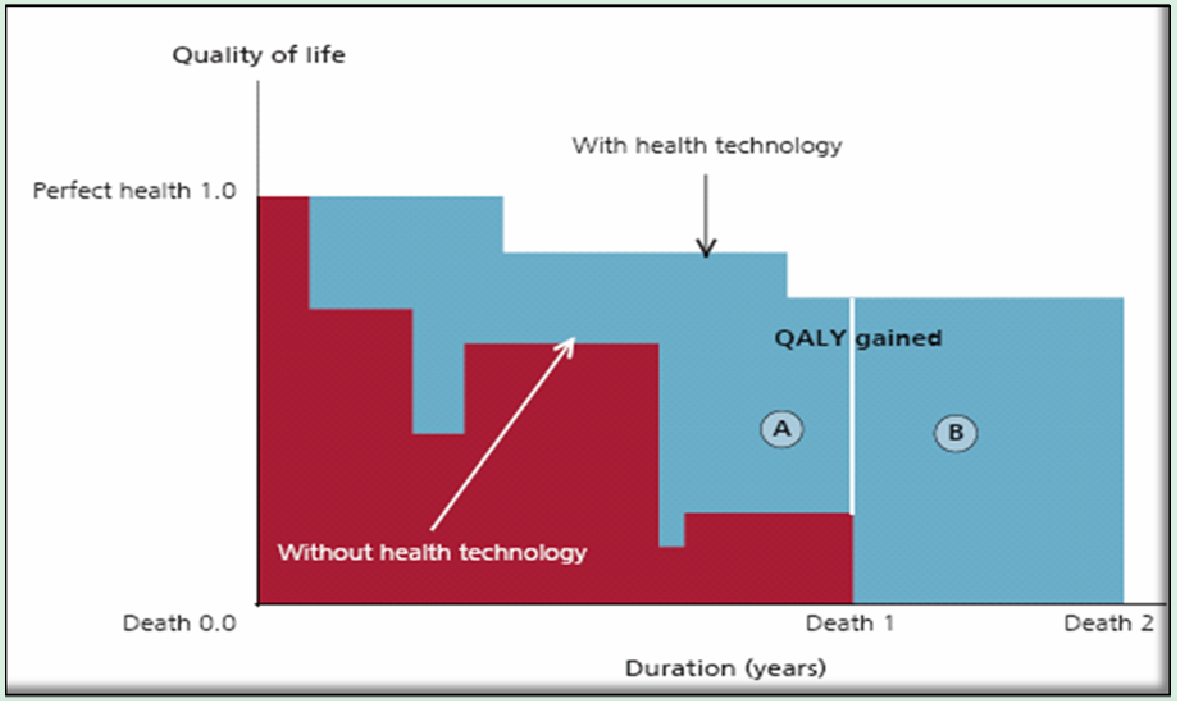


Measures of Program Effectiveness

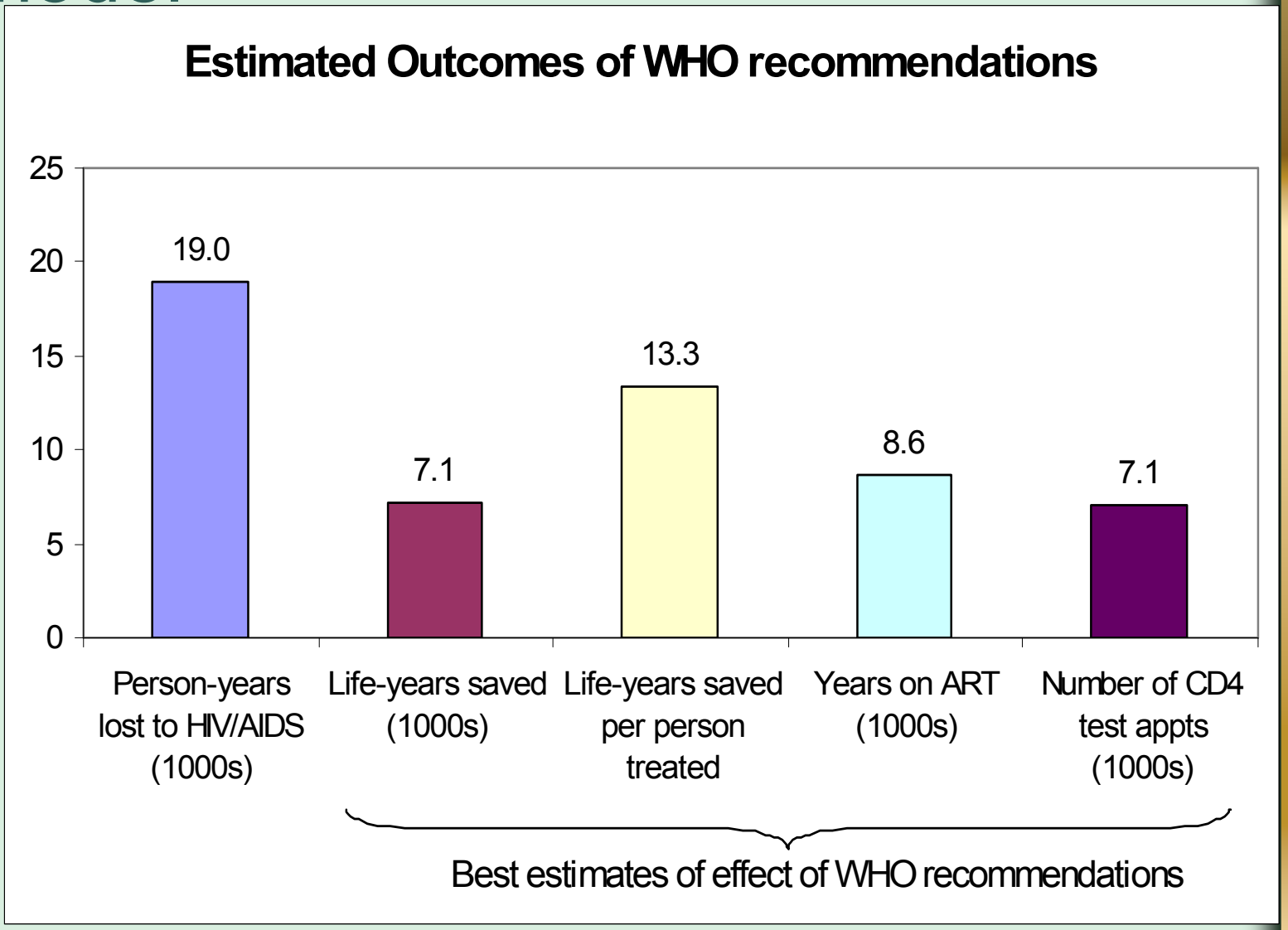
- Infections averted
- Expected survival increases
- Life-years gained
- *Mortality (deaths or deaths averted)*
- *Morbidity:* e.g., episodes of illness, infections, duration of disability (e.g., years of sight)

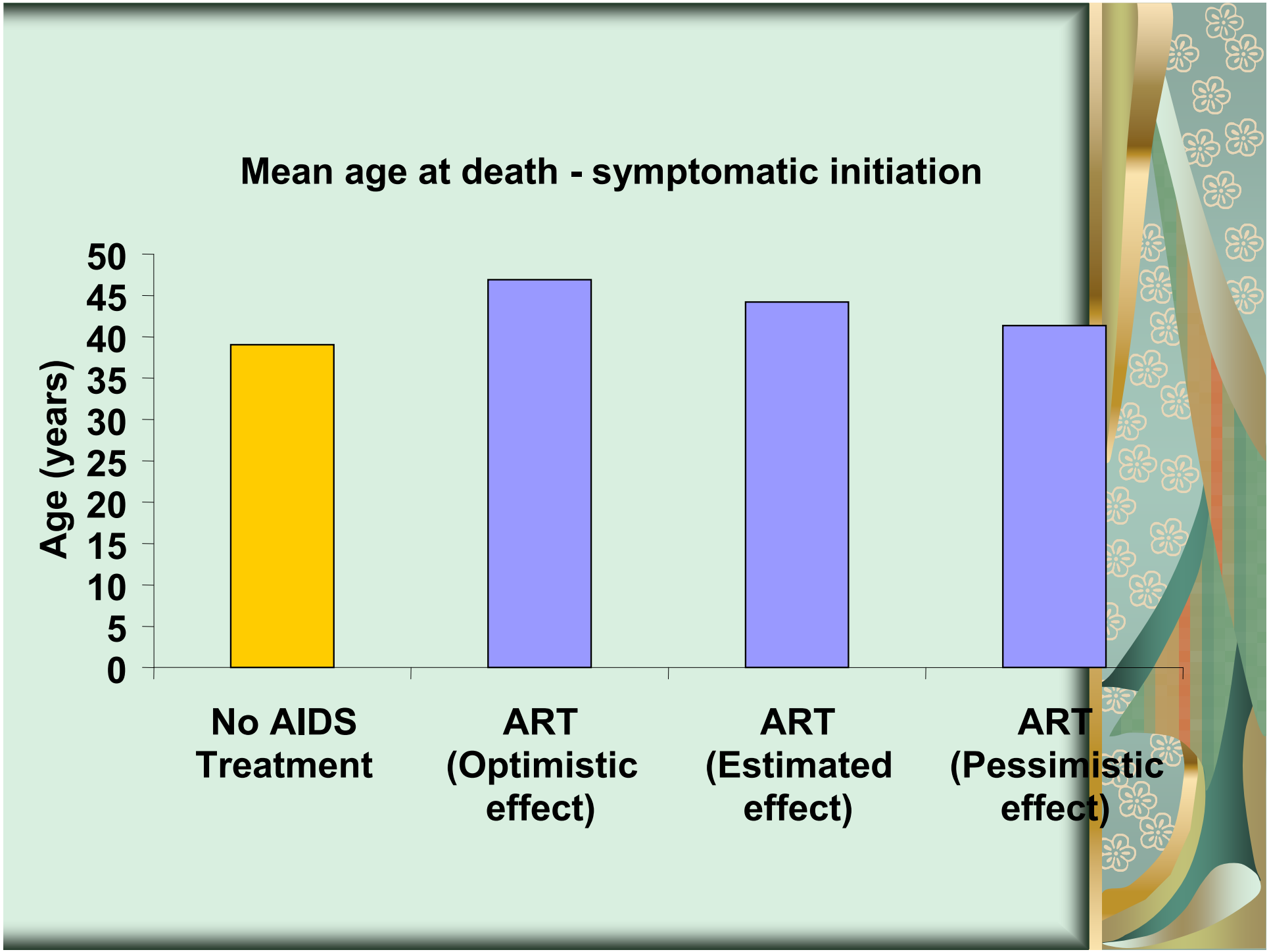
Utility

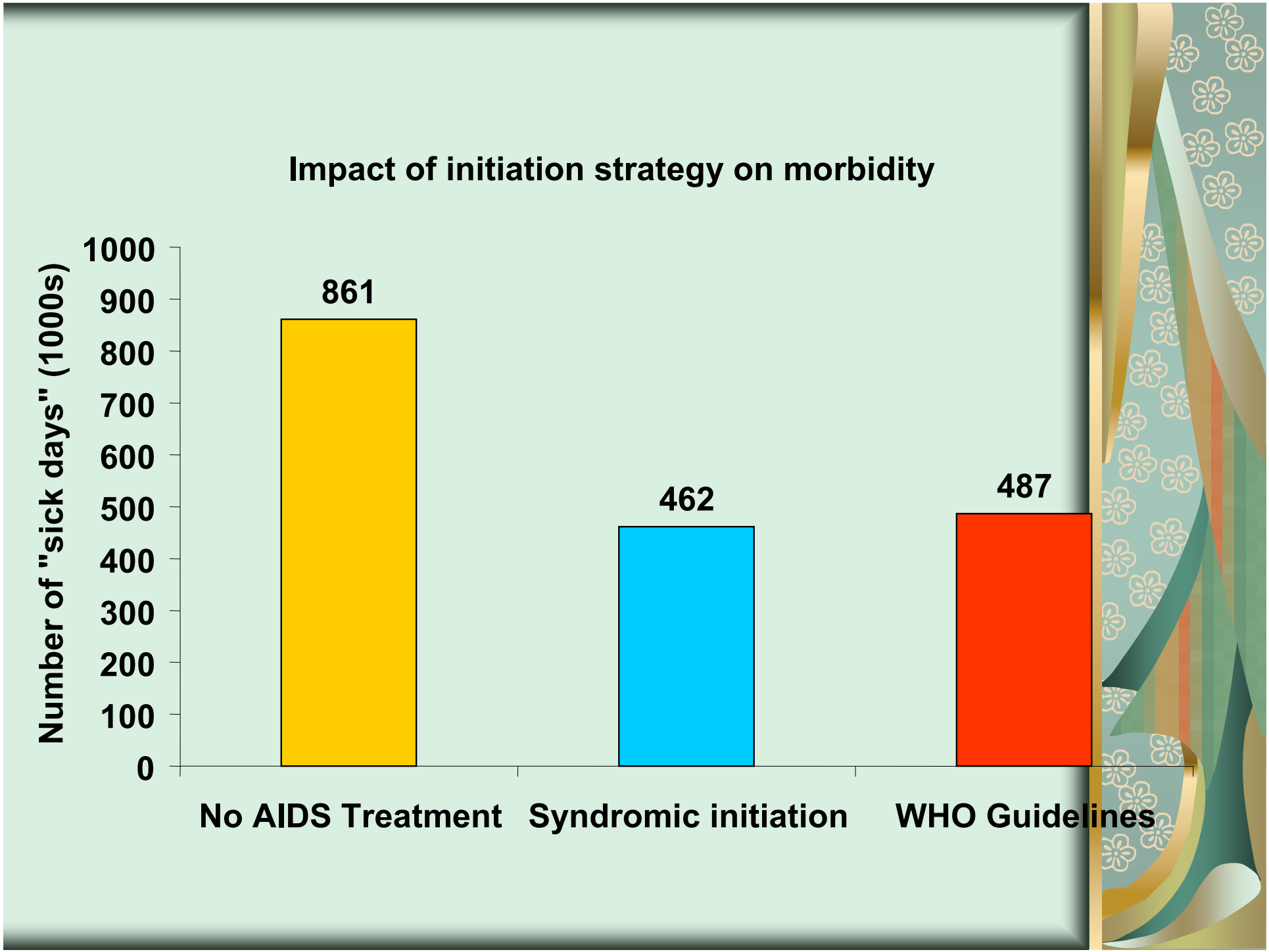
- *Quality-adjusted life years (QALYs):* **life years x utility scores**
- *Disability-adjusted life years (QALYs):* **life years x utility scores**



Information from epidemiological model

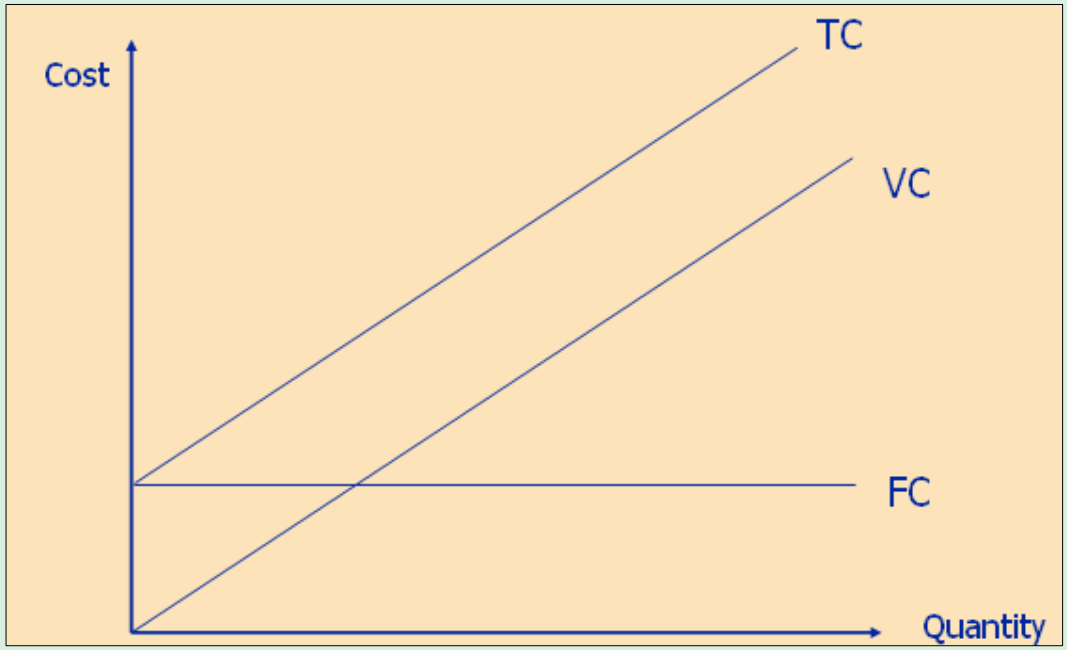



Mean age at death - symptomatic initiation
Age (years)
50
45
40
35
30
25
20
15
10
5
0
No AIDS Treatment
ART (Optimistic effect)
ART (Estimated effect)
ART (Pessimistic effect)

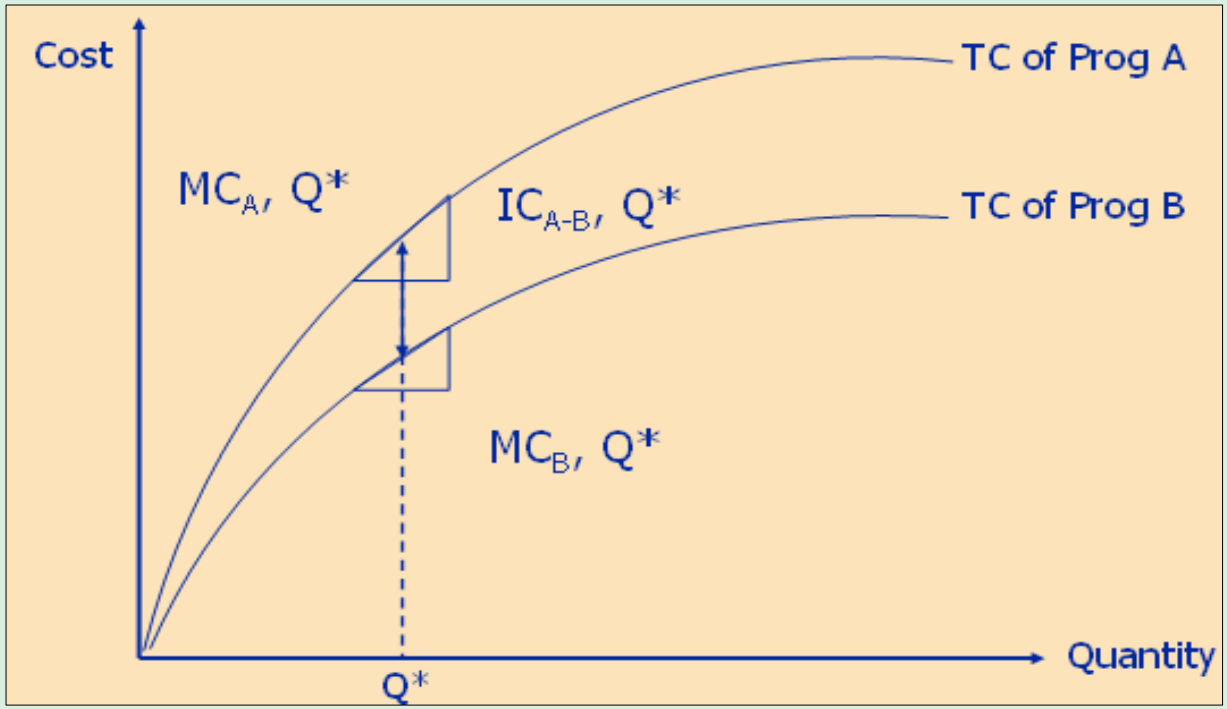

Impact of initiation strategy on morbidity
Number of "sick days" (1000s)
1000
900
800
700
600
500
400
300
200
100
0
861
462
487
No AIDS Treatment
Syndromic initiation
WHO Guidelines

Measurement of costs

- In natural physical units eg time, $
- Fixed, variable, total



- Average vs marginal
- Marginal vs Incremental

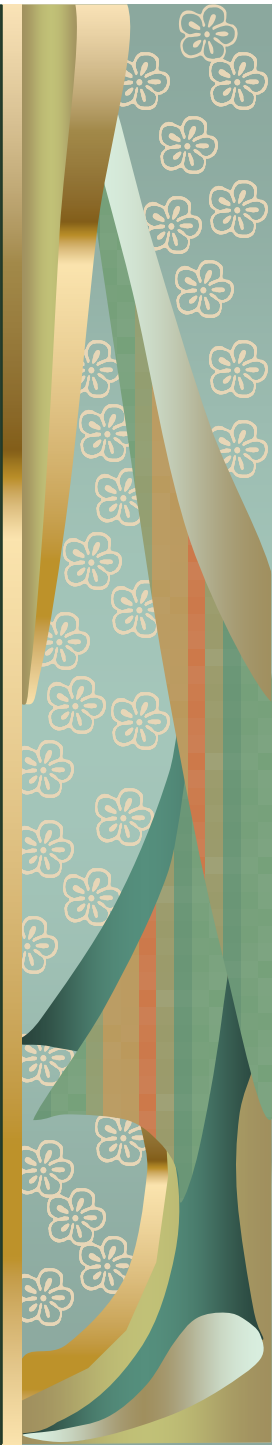


Cost per QALY gained

- Let cost with intervention = CI
- Let cost with no intervention = CNI
- QALY with intervention = QALYI
- QALY with no intervention = QALYNI
- Cost per QALY gained $= \dfrac{CI - CNI}{QALYI - QALYNI}$
- Always start with no intervention to intervention, like R_0 to R_e

Forms of Economic Evaluation

- *Cost Analysis (CA)*
- *Cost Minimization Analysis (CMA)*
- *Cost-Benefit Analysis (CBA)*
- *Cost-Effectiveness Analysis (CEA)*
- *Cost-Utility Analysis (CUA)*



Cost Analysis

- Measures or estimate the resources consumed by a particular intervention strategy
- Helps policy makers to decide whether they have sufficient resources to afford a particular intervention strategy

Example: Cost per life saved (CPLS)

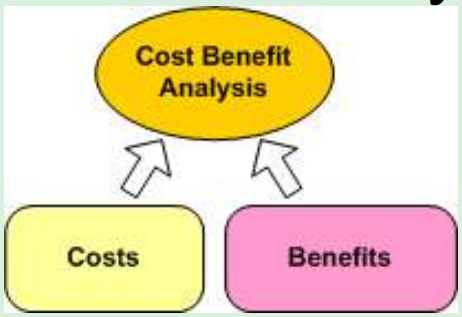
- This is given by $CPLS = \frac{Costpertreatment}{changeinprobablity}$
- Drug A: probability of avoiding death changes from 0.3 to 0,4, cost per treatment $6
- Drug B: probability of avoiding death changes from 0.3 to 0.35, cost per treatment $5
- CPLS = $60 for A and $ 100 cost per treatment $5

Cost Minimization Analysis (CMA)

- Determines the least costly intervention among equally effective interventions
- Based only costs comparisons
- Required: Least cost alternative
- When there is variation in terms of costs and consequences we need CBA, CEA and CUA

Cost-Benefit Analysis (CBA)

- Expresses both costs of interventions and their consequences in monetary terms



- Result: Net benefit or cost-benefit ratio.
- Assigning a monetary value to a consequence like human life saved is difficult and therefore controversial and not used

Cost-Effectiveness Analysis (CEA)

- Compares the costs of interventions per health outcome achieved
- No monetary value is assigned to outcomes, results are presented in the form of **cost per health outcome** like **cost per HIV infection averted, cost per life saved**
- Very useful in identifying the most effective intervention from a set of alternatives

CEA contd……..

- How to decide between strategy A and B
  - Effectiveness of B = Effectiveness of A → use CMA
  - Effectiveness of B > Effectiveness of A, Cost **B** < Cost **A**, → **B** is dominant
  - Effectiveness of B > Effectiveness of A, Cost **B** > Cost **A**, → Make a decision
  - How????

Cost-effectiveness ratio (CER)

- To make a decision on which intervention to choose, calculate a **cost-effectiveness ratio** (CER).
- The most commonly CERs used are the:
  - Average cost-effectiveness ratio (ACER)

$$ACER = \frac{CostB}{EffectivenessB}$$

  - Incremental cost-effectiveness ratio (ICER)

$$ICER = \frac{CostB - CostA}{EffectivenessB - EffectivenessA}$$

- The next question is : *Is the intervention "cost-effective"?*

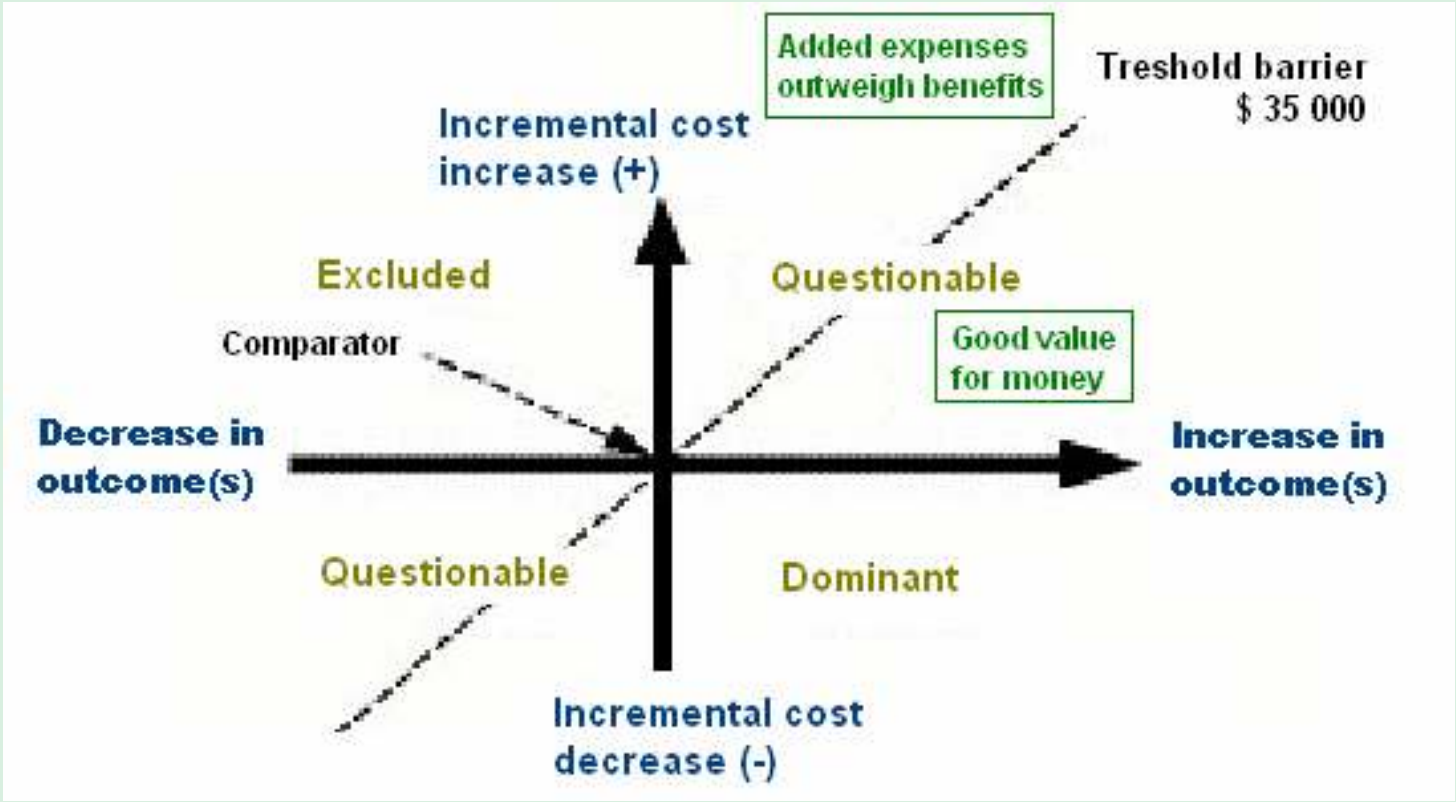
CEA contd…….

- There is no ‘magic’ cut-off number that establishes whether or not an intervention is ‘**cost-effective**’.
- It will depend on what is termed the decision maker’s ‘**ceiling ratio**’.
- The ceiling ratio can be inferred from the amount that decision-makers are **willing to pay.**

- To make a decision:
  - If ICER of the program ≤ ceiling ratio → adopt the program
  - If ICER of the program > ceiling ratio → do not adopt the program

CEA

- The cost-effectiveness acceptability Plane:



Example

Intervention	**Average costs ($)**	**QALY (average effectiveness)**	**ACER**	**ICER**
Int: 1	100	2	50	-
Int: 2	300	4	75	200
Int:3	200	2	100	∞
Int:4	150	6	25	12.5

Cost-utility Analysis

- Outcomes are measured in **healthy years**, to which a value will be attached.
- Considers **quality of life** as well as **quantity of life** using a common unit.
- Quality-adjusted life years (QALYs)
- Takes into account the impact of interventions on the quality and quantity of life

Example

- Eg 1 year with perfect health is equally desirable as 2 years with a 50% diminished quality of life
- Most appropriate if quality of life is an important outcome and when intervention affects both **morbidity** and **mortality**
- Disability-adjusted life year (DALY) widely used in economic evaluation of HIV prevention interventions outside USA

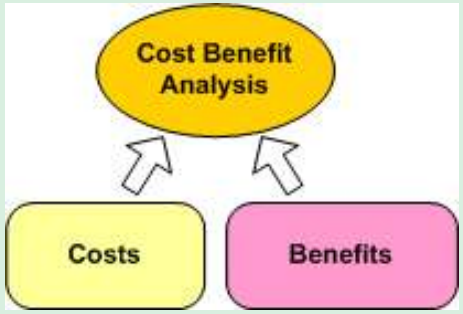
Cost-utility Analysis

- In CUA, the outcomes are measured in **healthy years**, to which a value has been attached.
- CUA is **multidimensional** and incorporates considerations of quality of life as well as quantity of life using a common unit.

- Result: Cost per unit of consequence (e.g. cost/QALY).

Cost-benefit Analysis

- CBA try to value the outcomes **in monetary terms**, so as to make them commensurate with the costs.



- Result: Net benefit or cost-benefit ratio.

- CBAs rarely used in health care.

Cost-utility Analysis (CUA)

- Outcomes are measured in **healthy years**, to which a value will be attached.
- Considers **quality of life** as well as **quantity of life** using a common unit.
- Quality-adjusted life years (QALYs)
- Takes into account the impact of interventions on the quality and quantity of life

CUA

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CUA

- Disability adjusted life years averted by each strategy
- Project the benefits of implementing particular strategy
- Assess the extent to which treatment improves population health

Adjusting for timing

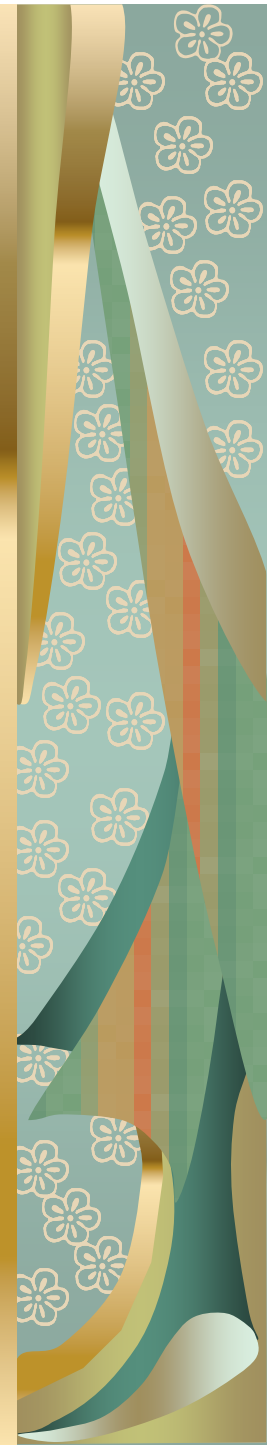
- Discounting (3% - 5%)
  - Prefer to have benefits now and bear costs in the future – ‘time preference’
  - Rate of time preference is termed ‘discount rate
  - To allow for differential timing of costs (and benefits) between programmes all future costs (and benefits) should be stated in terms of **their present value** using discount rate.
  - Thus, future costs given less weight than present costs.

8 Elements of CEA

- A clear study perspective, time frame, and analytic horizon
- An explicitly defined study question
- Relevant assumptions underlying the study
- Detailed descriptions of the interventions
- Existing evidence of the interventions' effectiveness

8 Elements of CEA contd….

- Proper identification of all relevant costs:
  - decide whether to include or exclude productivity losses
  - apply appropriate discount rate
  - confirm that included costs are relevant to perspective
- An appropriate choice of outcome:
  - calculate a suitable *CER*
  - report *ICER* results (unless the only comparator is baseline)
  - conduct sensitivity analyses
- A comprehensive discussion of the results:
  - deal with issues of concern
  - address implications of underlying assumptions



Conclusion

- Epidemiological models taking account of economic constraints or incentives faced by individuals or institutions will be helpful
- Economic models taking into account the spatial and temporal dynamics of disease will be more practical.
- Change of behaviour reduces the economic impact of the epidemic
- Therefore there is need to strengthen the **marriage** between Economics and Epidemiology to enable policy makers to make informed decisions

THANK YOU ALL AND ESPECIAL TO DIMACS

TO GOD BE THE GLORY

Economic Modelling: With special reference to HIV/AIDS

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