Modelling Club: Week 4

Welcome to Modelling Club!

Modelling Scenario

- Scenario: BF.7 subvariant in Bangladesh
- Main purpose: estimate number of cases, number of hospitalizations, number of deaths caused by BF.7
- Three teams with questions related to this scenario

waning immunity of vaccines
-protection from vaccine could be permanent, long-term, or short-term
-depends on number of doses/boosters
-different for every vaccine

Model Building Steps

Teams 1 & 2: assume high level of protection, no waning immunity

1. Identify the question
   a. Team 1: What is the impact of vaccination on indirect costs?
   b. Team 2: What is the impact of vaccination on direct costs?
   c. Team 3: Transmission, virulence of BF.7, intervention, vaccine effectiveness
      a. transmission between districts: spread from infected to uninfected
      b. virulence of BF.7: testing range of virulence values for BF.7 and compare
      c. intervention: compare with/without intervention or more than one intervention
      d. vaccine effectiveness: compare range of effectiveness values

Taifur
Motahara
Sudeb

effectiveness is <100% for many reasons
-how vaccine is made (differs by manufacturer)
-decreases over time (waning immunity)
-evolution of virus subtypes

days	1	30	90
protection	99%	90%	80%

effectiveness: 80% protection among those vaccinated
coverage: percent of population that is vaccinated

Tasks from Week 3

- Meet with your team!
    - Communication plan? Tasks?

Model Building Steps

1. Identify the question
    a. Team 1: What is the impact of vaccination on indirect costs?
    b. Team 2: What is the impact of vaccination on direct costs?
    c. Team 3:
2. Identify existing knowledge: structure, values for parameters

Tasks from Week 3

- Meet with your team!
  - Communication plan? Tasks?
- Find sources of existing knowledge
  - sources for parameters and inputs?
  - similar models?

Modelling Club

- Today's goals:
  - review each team's initial model structure
  - discuss calculations for questions related to health economics
  - find values for parameters, inputs, and costing calculation (model quantification)

Choose Model Structure

- Team 1: Sohel
  - number of age groups: 4 groups
  - 0-14, 15-45, 45-60, 60+
  - SEIRHD with age groups
- Team 2: Sharif & Farzana
  - SEIRS with hospitalization
  - deaths?
- Team 3: Taifur, Motahara, & Sudeb

Identify the question

Identify existing knowledge

Choose model structure

Remember: all models are wrong

Health Economics

Economic Evaluations

- Health economics: making the best use of scarce resources
- Comparing interventions: costs associated with and without intervention(s)
- Types of evaluations

  economic costs

  Team 2 ← - cost-minimization: compare net (direct) costs

  Team 1 ← - cost-effectiveness: compare net costs as well as net health benefits (indirect costs)
    - cost-utility: special type of cost-effectiveness using generic health benefit measurement
  - cost-benefit: all costs and benefits are expressed in monetary units

Economic Evaluations

<u>measuring health benefits</u>
-decreased number of cases
-decreased number of hospitalizations
-generic benefit measurement

- Health economics: making the best use of scarce resources
- Comparing interventions: costs associated with and without intervention(s)
- Types of evaluations
  - cost-minimization: compare net (direct) costs
  - cost-effectiveness: compare net costs as well as net health benefits (indirect costs)
    - incremental cost-effectiveness ratio
    - cost-utility: special type of cost-effectiveness using generic health benefit measurement
  - cost-benefit: all costs and benefits are expressed in monetary units

-YLL
-QALY
-DALY

family of patient
-accommodation
-transportation
-etc. could be included in direct costs

health impacts of COVID-19
-death
-long COVID
-breathlessness
-weakness
-fatigue
-memory loss

Types of Costs

Net (Direct) Costs

- Treatments for non-hospitalized
- Hospitalization
  - bed
  - treatment
- Vaccination
  - dose, booster
  - staff/facilities to administer vaccination

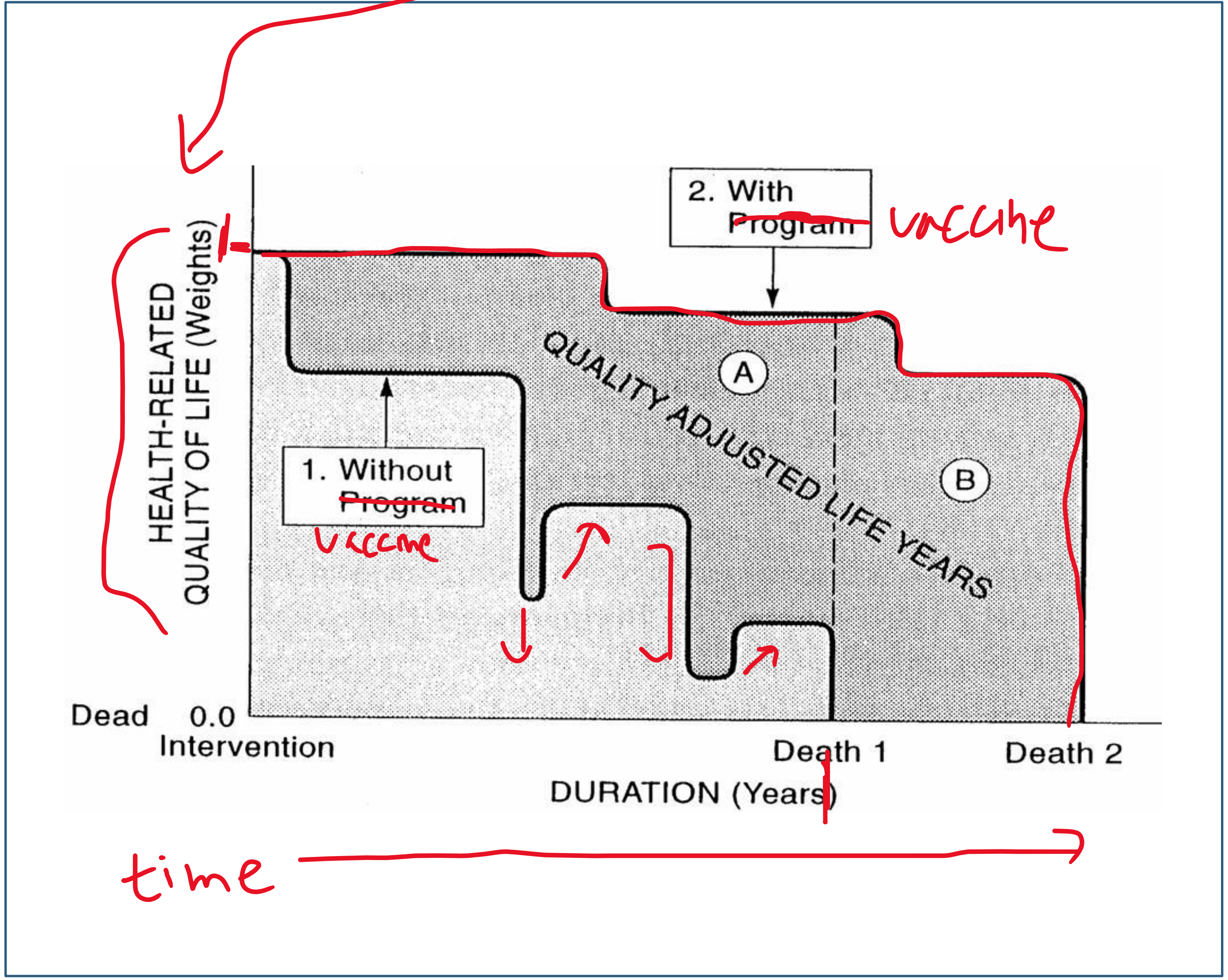
-scale between 0 and 1
-all health conditions have a number in between
-lower if quality of life if more restricted
-higher if health has little impact on quality of life

Health (Indirect) Benefits

- years of life lost (YLL)
  - deaths only
- adjusted life-years
  - QALY or DALY
  - includes deaths as well as disability (diminished state of health)
  - most countries use QALYs

-QALY and DALY are same scale, reversed
-QALY: 0=dead to 1=perfect health
-DALY: 1=dead to 0=no disability

-QALYs developed in US in 1970s
-DALYs started from Global Burden of Disease



QALY

Health Quality over Time

-0-20: 0.95
-20-50: 0.9
-51-78: 0.7
-79: 0

-how are QALYs calculated?

- Health-related quality of life
  - scale of 0 (dead) to 1 (perfect health)
  - values in between for diminished health
- Considers quality of life, duration, and death with and without intervention
  - death 1: no intervention, earlier death, poorer life quality
  - death 2: intervention, later death, better life quality

difference between these is QALY for the interventi on

-QALY estimates available for COVID-19

from
model

Calculating Costs

net costs
-economic/direct
costs

Model	Output		Cost		Total	
No vaccine	Non-hospitalized cases (n)	3587	Treatment	$1	$3587	$244022
	Hospitalized cases (n)	1233	Treatment	$27	$33291	
	Duration of stay (days)	14	Bed per day	$12	$207144	
Vaccine	Non-hospitalized cases (n)	2877	Treatment	$0.80	$2301.60	$116241.60
	Hospitalized cases (n)	844	Treatment	$27	$22788	
	Duration of stay (days)	9	Bed per day	$12	$91152	
	Vaccinations (n)	50000	Dose	$1.20	$60000	$72000
			Administration	$12000	$12000	

Team 2: top part of equation, cost/gain of vaccination
Team 1:

Incremental Cost-Effectiveness Ratio

compare net costs to health benefits

- IECR: incremental cost per health gained
- $ICER = \dfrac{incremental\ cost\ of\ intervention\ compared\ to\ none}{Incremental\ health\ benefit\ of\ \ intervention\ compared\ to\ none}$
- $ICER =$

vaccine

$$\frac{Cost\ of\ intervention + (All\ costs\ for\ cases\ with\ intervention) - (All\ costs\ for\ cases, no\ intervention)}{Health\ burden\ with\ intervention - Health\ burden\ without\ intervention}$$

- $ICER = \dfrac{\$72000+\$116241.60-\$244022}{37-30} = \dfrac{-\$120602.40}{7} = -\$17{,}228.91$
- Save \$17228 per QALY

-cost or savings per QALY

QALY → 37 30

Model Quantification

Choose Modeling Method

Which one?
-stochastic takes longer and take more computational power

$\beta = 0.7$

Which one?
-how certain are we about model parameters?
-stochastic allows some variation

-can also perform a sensitivity analysis after running deterministic model
-check impact of different values

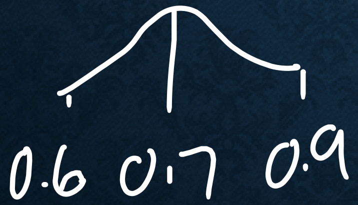
1. Identify the question
2. Identify existing knowledge
3. Choose model structure
4. **Choose modeling method**

- Deterministic models
  - results will be the average result
  - uses average parameter estimates
  - no estimate of precision
- Can add a stochastic element later if needed

range/randomness

-model outputs are single values
-5000 cases, 200 hospitalizations, etc.

parameter distribution β



run model many times (1000 times) $\rightarrow$ 5000 cases (95% CI: 4500-5600)

$\boxed{S} \xrightarrow{\beta} \boxed{I} \xrightarrow{\gamma} \boxed{R}$

Model Quantification

- Values for parameters
  - parts of the model that represent movement between compartments
  - usually a rate, proportion, coefficient
  - example: transmission coefficient ß
- Values for inputs
  - starting values for model compartments
  - whole number
  - example: number of susceptibles
- Values for calculations
  - costs/benefits related to health

Identify the question

Identify existing knowledge

Choose model structure

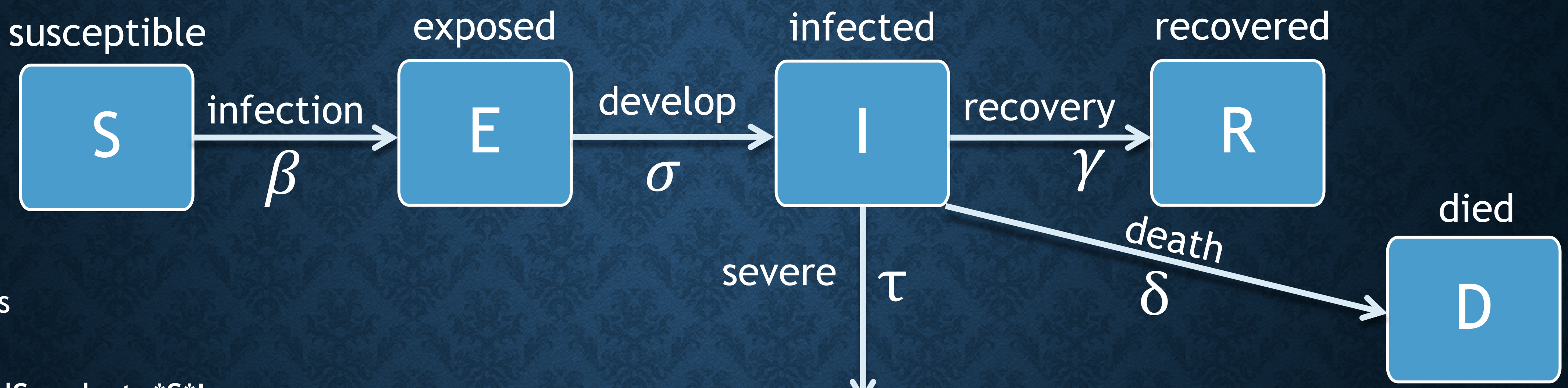
Choose modeling method

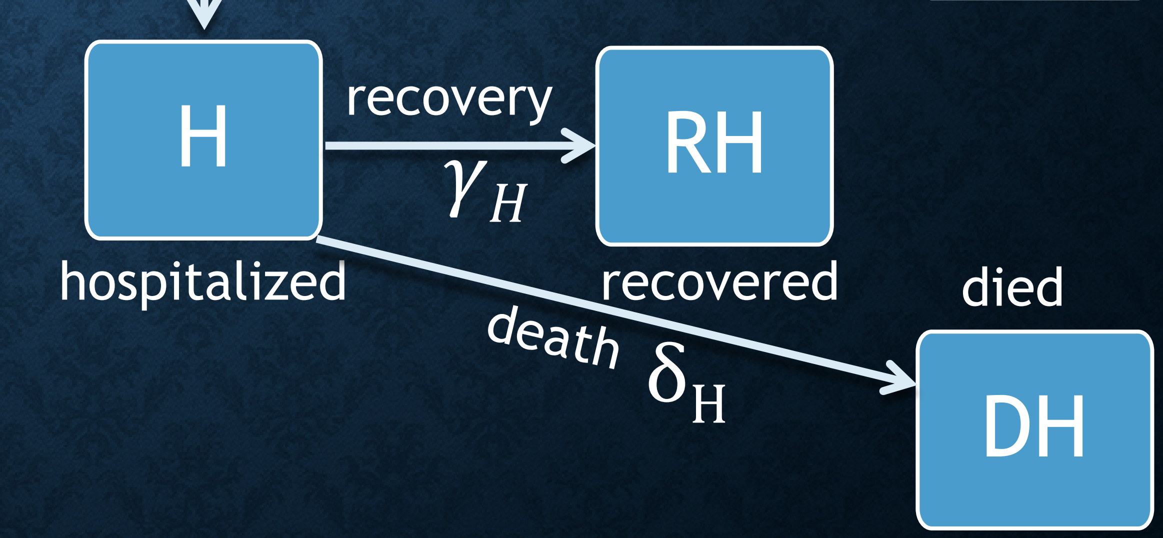
Model quantification

SEIR with Hospitalization and Death

β	beta
σ	sigma
γ	gamma
γ_H	gammaH
δ	delta
δ_H	deltaH
τ	tau

7 parameters





1. dS = -beta*S*I
2. dE = beta*S*I - sigma*E
3. dI = sigma*E - gamma*I - delta*I - tau*I
4. dH = tau*I - gammaH*H - deltaH*H
5. dR = gamma*I
6. dD = delta*I
7. dRH = gammaH*H
8. dDH = deltaH*H

Model Quantification Table

Tasks for Next Guided Session

- Meet with your team!
- Model quantification
  - add values and sources to the shared table
- Make a structure for your model
  - draw graphic
  - generate code