Modelling Club: Week 3

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

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: To be determined…

Health economics

Tasks from Week 2

- Meet with your team!
  - Who is on Team 1? Sohel
  - Who is on Team 2? Sharif & Farzana
  - Who is on Team 3? Taifur & Motahara
  - 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: To be determined
2. Identify existing knowledge: structure, values for parameters

Tasks from Week 2

- Meet with your team!
  - Who is on Team 1?
  - Who is on Team 2?
  - Communication plan? Tasks?

Estimating proportion hospitalized is very difficult
-all people hospitalized at any point with COVID-19
-all people who had COVID-19
-proportion of infected who are hospitalized

- Find sources of existing knowledge
  - human demographics, natural history of virus, impacts of control
  - similar models?

-SEIR model structure for COVID-19
-WHO has estimates for some parameters
-hospitalization for Bangladesh?
	-may not be accurate
	-from previous variants

Modelling Club

- Today's goals:
  - discuss possible model structures
  - look at example code for these structures

Choose Model Structure

- What structure is appropriate for COVID-19? SEIR captures stages of disease
- What components do we need to answer our questions?

Identify the question

Identify existing knowledge

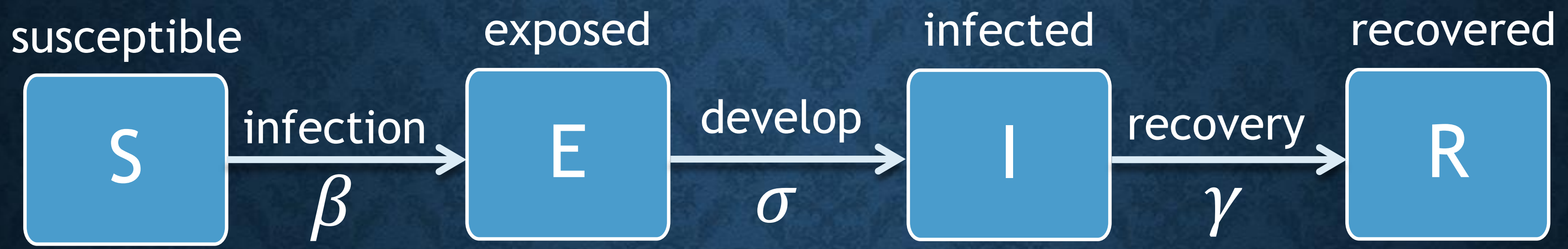
Choose model structure

Remember: all models are wrong

SEIR Model

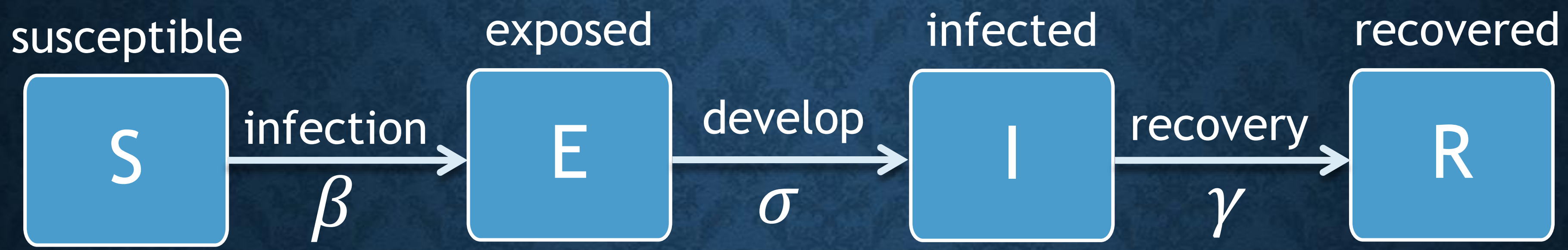
$$S \xrightarrow{\beta} E \xrightarrow{\sigma} I \xrightarrow{\gamma} R$$

SEIR Model



- Susceptible, Exposed, Infected, Recovered
  - β is a transmission coefficient
  - γ is recovery rate
  - $1/\gamma$ is the recovery period
  - σ is the rate of change from exposed to infectious
  - $1/\sigma$ is the latent period

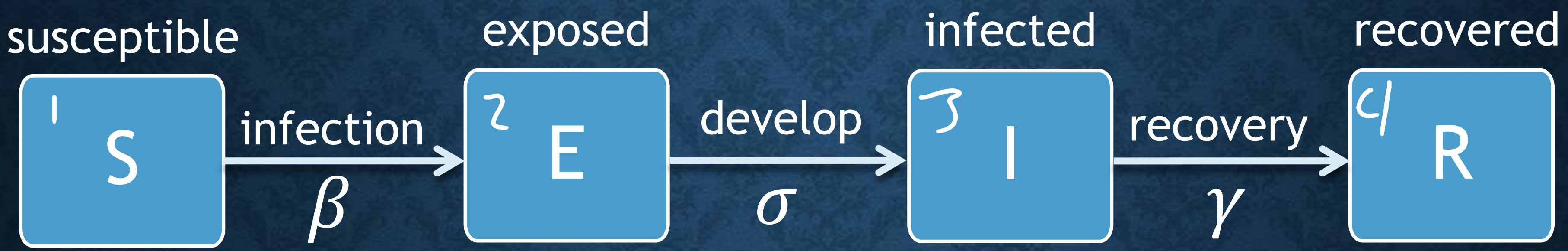
SEIR Model



- Susceptible, Exposed, Infected, Recovered
  - β is a transmission coefficient
  - γ is recovery rate
  - $1/\gamma$ is the recovery period
  - σ is the rate of change from exposed to infectious
  - $1/\sigma$ is the latent period
- Assumptions:
  - no births, migrations, deaths
  - everyone recovers
  - no re-infections

SEIR Model

-start by drawing graphic
-then write equations
-same number of equations as compartments
-incoming arrows are positives
-outgoing arrows are negatives



- Susceptible, Exposed, Infected, Recovered
  - β is a transmission coefficient
  - γ is recovery rate
  - 1/γ is the recovery period
  - σ is the rate of change from exposed to infectious
  - 1/σ is the latent period

1 $$\frac{dS(t)}{dt} = -\beta S(t)I(t)$$

2 $$\frac{dE(t)}{dt} = \beta S(t)I(t) - \sigma E(t)$$

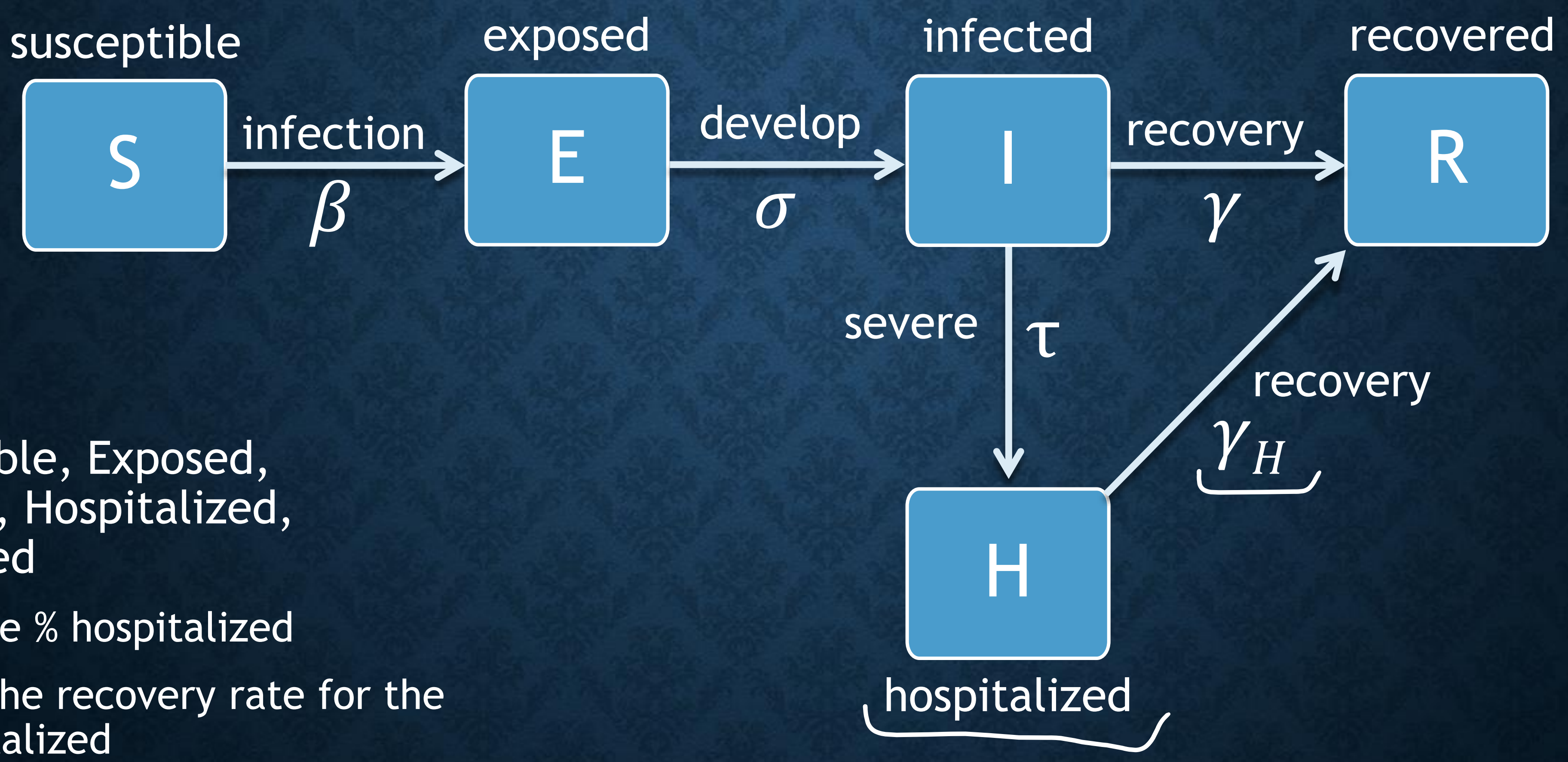
3 $$\frac{dI(t)}{dt} = \sigma E(t) - \gamma I(t)$$

4 $$\frac{dR(t)}{dt} = \gamma I(t)$$

-equations describe how everyone moves between compartments
-we set up these equations in R to run the model

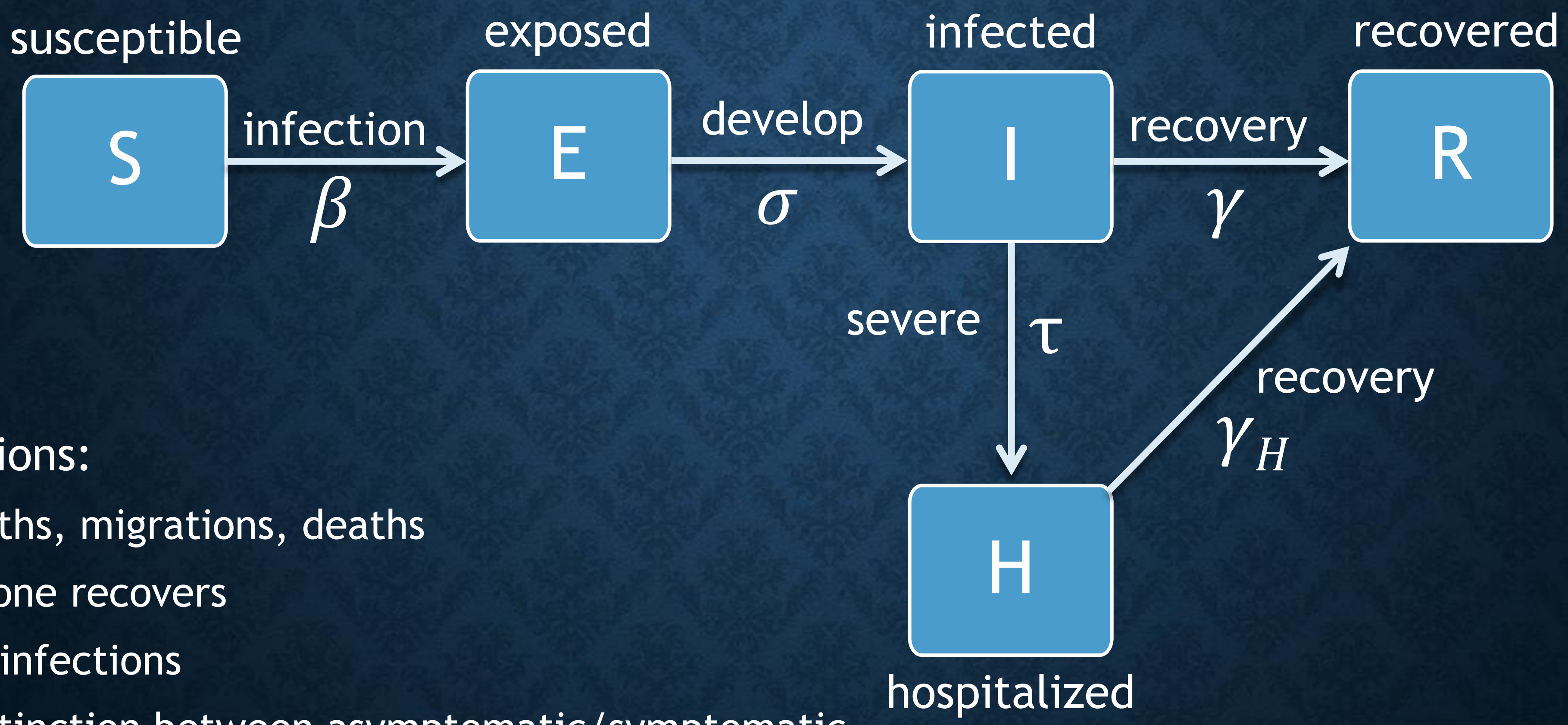
Example Code: SEIR

SEIR with Hospitalization



- Susceptible, Exposed, Infected, Hospitalized, Recovered
  - τ is the % hospitalized
  - γ_H is the recovery rate for the hospitalized

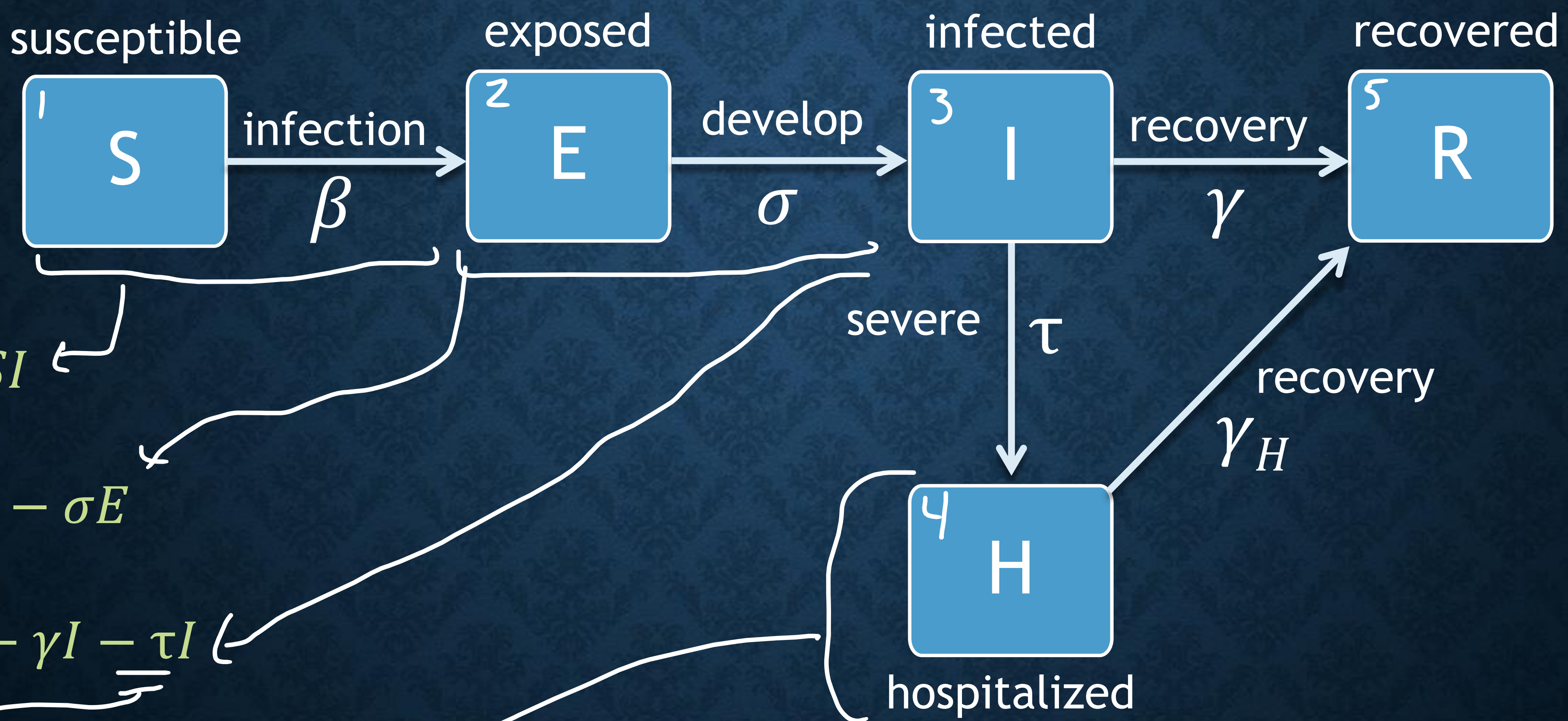
SEIR with Hospitalization



- Assumptions:
  - no births, migrations, deaths
  - everyone recovers
  - no re-infections
  - no distinction between asymptomatic/symptomatic
  - some infected are hospitalized
  - hospitalized have slower recovery

Number of equations? 5

SEIR with Hospitalization



same

1. $dS = -\beta SI$

same

2. $dE = \beta SI - \sigma E$

3. $dI = \sigma E - \gamma I - \tau I$

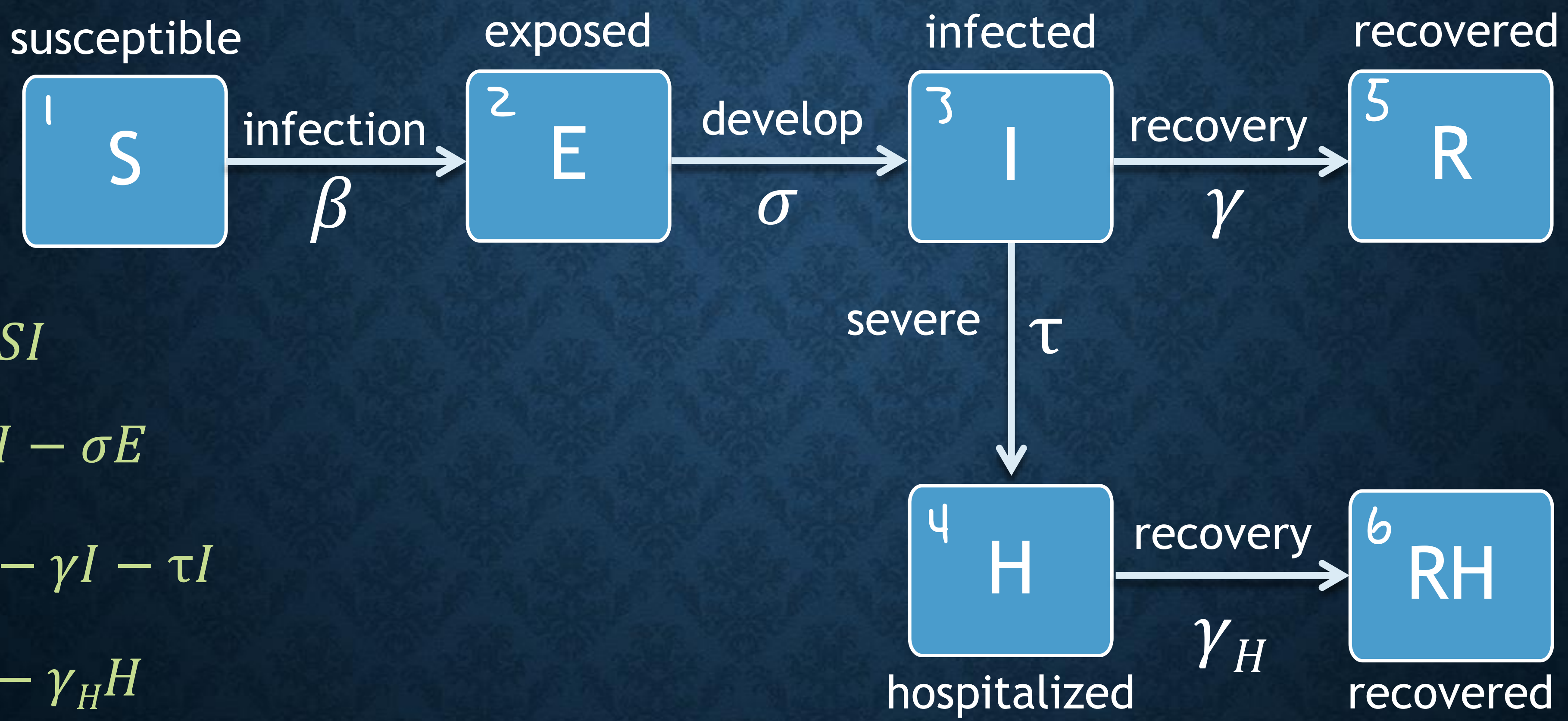
4. $dH = \tau I - \gamma_H H$

5. $dR = \gamma I + \gamma_H H$

Example Code: SEIHR

One more equation to capture the recovered hospitalizations separately

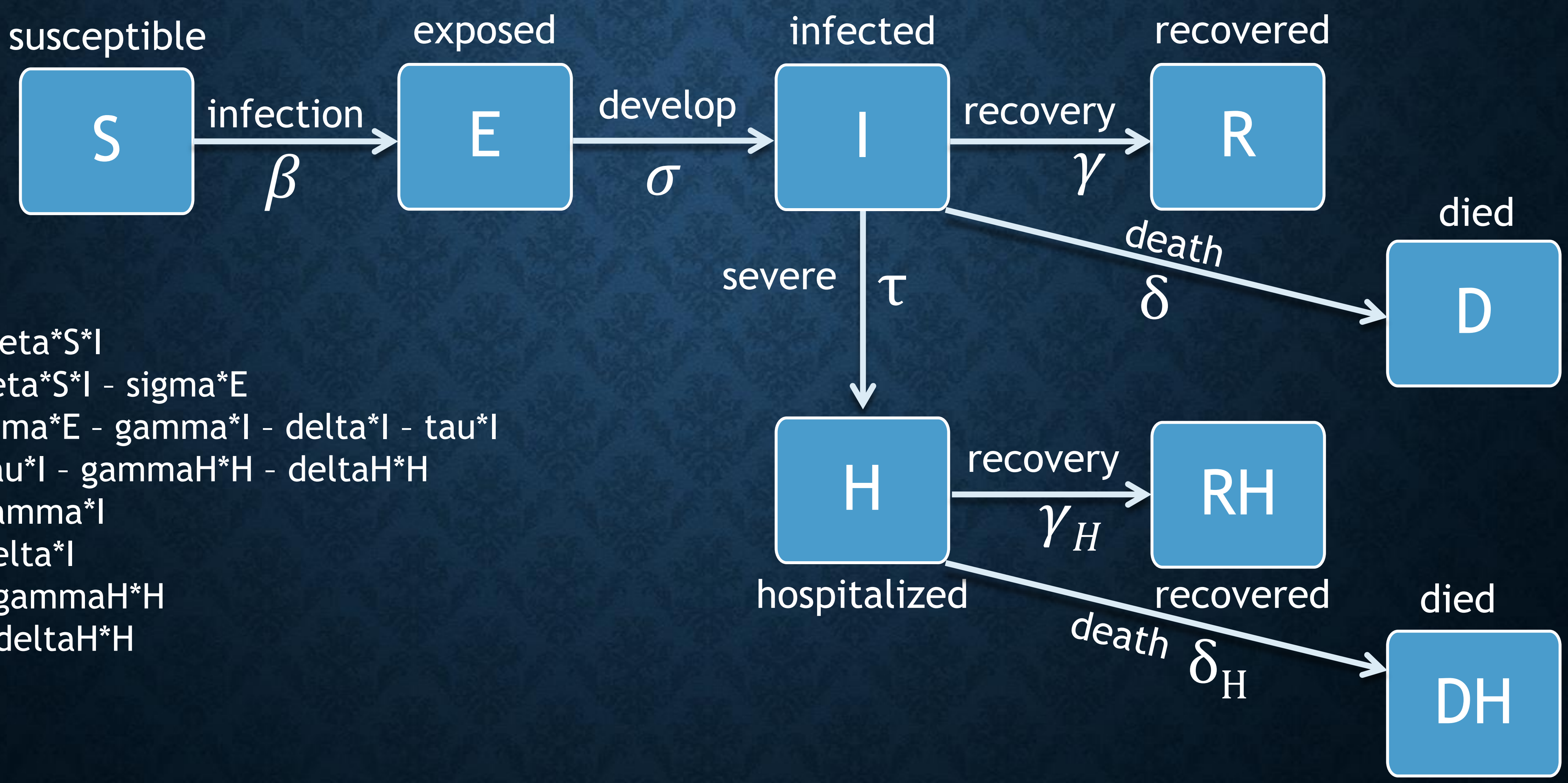
SEIR with Hospitalization



1. $\mathrm{d}S = -\beta S I$
2. $dE = \beta S I - \sigma E$
3. $dI = \sigma E - \gamma I - \tau I$
4. $dH = \tau I - \gamma_H H$
5. $dR = \gamma I$
6. $dRH = \gamma_H H$

Example Code: SEIHR Modified

SEIR with Hospitalization and Death



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

Modelling Teams

Tasks for Next Guided Session

- Meet with your team!
  - discuss how to share the tasks
  - make a plan for communicating with each other
- Find potential sources for existing knowledge
  - make a list or copy the links and send them to me
- Make a structure for your model
  - start with a simpler version
  - add pieces until you have a version that could answer your question

Team 3
-identify key question and send to me

SEIR + H + D
-also need to think about vaccination

Health Economics

- To calculate direct costs, we would take the total cases, hospitalizations, and deaths, and multiply by the different costs associated with each
- For indirect costs, there are several metrics
  - e.g. YLL, DALY, lost productivity
  - YLL: years of life lost, calculated when someone dies of an illness
- For YLL, we would need to know the ages of the person dying
  - the age of those who died is subtracted from life expectancy to get the number of years of life that were lost (because they died prematurely)

Health Economics

- For YLL, we would need to know the ages of the person dying
  - the age of those who died is subtracted from life expectancy to get the number of years of life that were lost (because they died prematurely)
- One way to calculate would be to use averages
  - use estimate of the average age of cases who died (D_{age})
  - use estimate of life expectancy (LE)

$$YLL = \# \, deaths \; * (LE - D_{age})$$

  - so if LE=70 and average age of cases who died is 68, and there are 600 deaths, then there are 1200 years of life lost

Health Economics

- For YLL, we would need to know the ages of the person dying
  - the age of those who died is subtracted from life expectancy to get the number of years of life that were lost (because they died prematurely)
- Another way could add age groups to the models
  - this would allow for different ages to have different hospitalization and death parameters, which is more realistic
  - this would give separate estimates for numbers of hospitalizations and deaths for each age group, then these numbers could be used in the YLL calculation