Back of the Envelope Modelling of Infectious Disease Transmission Dynamics for Veterinary Students

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By

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Cambridge Scholars Publishing

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For my family.

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use

1.1 Introduction

1.2 Draw a flow chart

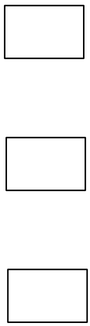


Fig. 1-1 *The beginnings of a basic flow chart consisting of three host states: susceptible (S), infected (I) and recovered (R).*

S

S

is

S I I

R S I

λ

I R

δ

I R

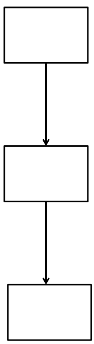


Fig. 1-2 *A basic flow chart consisting of three host states: susceptible (S), infected (I) and recovered (R). Hosts in state S can move into state I as the result of* ***transmission*** *(the rate of transmission is represented by λ). Recovery is represented by a* ***transition*** *from box I to box R (the arrowed labeled δ).*

1.3 Writing the equations

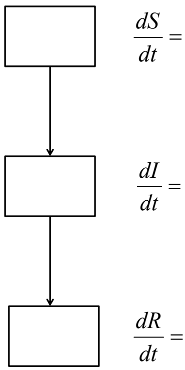


Fig. 1-3 *Begin by writing the derivative alongside the corresponding box.*

dS/dt

S dI/dt

I

dR/dt R

S

S

S

S I

S

S

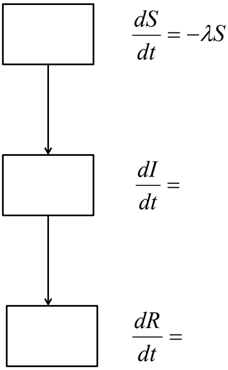


Fig. 1-4 *The right-hand side of the equation for S is constructed by first noting that there is a single arrow leaving box S. This means that there is only one term to the right of the equals sign and it must be negative. We supply the term by multiplying the arrow label (λ) by S, which is the label of the box from which the arrow originates.*

S S

λ

S

λ S

I

I

I

λ S λS

$\delta,$

$I.$

$$\frac{dI}{dt} = +\lambda S - \delta I$$

$$\frac{dS}{dt} = -\lambda S$$

$$\frac{dI}{dt} = \lambda S - \delta I$$

$$\frac{dR}{dt} =$$

S $I.$ λS

S I

λS

S I

λS λI

I

$S.$ λI I

λS

R

R

R R

δ I δI

$$\frac{dS}{dt} = -\lambda S$$

$$\frac{dI}{dt} = \lambda S - \delta I$$

$$\frac{dR}{dt} = \delta I$$

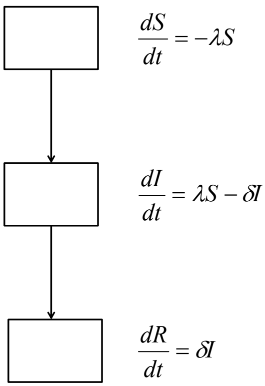


Fig. 1-5 *A complete SIR model of avian influenza in a broiler house. S = number of susceptible birds in a single broiler house, I = number of infected birds, R = number of recovered birds, λ = the force of infection, δ = the recovery rate.*

1.4 Using the recipe for other systems

S I

R λ

δ

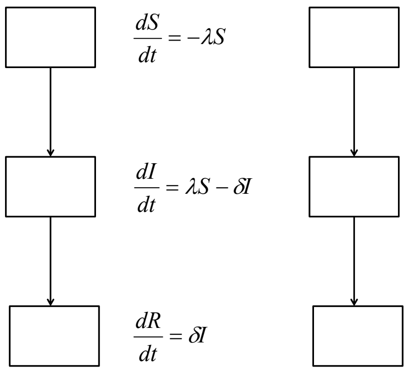
S

I

R

λ

δ



$$\frac{dS}{dt} = -\lambda S \qquad \frac{dS}{dt} = -\lambda S$$

$$\frac{dI}{dt} = \lambda S - \delta I \qquad \frac{dI}{dt} = \lambda S - \delta I$$

$$\frac{dR}{dt} = \delta I \qquad \frac{dR}{dt} = \delta I$$

Fig. 1.6 *SIR odel of how avian influenza infection spreads between broilers in a single broiler house; An SIR model of how avian influenza spreads between broiler houses.*

1.5 Adding new boxes

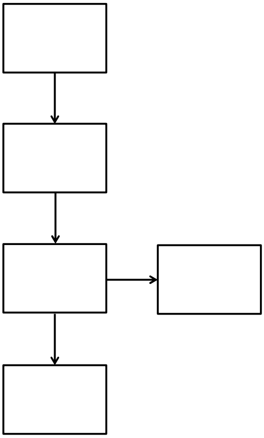
E

D

I

E *I* *E*

I



$$\frac{dS}{dt} = -\lambda S$$

$$\frac{dE}{dt} = \lambda S - \sigma E$$

$$\frac{dI}{dt} = \sigma E - \alpha I - \delta I$$

$$\frac{dD}{dt} = \alpha I$$

$$\frac{dR}{dt} = \delta I$$

Fig. 1-7 *An SEIR model of avian influenza in a broiler house. S = number of susceptible birds in a single broiler house, E = number of infected-but-not-yet-infectious birds, I = number of infectious birds, R = number of recovered birds, λ = the force of infection, σ = rate at which infected birds become infectious, δ = the recovery rate.*

E

E

I

I

I

σ

E *σE*

α

I *αI* *δ*

I *δI*

$$\frac{dI}{dt} = \sigma E - \alpha I - \delta I$$

1.6 Suggested further reading

et al.

1.7 Summary

1.8 References

) *Infectious Diseases of Humans. Dynamics and Control*

: *Parasitic and Infectious Diseases: Epidemiology and Ecology.*

Modelling Infectious Diseases in Humans and Animals.

An introduction to Infectious Disease Modelling.

et al

2.1 Introduction

transition

I_1 I_2

I_2

I_1 S E

λ S

E

E I_1 σ I_1

I_2 κ I_2 δ

α σ κ δ α

σ E I_1

κ I_1 I_2