

Host – Parasite

Microparasites: Virus, Bacteria, Fungus, Protozoa

Macroparasites: Metazoa

Pathogen: Virulent / Deleterious



Population Dynamics of Infectious Disease

Don't Track Pathogen Numbers

Track Numbers/Densities of Hosts Categorized:

Susceptible

(**E** Latent Period; Infected but Not Infectious)

Infective

Removed

Epidemic: Simple, General, Recurrent

Simple Epidemic: No Removal (No Recovery)

Only Transition: $S \rightarrow I$

β Rate at which infection occurs when S & I interact

Simple Epidemic: pathogen fitness

Upper Respiratory Infection

Epidemic Curve: Rate at which new cases occur



Simple Epidemic (SI)

S_t Density of Susceptibles, Time t

I_t Density of Infectives, Time t

Dynamics

$$\frac{dI}{dt} = \beta S_t I_t = -\frac{dS}{dt}$$

$$S_t + I_t = (n + 1); S_0 = n$$

Let $\beta = 1$; Solve:

$$S_t = n(n + 1) / [n + \exp\{(n + 1)t\}]$$

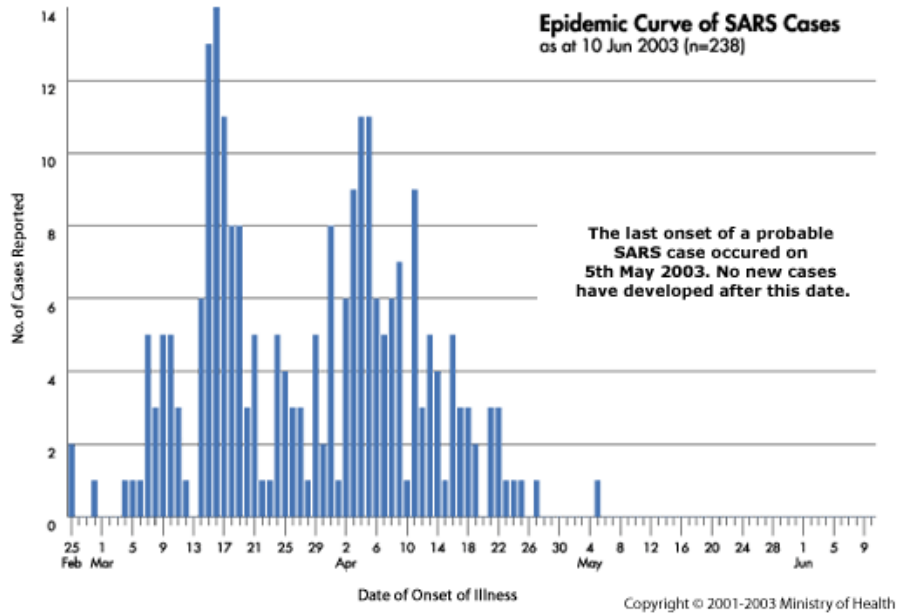
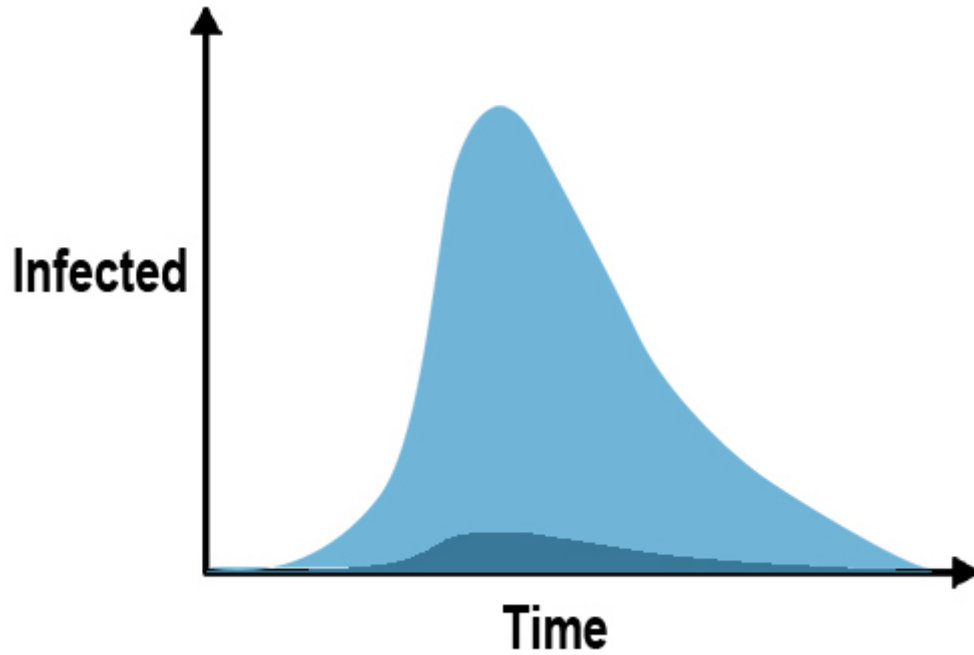
$$t \rightarrow \infty; S_t \rightarrow 0$$

Epidemic Curve: dI/dt ; unimodal, symmetric

Increases quickly at first, maximum, declines to 0

New cases per unit time:

1. Few infectives, slower spread
2. Both susceptibles and infectives numerous, rapid spread
3. Few susceptibles, slower spread



SARS: Singapore Ministry of Health

Not SI, but SIR



General Epidemic (SIR)

$$\frac{dS}{dt} = -\beta S_t I_t$$

$$\frac{dI}{dt} = \beta S_t I_t - \gamma I_t$$

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

Infection & Removal

Relative Removal Rate = γ / β

Pathogen's R_0 :

Number new cases/case when disease (pathogen) rare

Susceptible Density, Transmission Rate &
Time Elapsing Until Infective Removed

$$R_0 = \frac{\beta S_0}{\gamma}$$

Pathogen Rare: Will Epidemic Occur?

Invasion Analysis: *Critical Population Size*

$$S_0 = S_{\text{CRIT}} \quad \mathbf{IF} \quad S_0 = \gamma / \beta \Rightarrow R_0 = 1$$

Pathogen Extinction Marginally Stable

$$S_0 > S_{\text{CRIT}}, \text{ Pathogen's } R_0 > 1, \text{ Epidemic}$$

Pathogen Extinction Unstable; Disease Invades

$$S_0 < S_{\text{CRIT}}, \text{ Pathogen's } R_0 < 1,$$

Pathogen Extinction Stable

Pathogen Fails to Invade Host Population