The impact of media coverage on the transmission dynamics of human influenza

Robert Smith?

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Outline

- Effects of media

Outline

- Effects of media
- The model

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- Analysis

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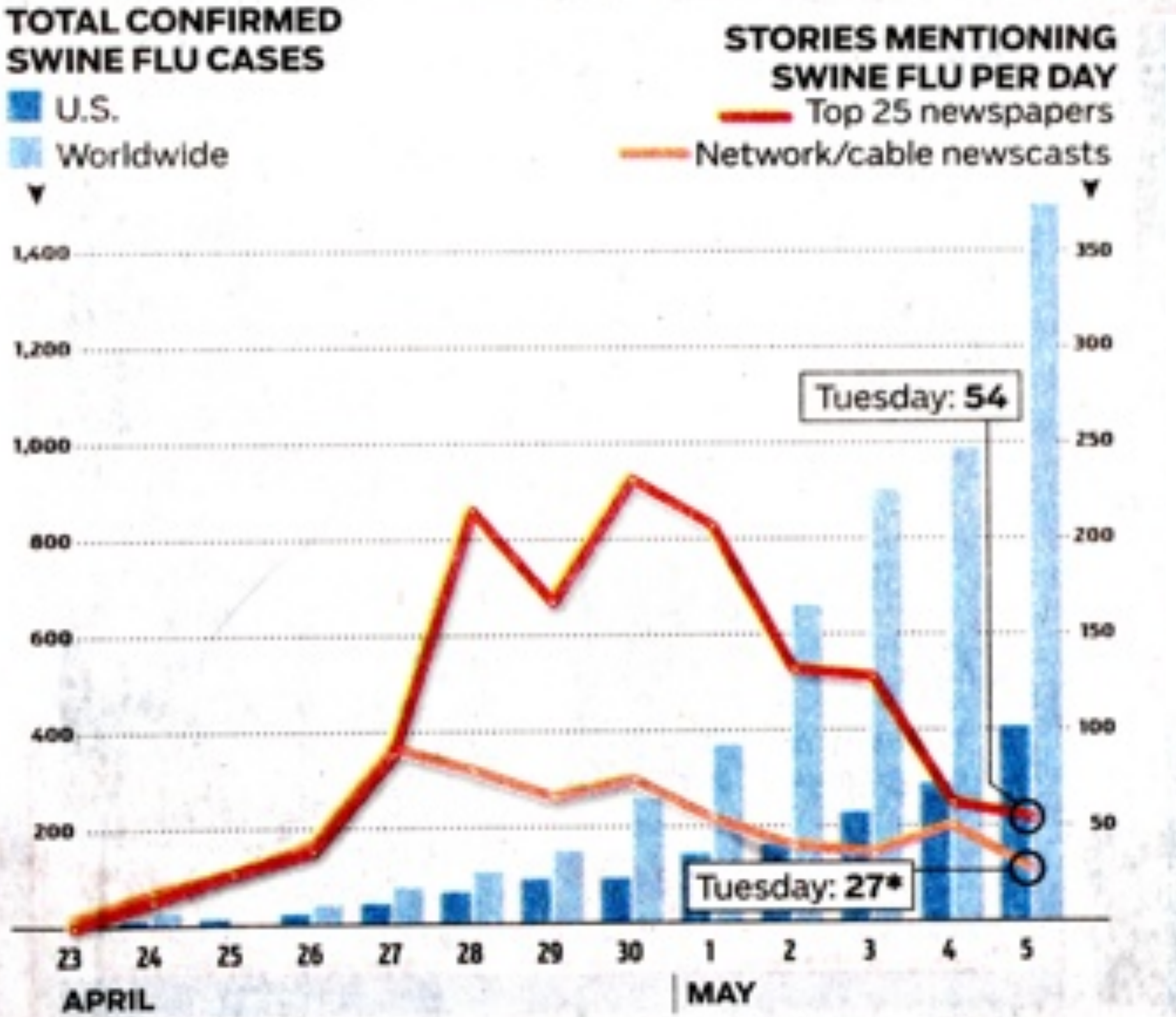
- Implications.

Story arc: Media and swine flu

The swine flu outbreak appears to have peaked, at least in terms of media coverage. While the number of confirmed cases continues to grow, the number of fatalities associated with the virus remains low, especially when compared to typical seasonal flu deaths.



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SOURCES: Centers for Disease Control and Prevention, World Health Organization

ADAM ZOLL AND PHIL GEIB/TRIBUNE

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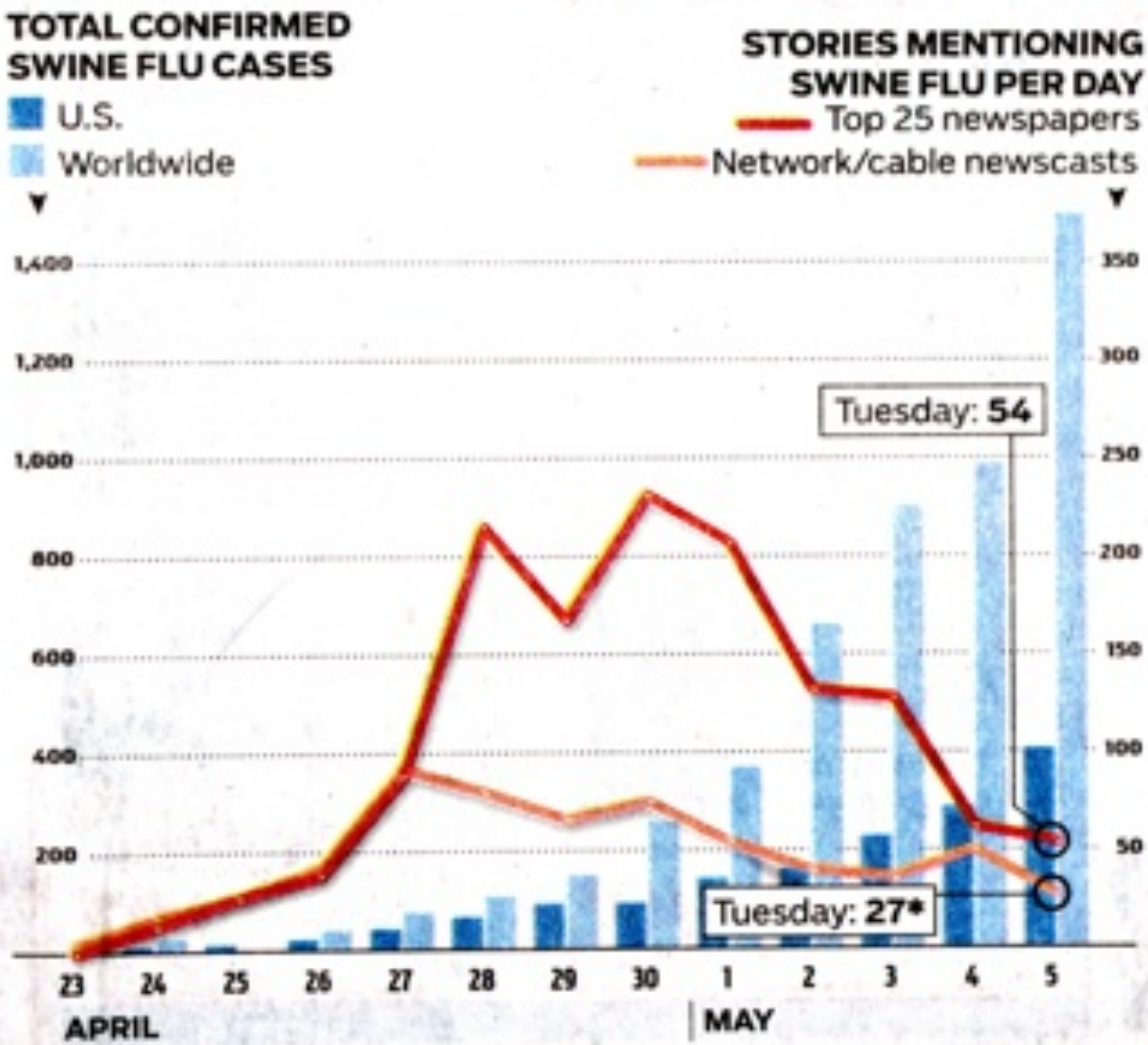

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Number of swine flu deaths worldwide as of Tuesday (Mexico, **29**; U.S., **2**)

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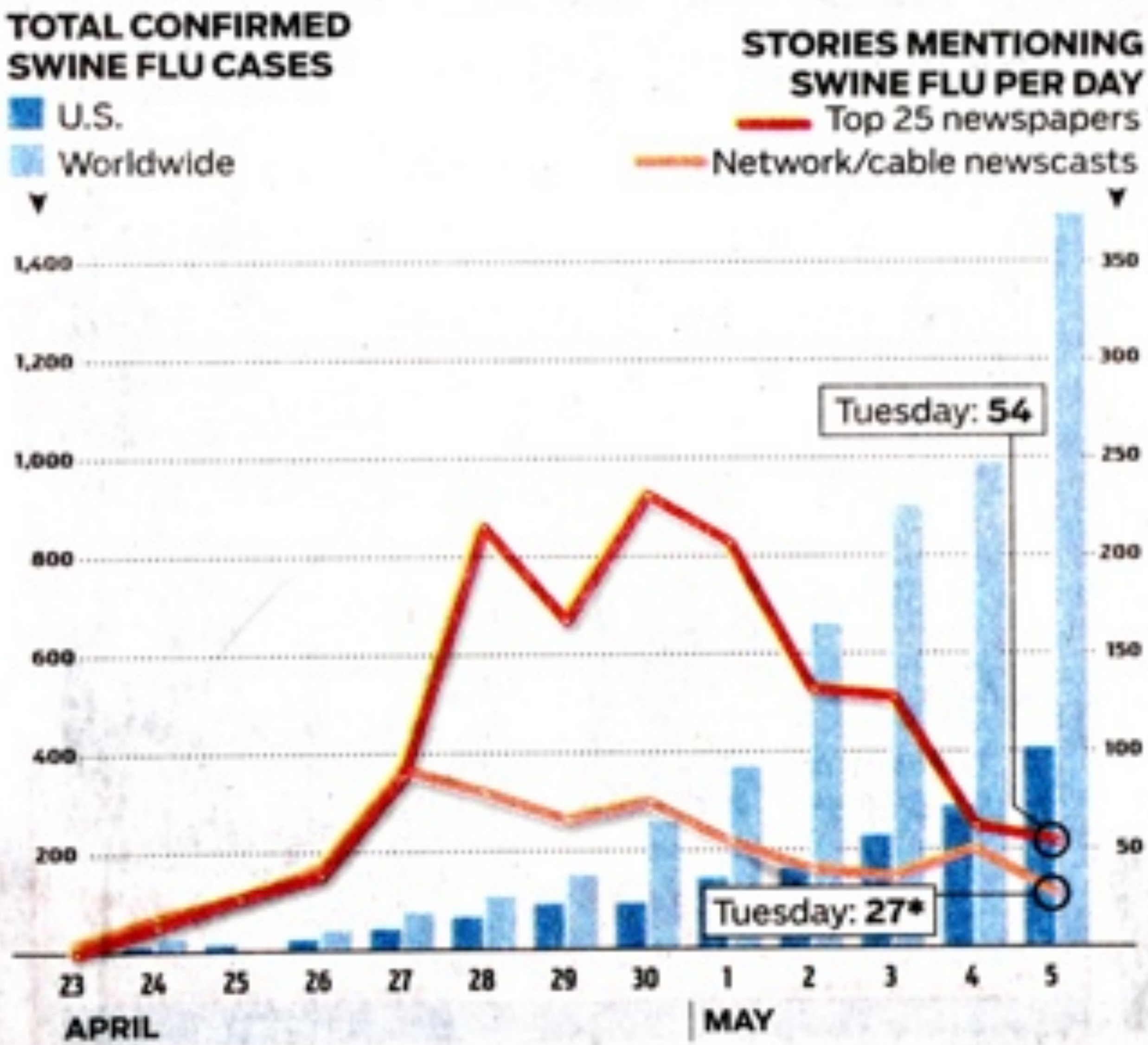

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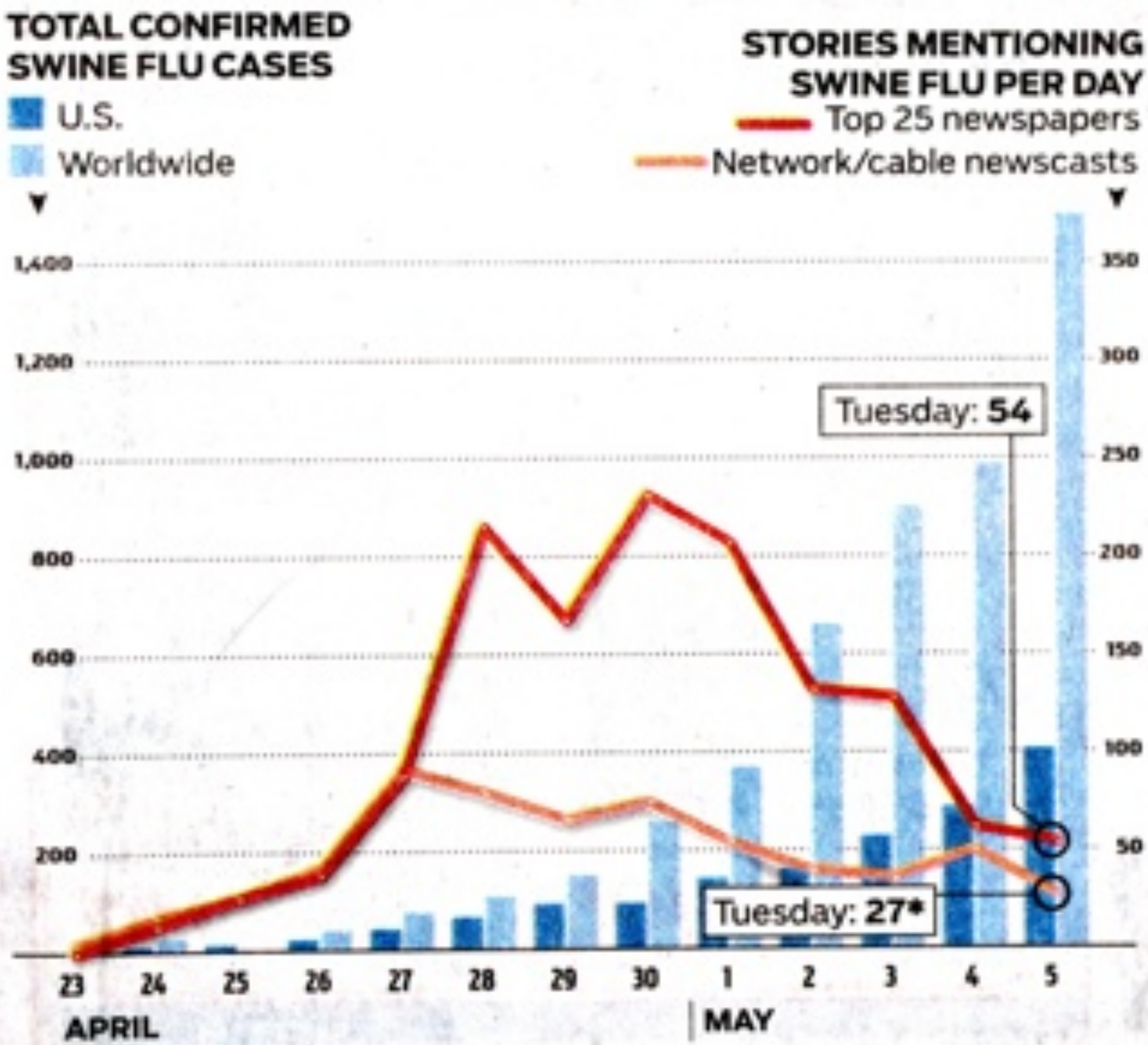

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Number of U.S. children who have died from other flus so far this season

36,000

Estimated number of Americans who die from the flu each year

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ADAM ZOLL AND PHIL GEIB/TRIBUNE

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The media influences:

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- individual behaviour

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- perception of risk (eg SARS in Chinatown).

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- Mass media are key tools in risk communication
- However, they have been criticised for making risk a spectacle.

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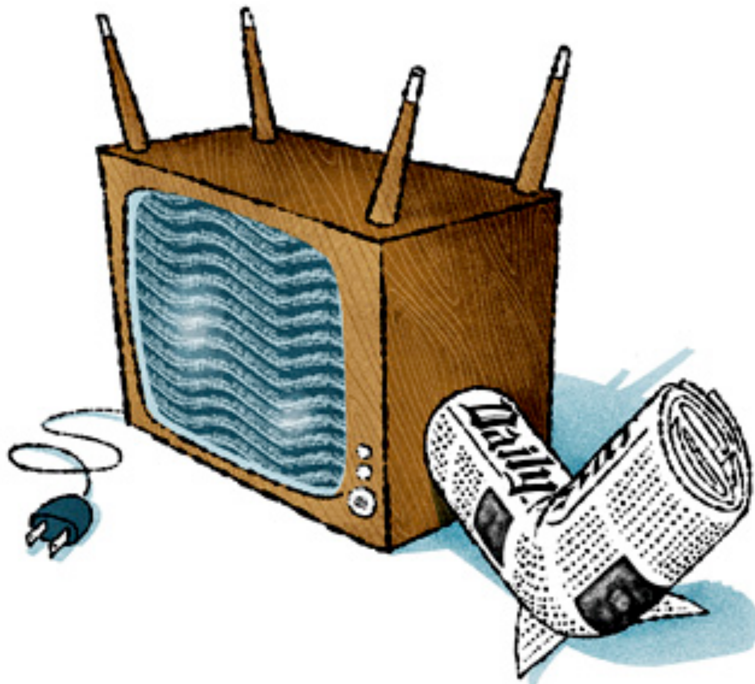
- However, this has been revised in recent years.

Contemporary media theories

- Media is shaped by the dominant cultural norms



Contemporary media theories

- Media is shaped by the dominant cultural norms
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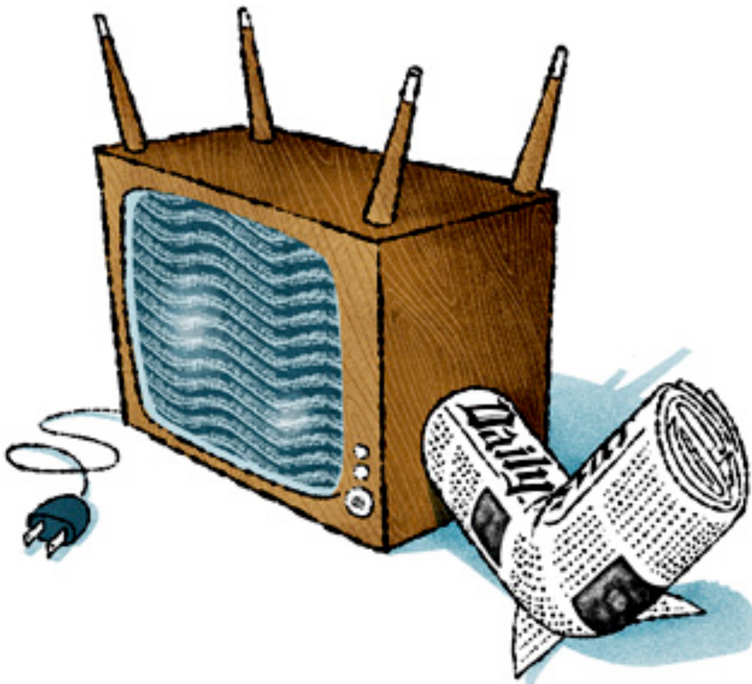

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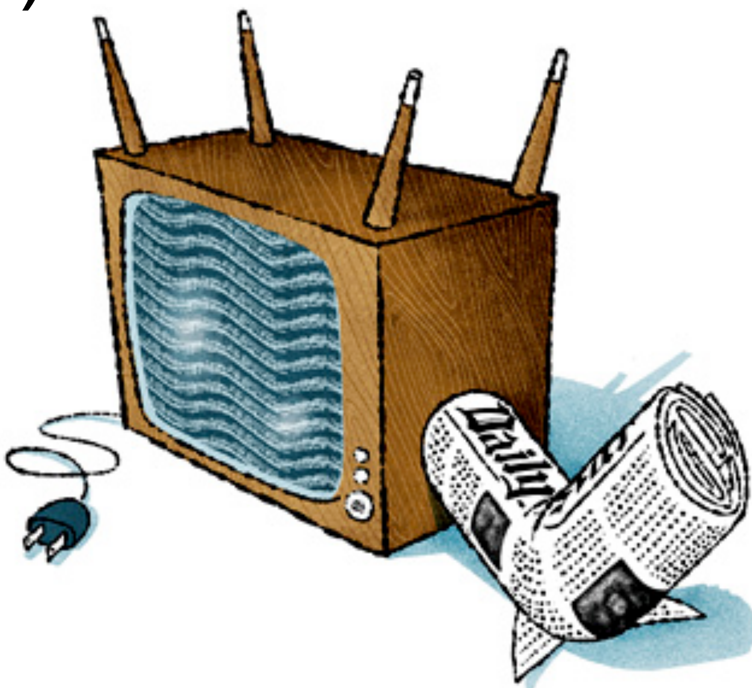

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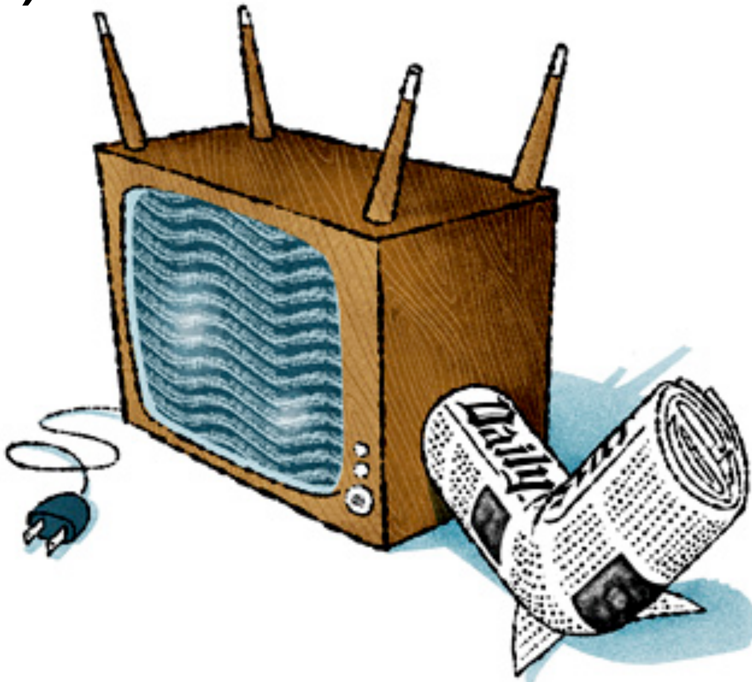

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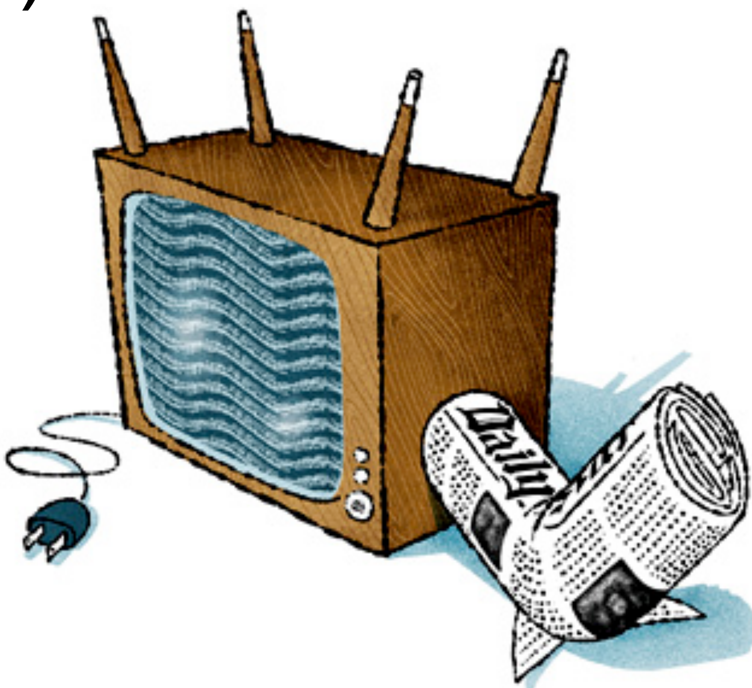
- Or they may resist the dominant media messages altogether.



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- Conversely, media may have little effect on more familiar diseases

  (eg seasonal influenza).

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An intersubjective anchorage

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  (eg climate change).

Media and risk protection

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- Individuals may overprotect, which may have additional consequences for the disease
- eg, after an announcement of the 1994 outbreak of plague in Surat, India, many people fled to escape the disease, thus carrying it to other parts of the country
- Media influences behaviour, which in turn influences media.

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- eg, rumours that the polio vaccine could cause sterility and spread HIV hampered polio eradication efforts in Nigeria
- Misplaced fears of autism in the developed world have stoked fears of vaccinations against childhood diseases.

Demographic interruption

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  (eg HPV vaccine).

The model

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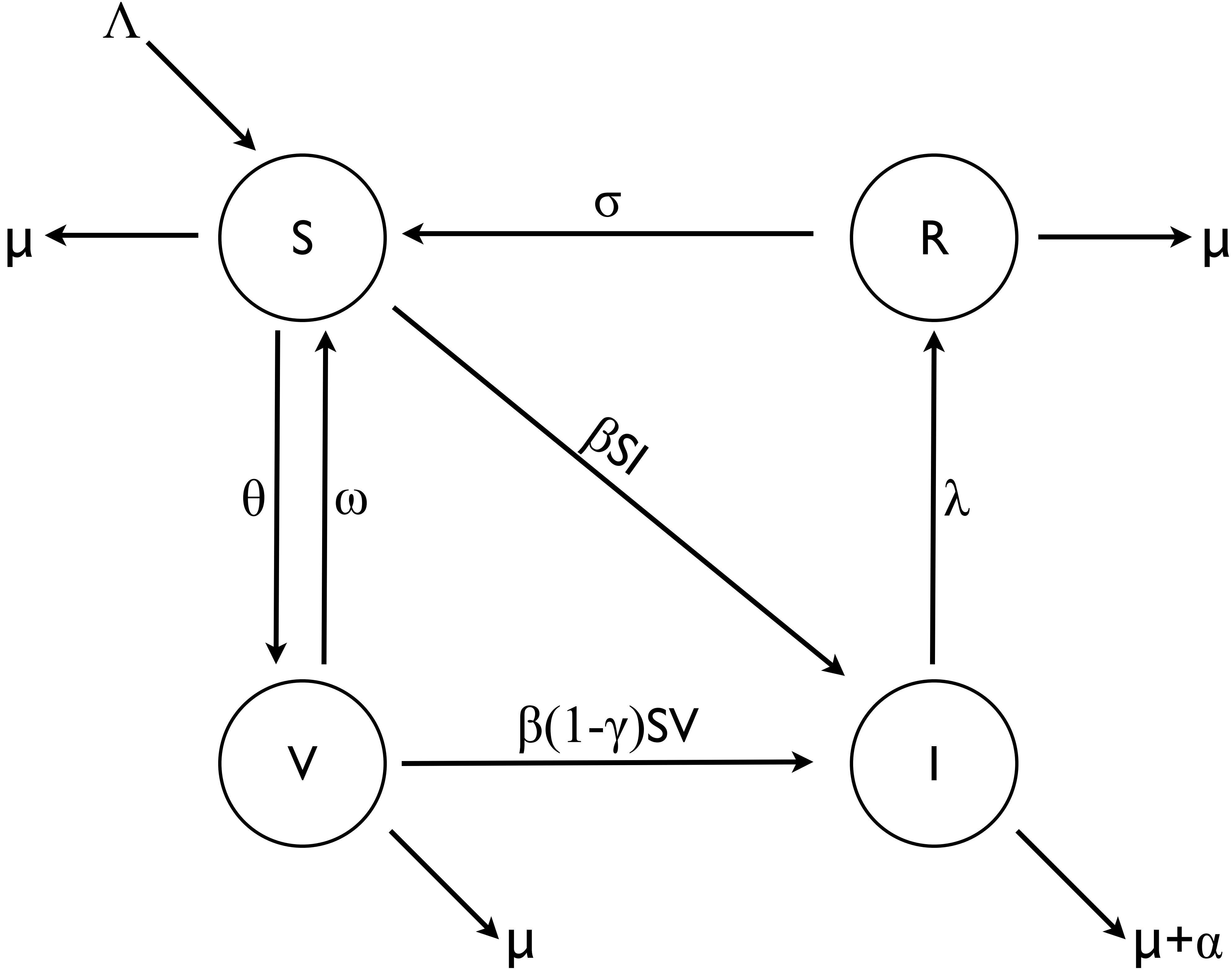
- We include a vaccine that confers temporary immunity
- Vaccinated individuals may still become infected but at a lower rate than susceptibles
- Media converage is included via a saturated incidence function.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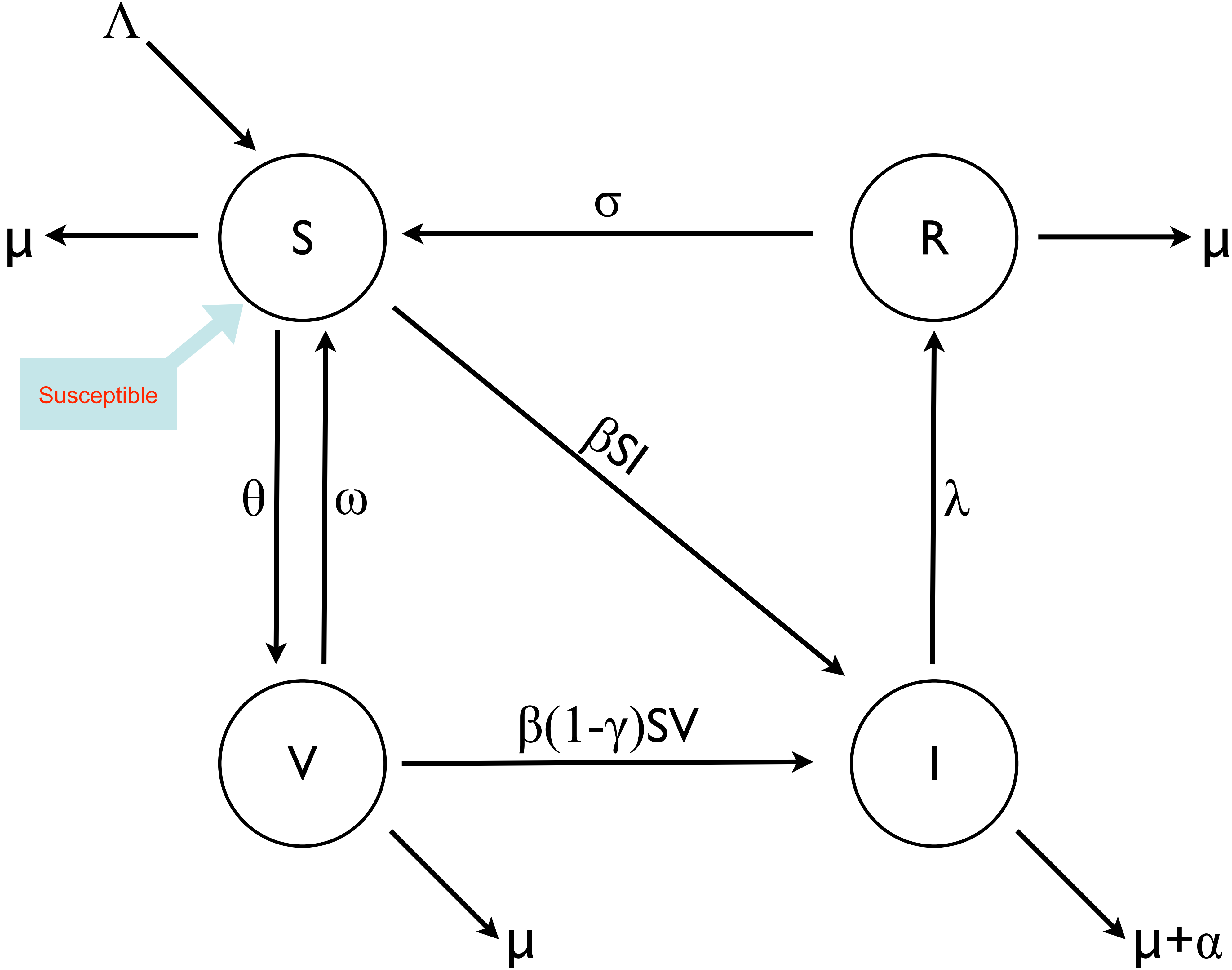

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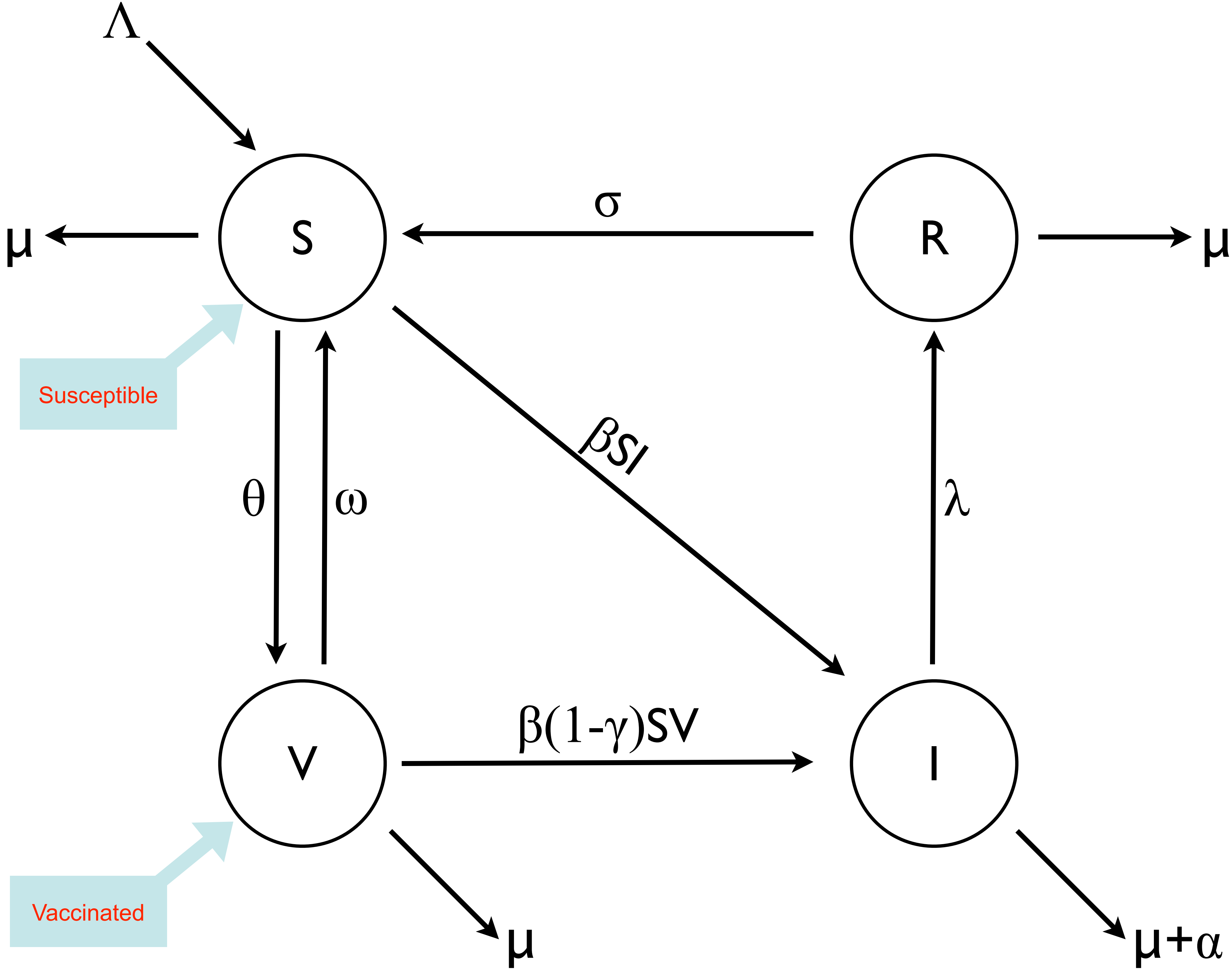
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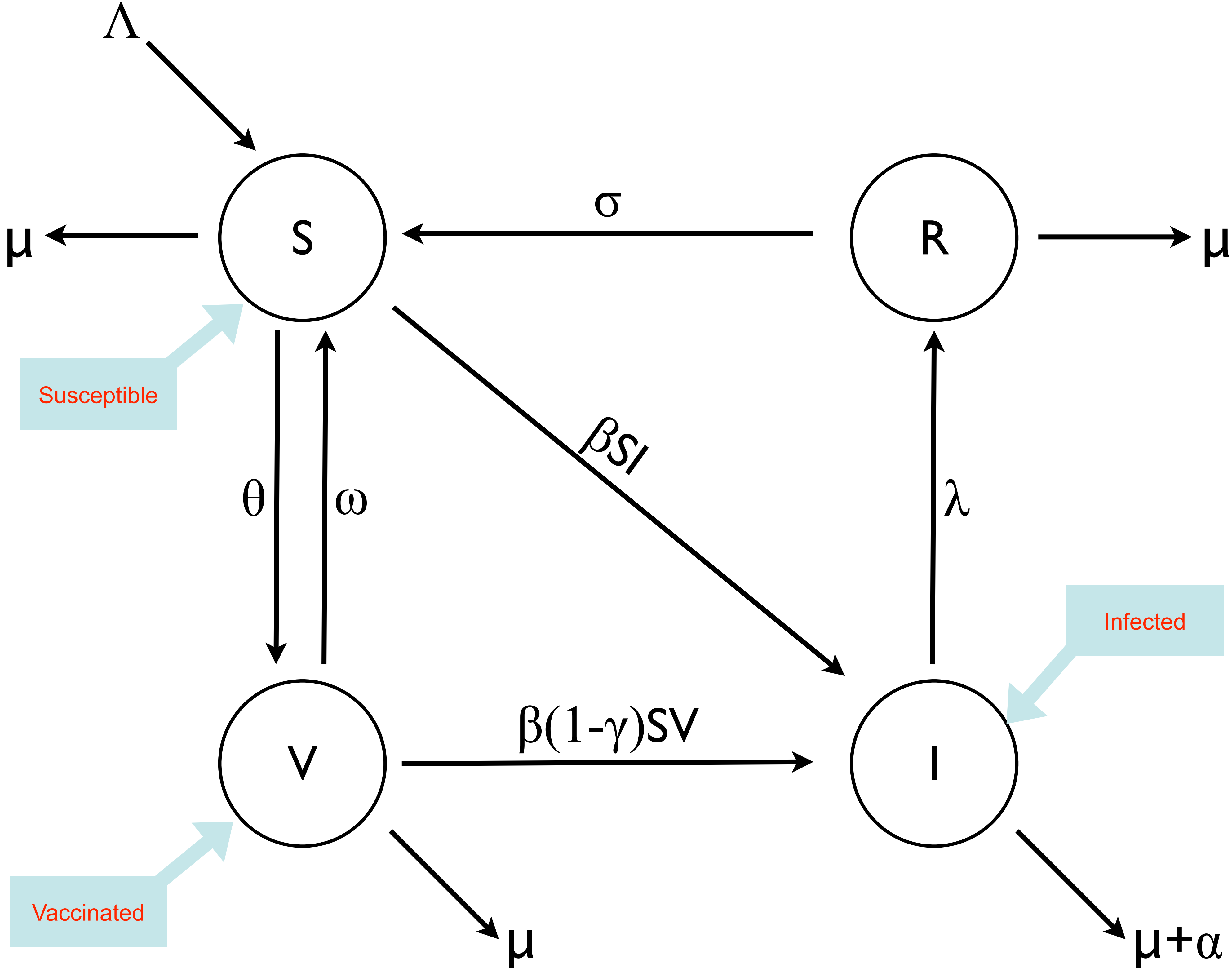
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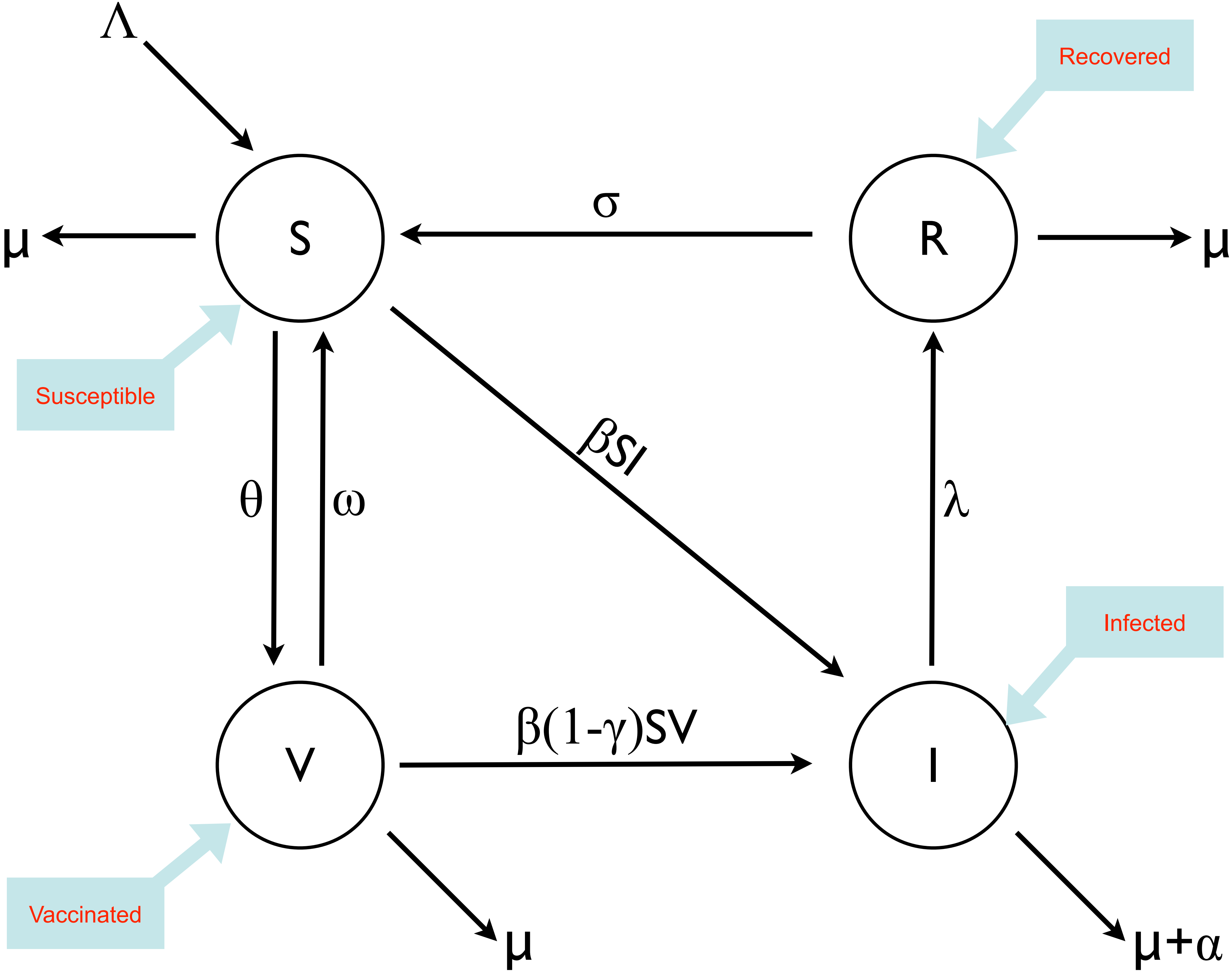

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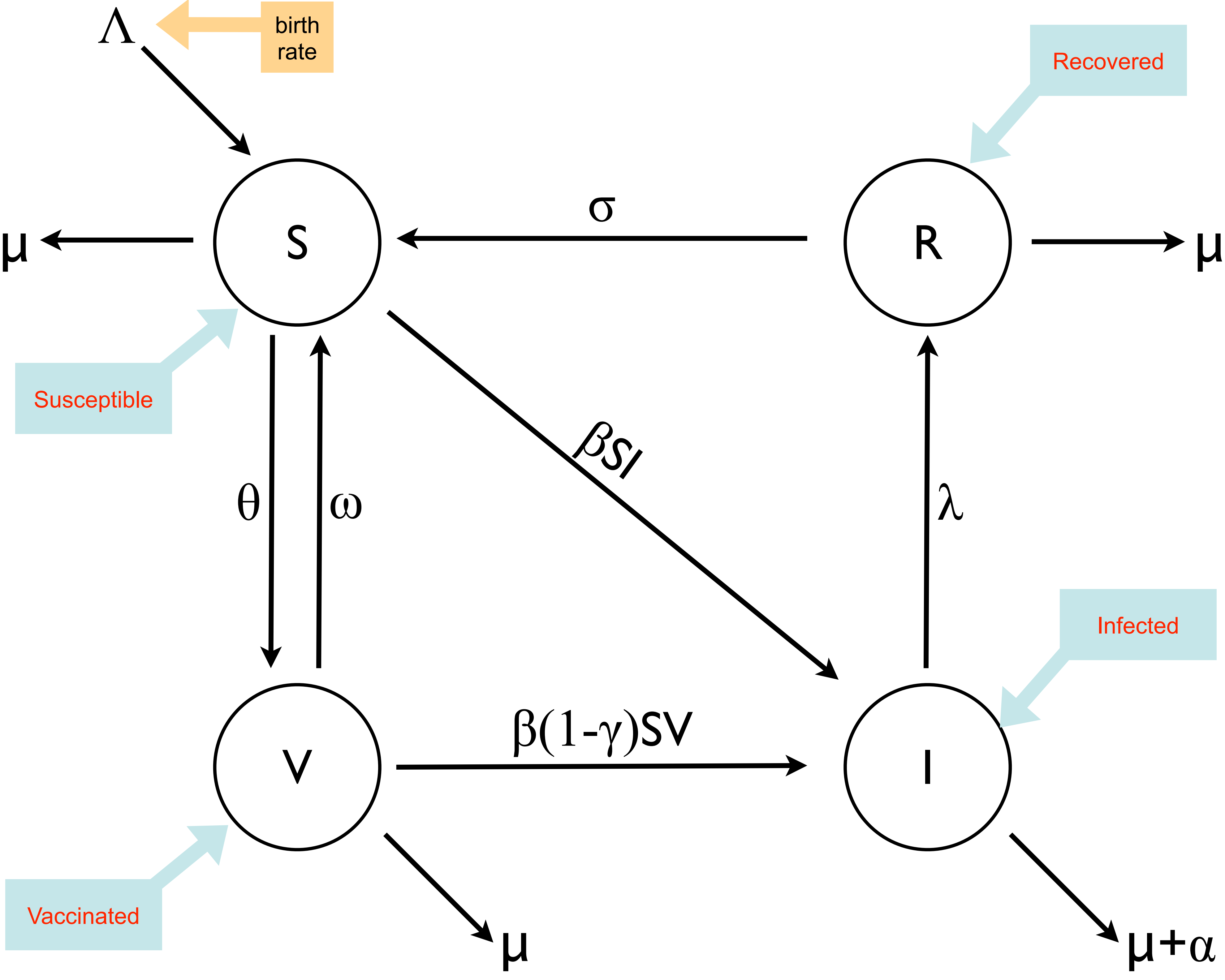

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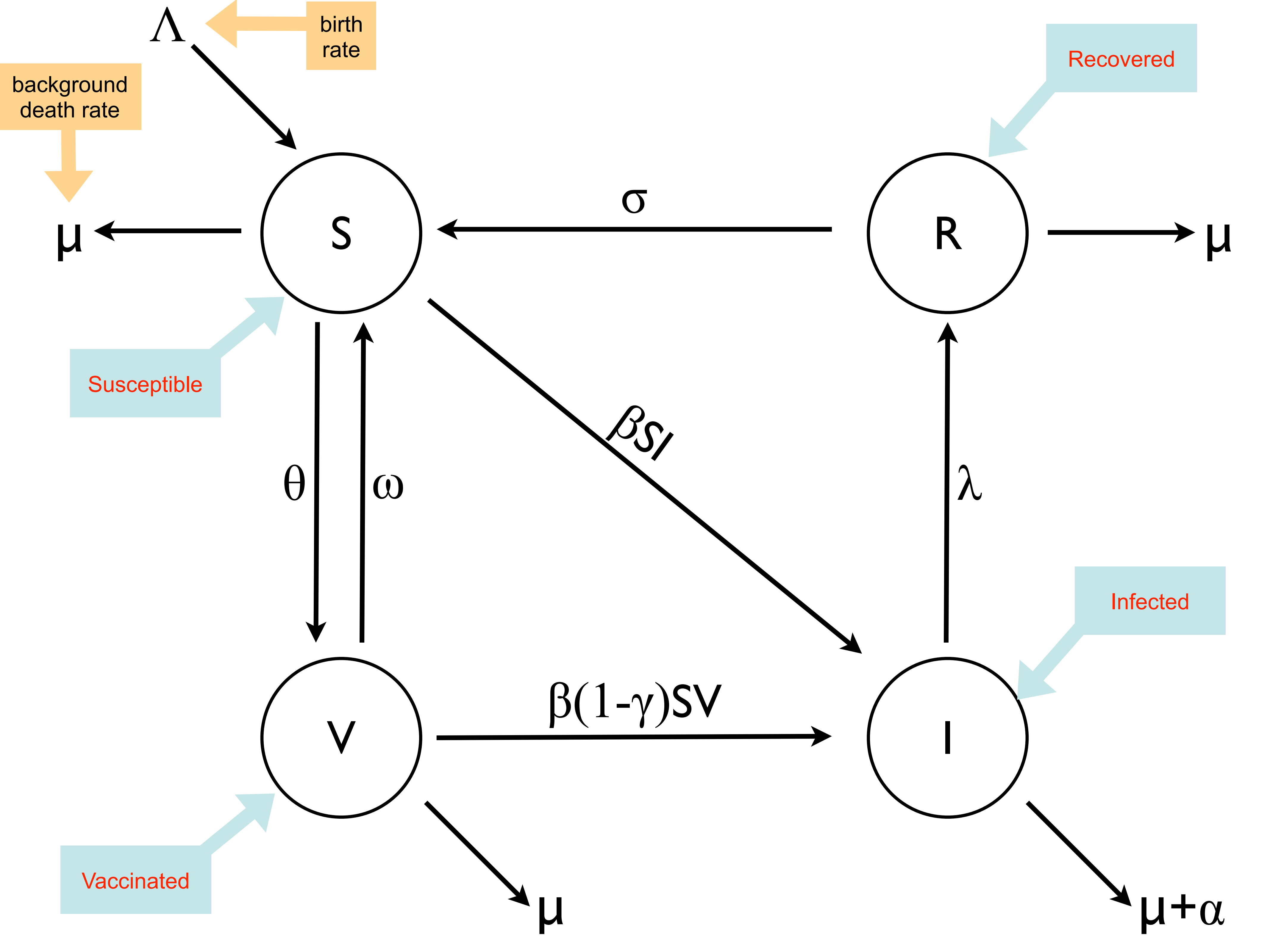

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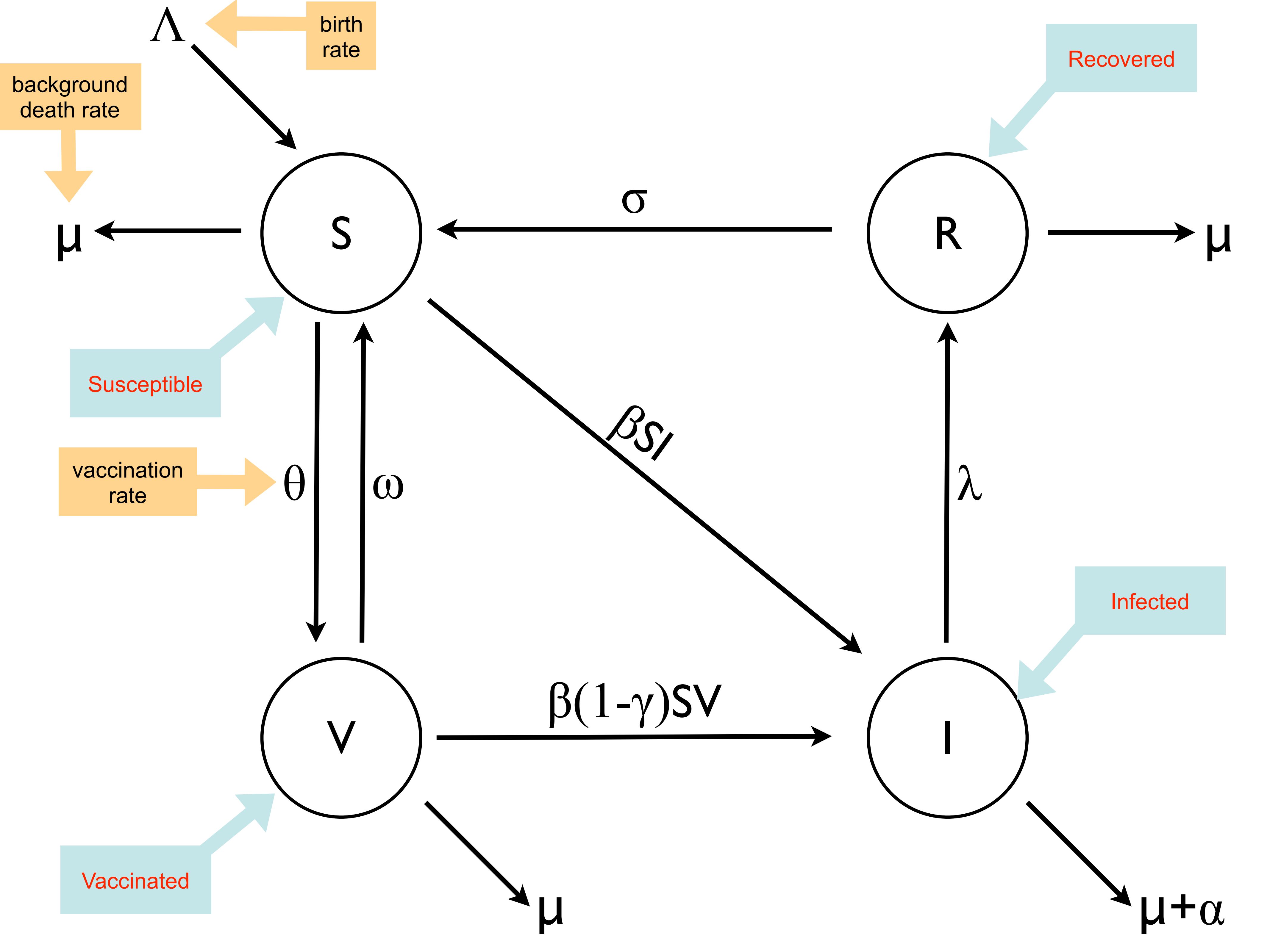
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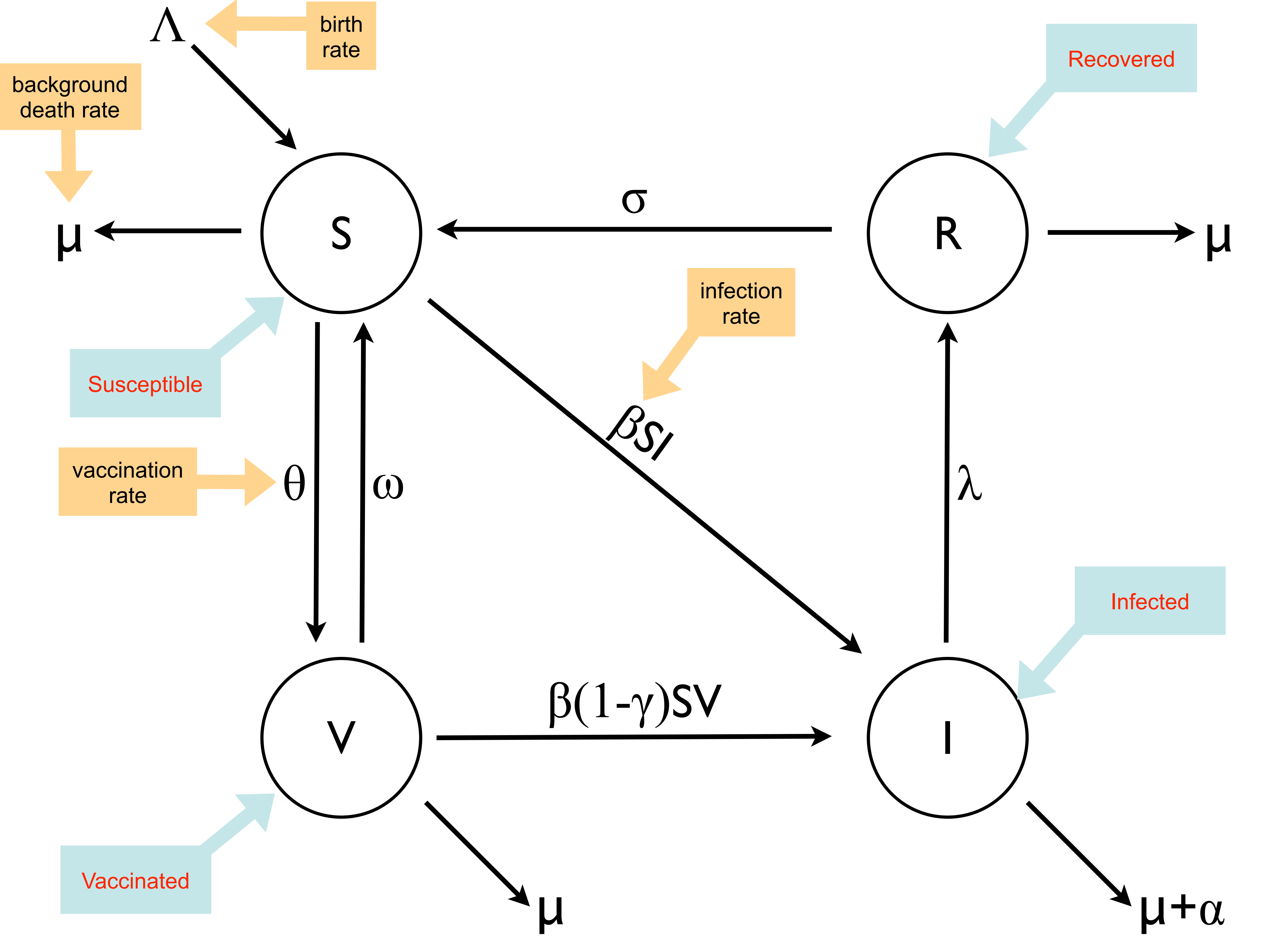

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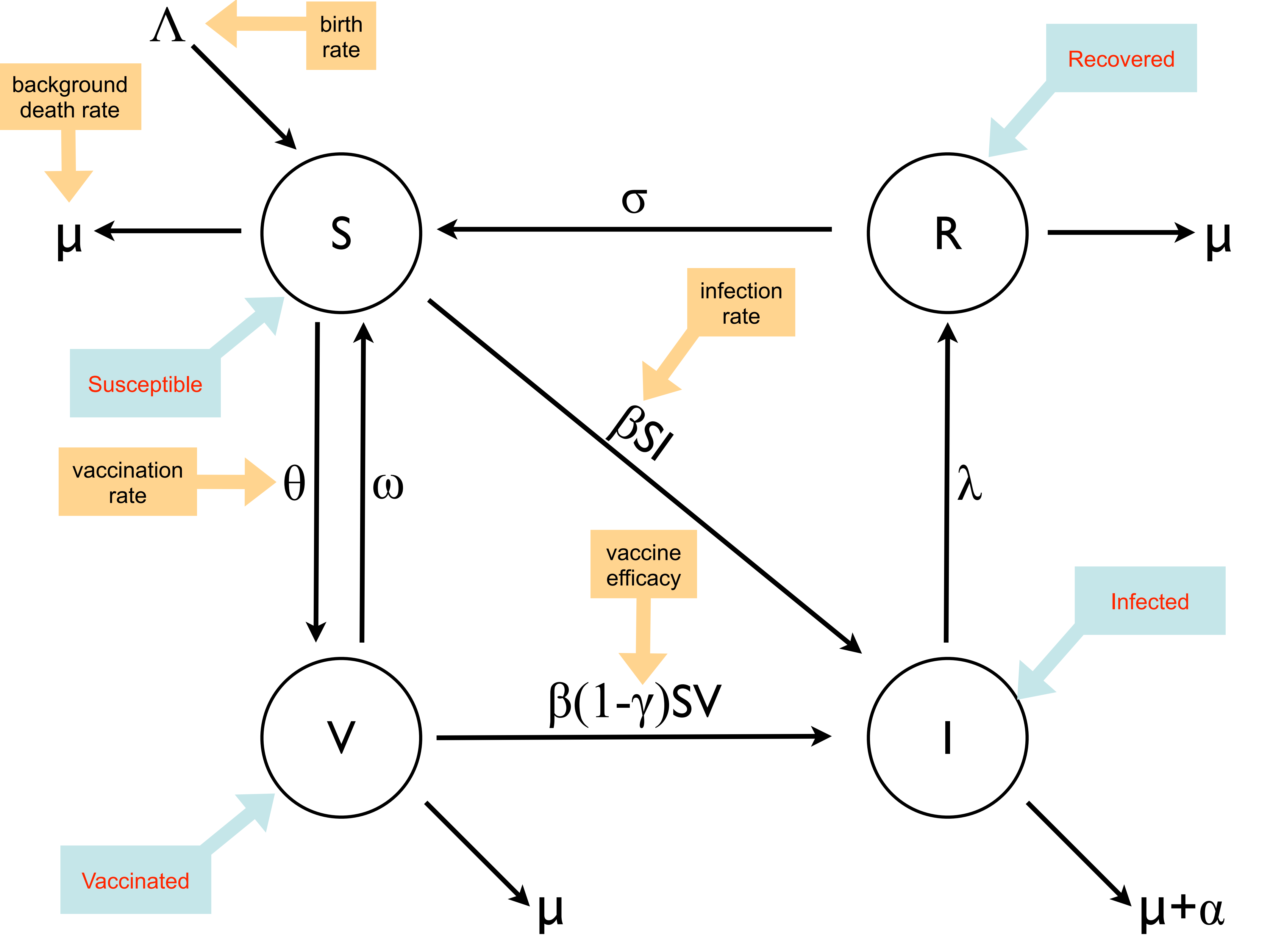

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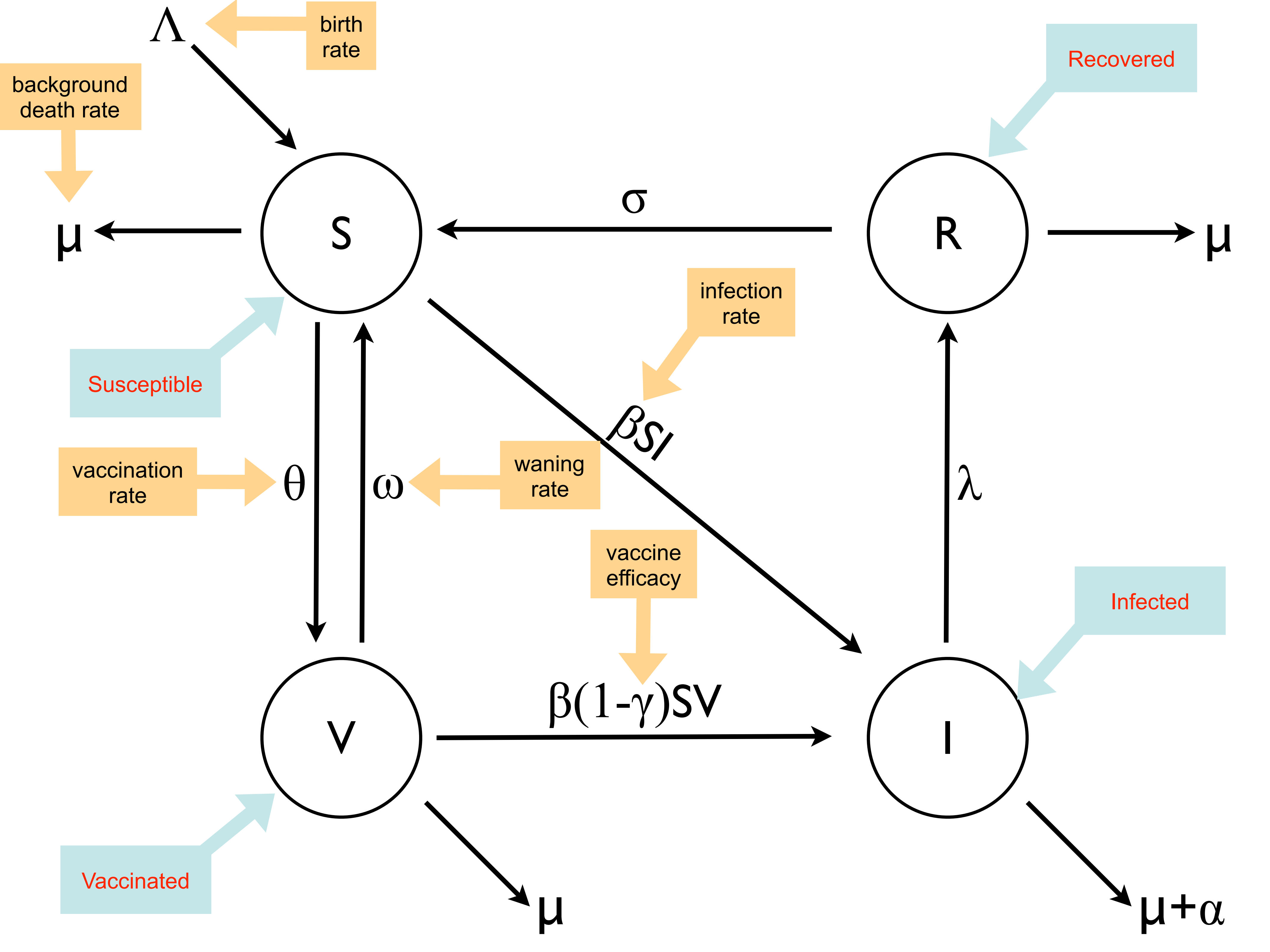
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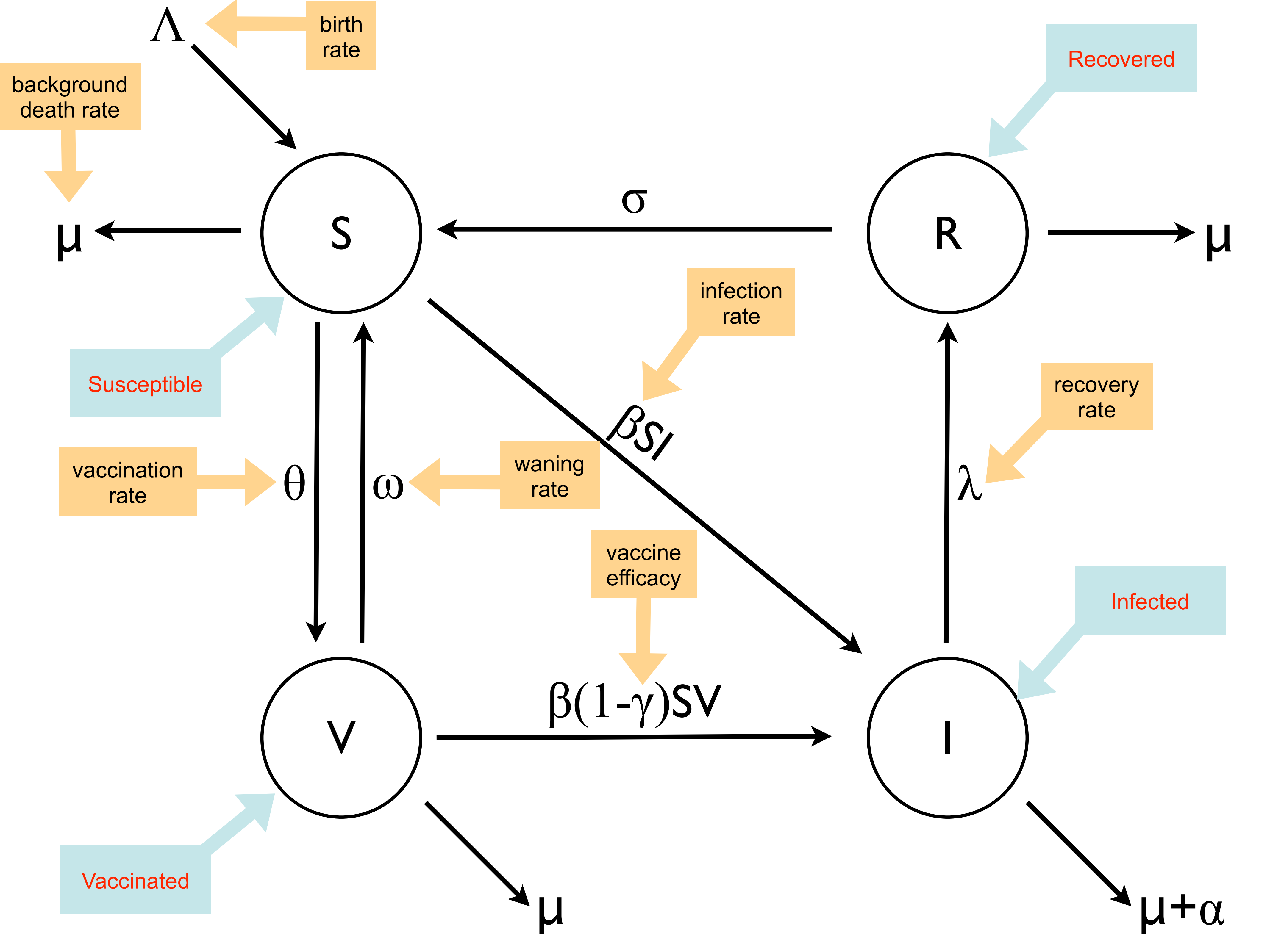

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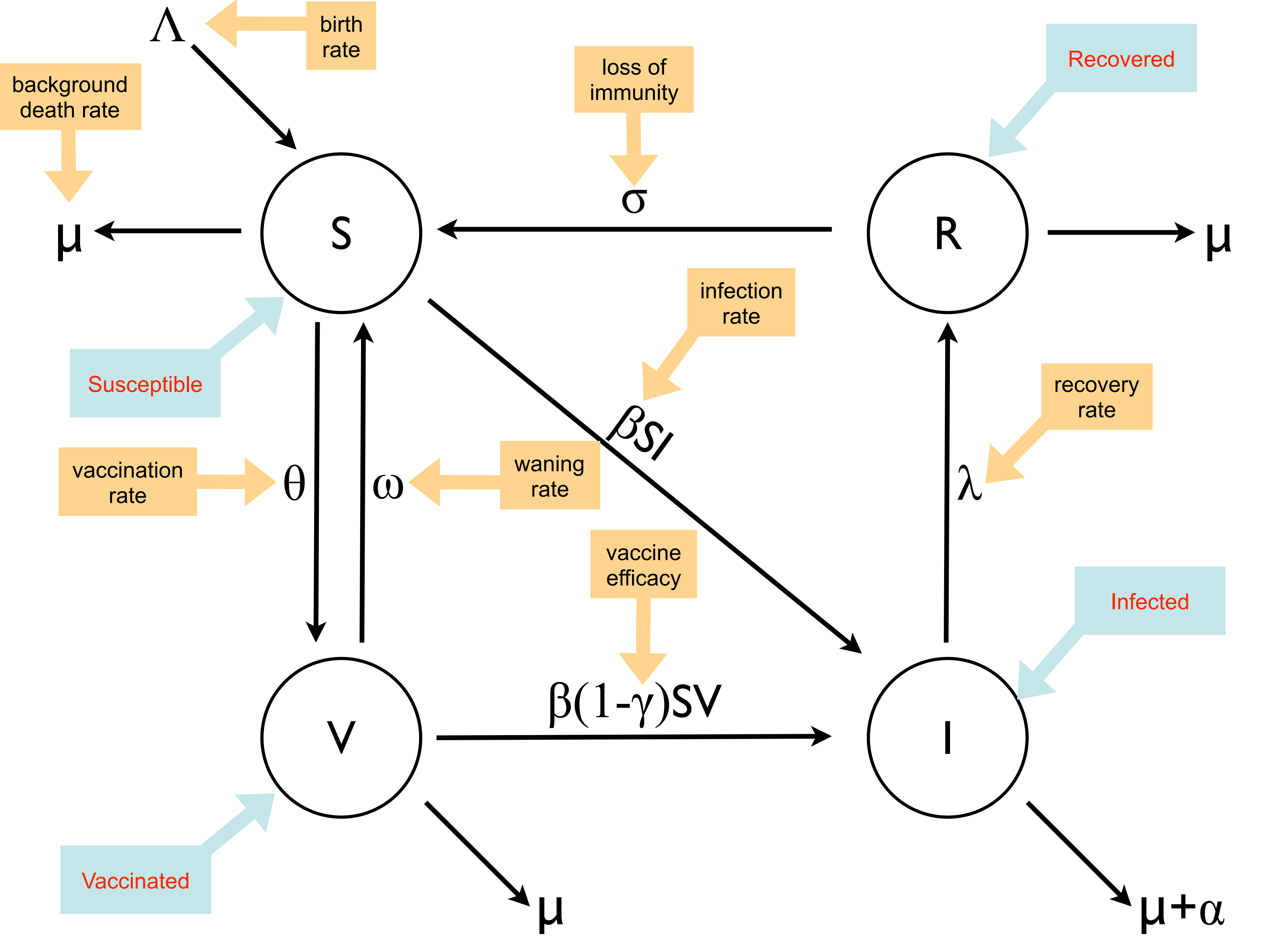
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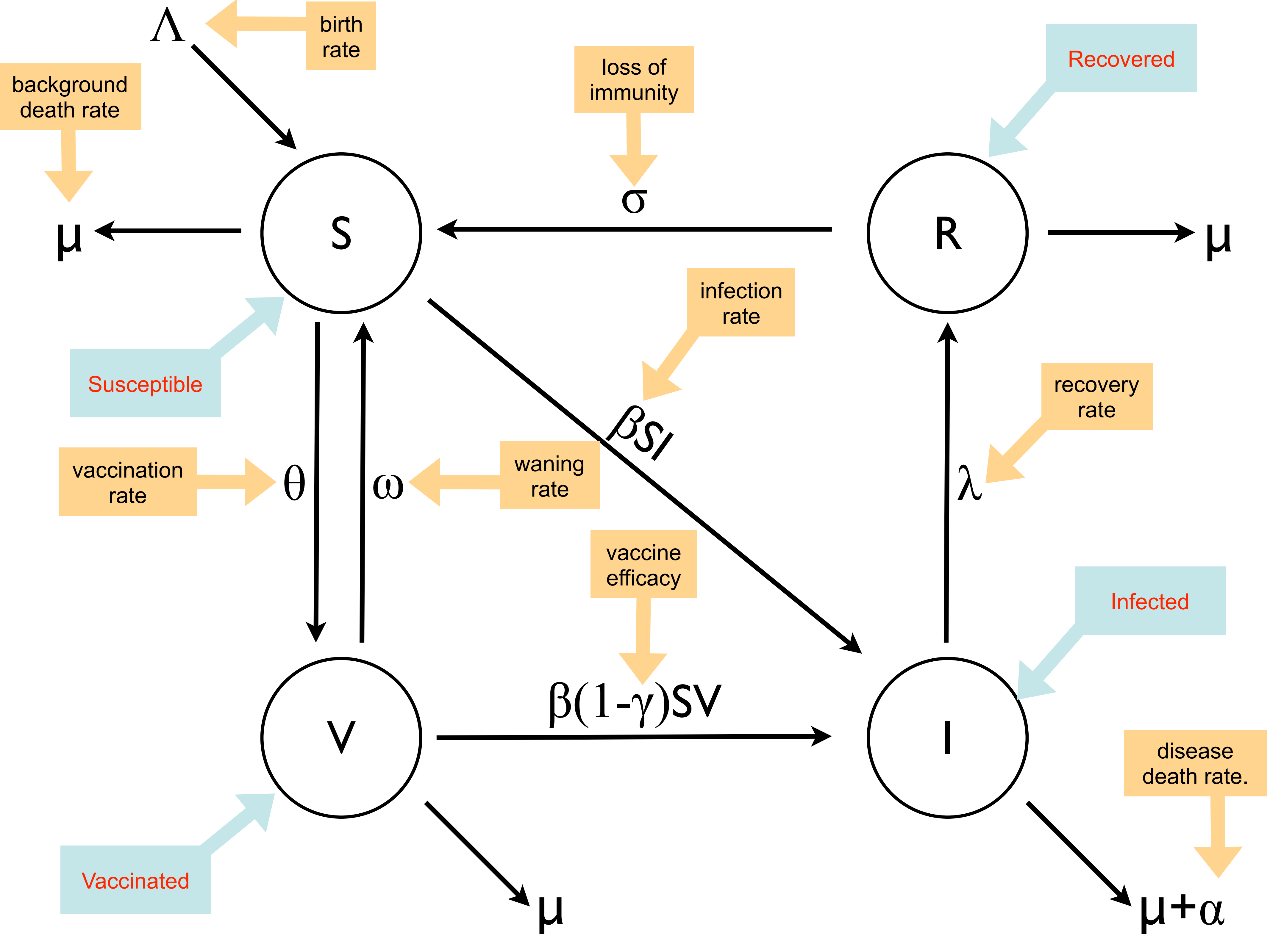
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The model equations

$$\frac{dS}{dt} = \Lambda + \omega V - (\theta + \mu)S - \left(\beta_1 - \beta_2 \frac{I}{m_I + I}\right) SI + \sigma R$$

$$\frac{dI}{dt} = \left(\beta_1 - \beta_2 \frac{I}{m_I + I}\right) SI + \left(\beta_1 - \beta_3 \frac{I}{m_I + I}\right) (1 - \gamma)VI - (\alpha + \mu + \lambda)I$$

$$\frac{dV}{dt} = \theta S - (\mu + \omega)V - \left(\beta_1 - \beta_3 \frac{I}{m_I + I}\right) (1 - \gamma)VI$$

$$\frac{dR}{dt} = \lambda I - (\mu + \sigma)R$$

Λ=*birth rate* μ=*background death rate* θ=*vaccination rate*
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γ=*vaccine efficacy* λ=*recovery rate*

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Media affects mixing rates

Λ=birth rate μ=background death rate θ=vaccination rate
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- β_i are the relative transmissibilities.

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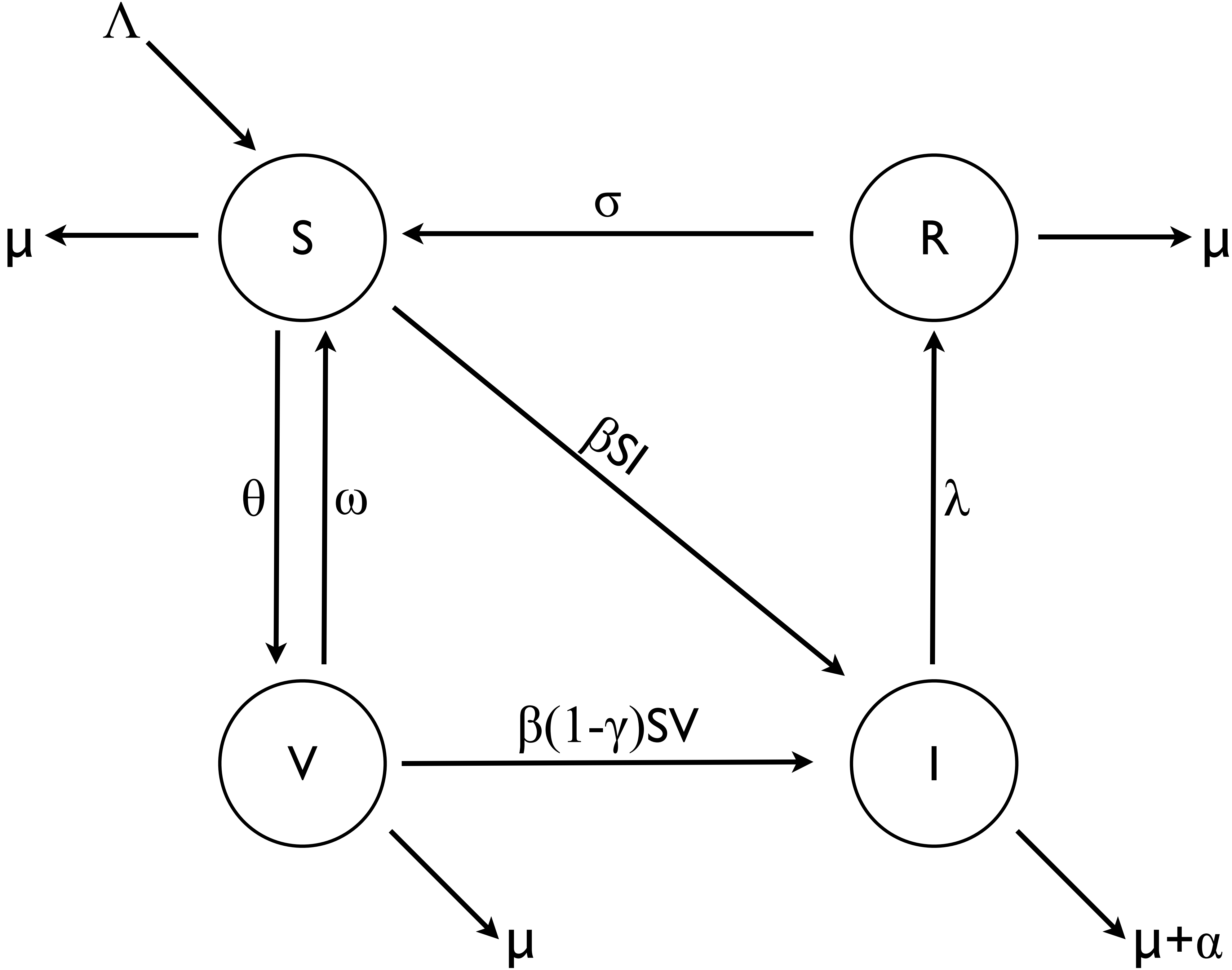

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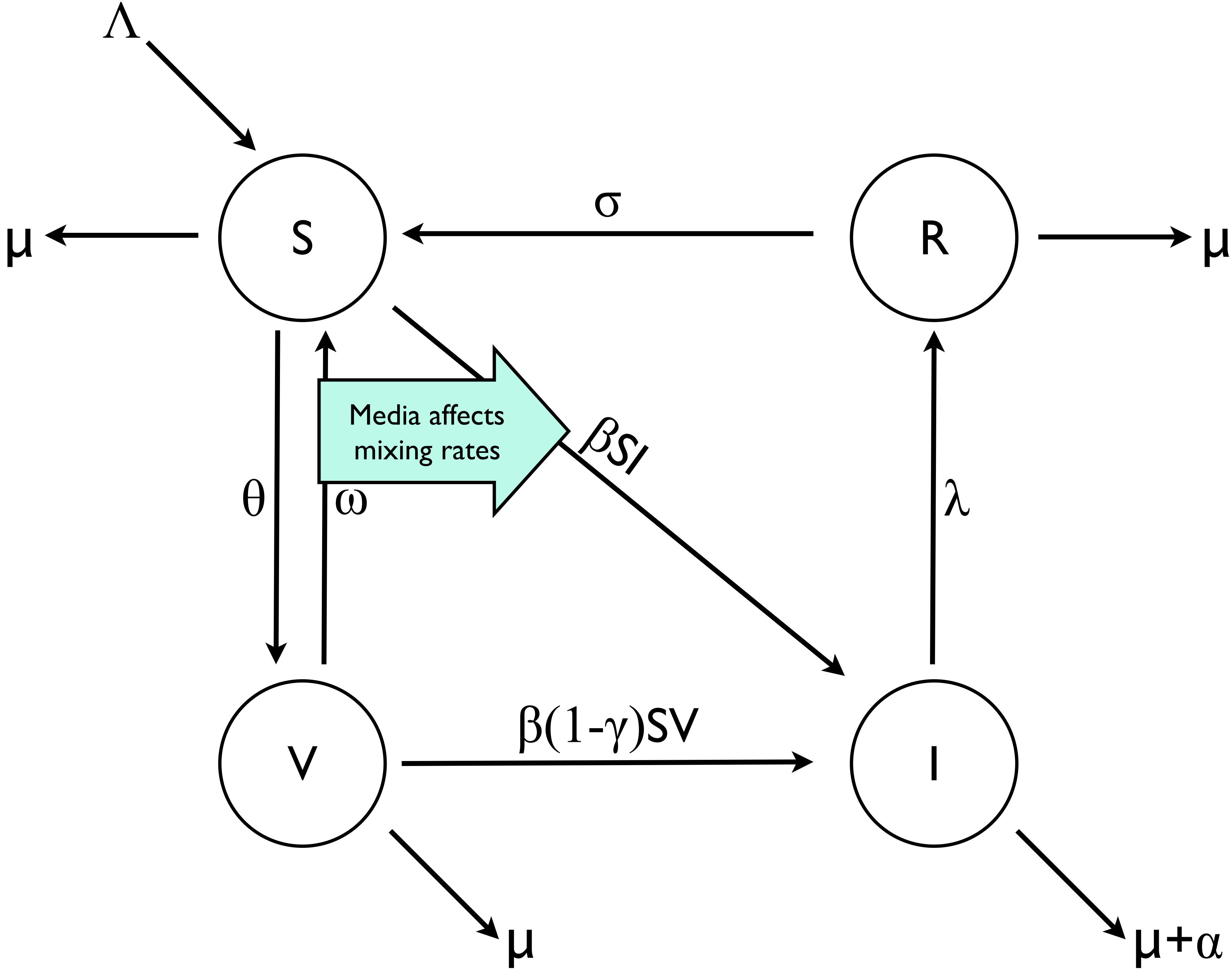
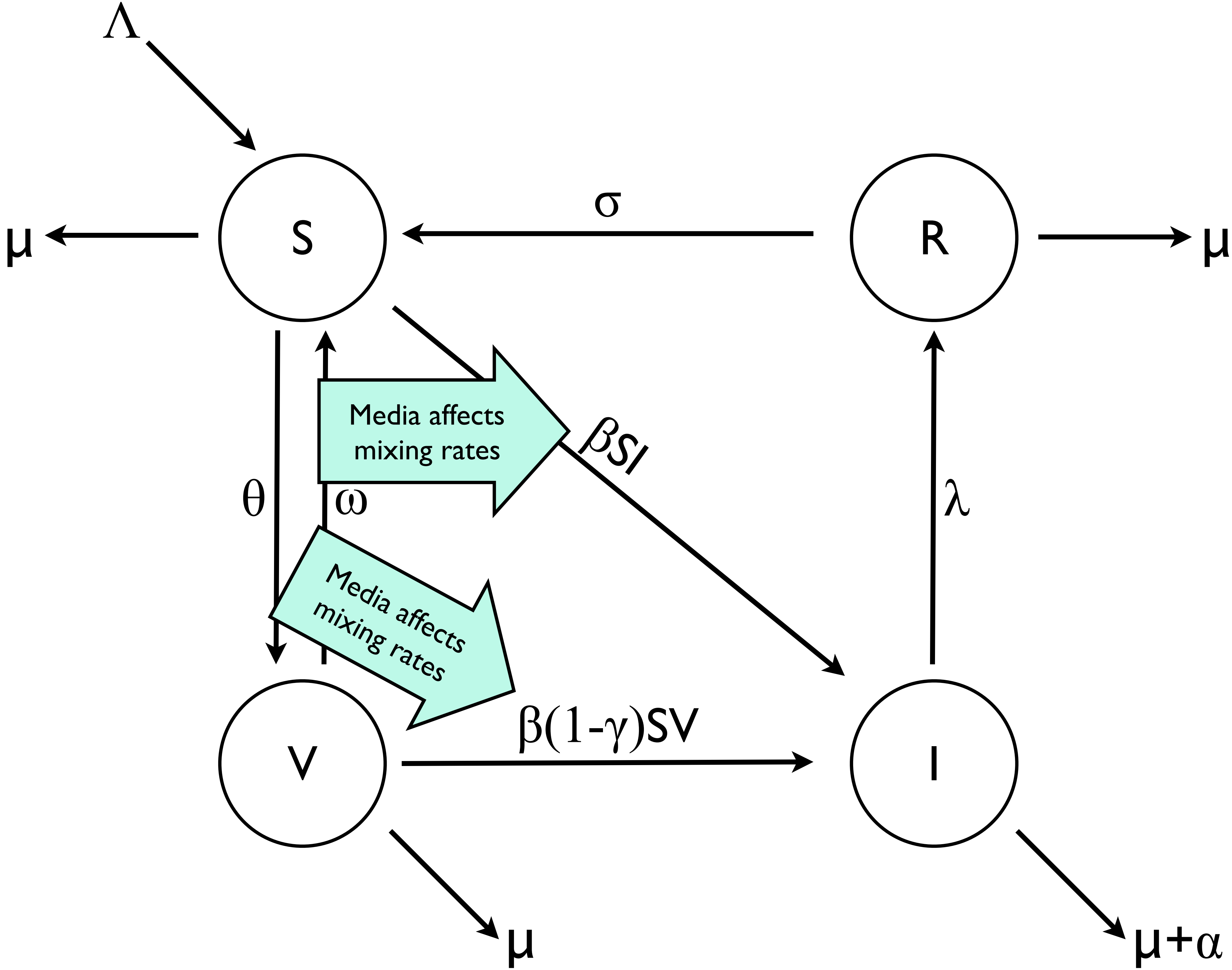
λ
β(1-γ)SV


Λ
S
σ
R
μ
μ
Media affects mixing rates
βSI
θ
ω
λ
V
β(1-γ)SV
I
μ
μ+α


Λ
μ
S
σ
R
μ
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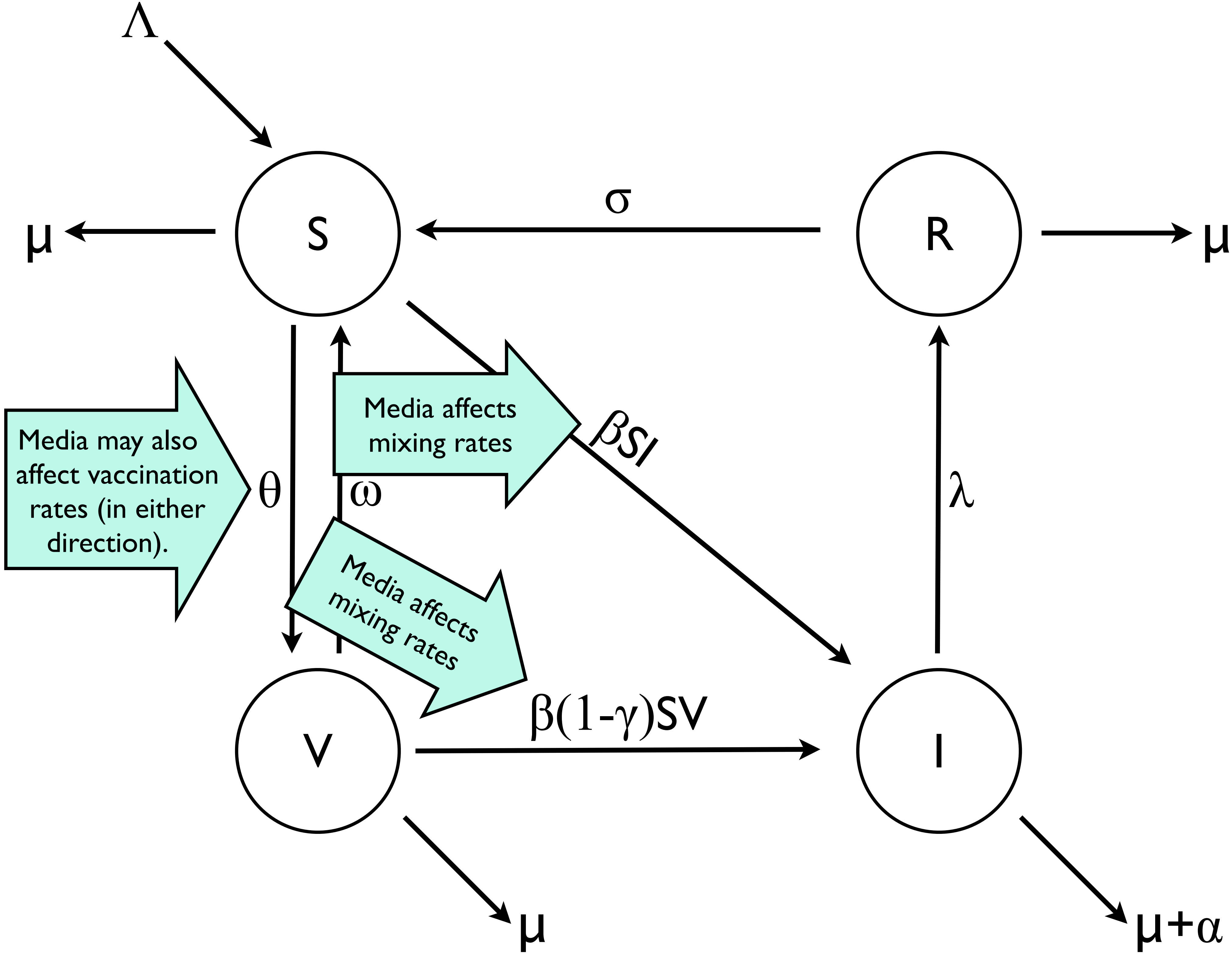
Λ
S
R
V
I
μ
σ
μ
Media may also affect vaccination rates (in either direction).
θ
ω
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λ
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Media effects

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- This also reflects the fact that the media are less interested in a story once it's established in society.

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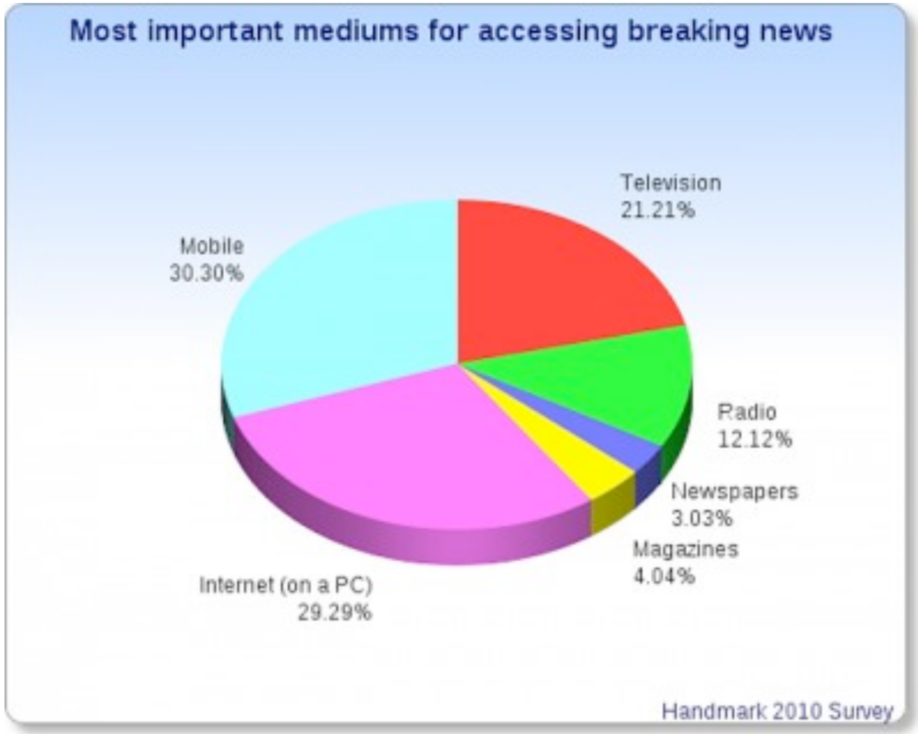
Optimal control

We introduce two controls, each representing a possible method of influenza control:



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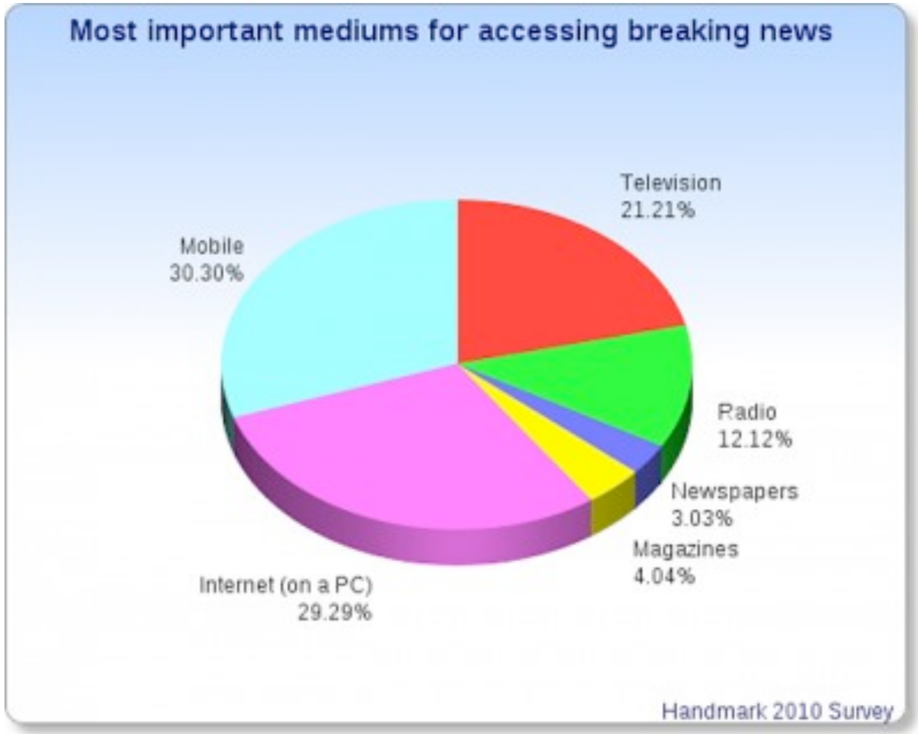

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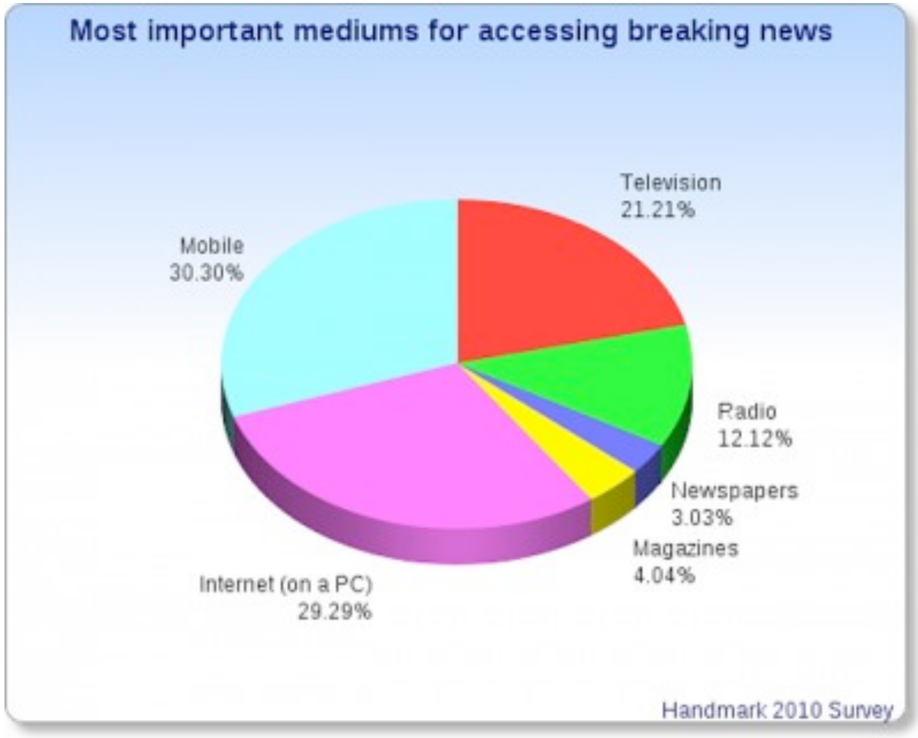

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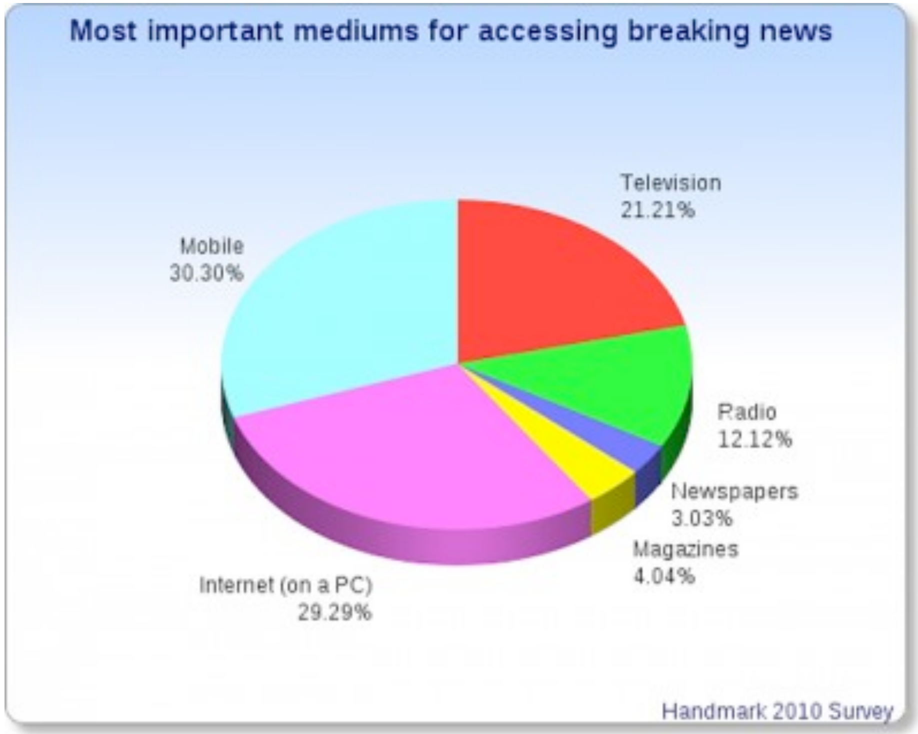

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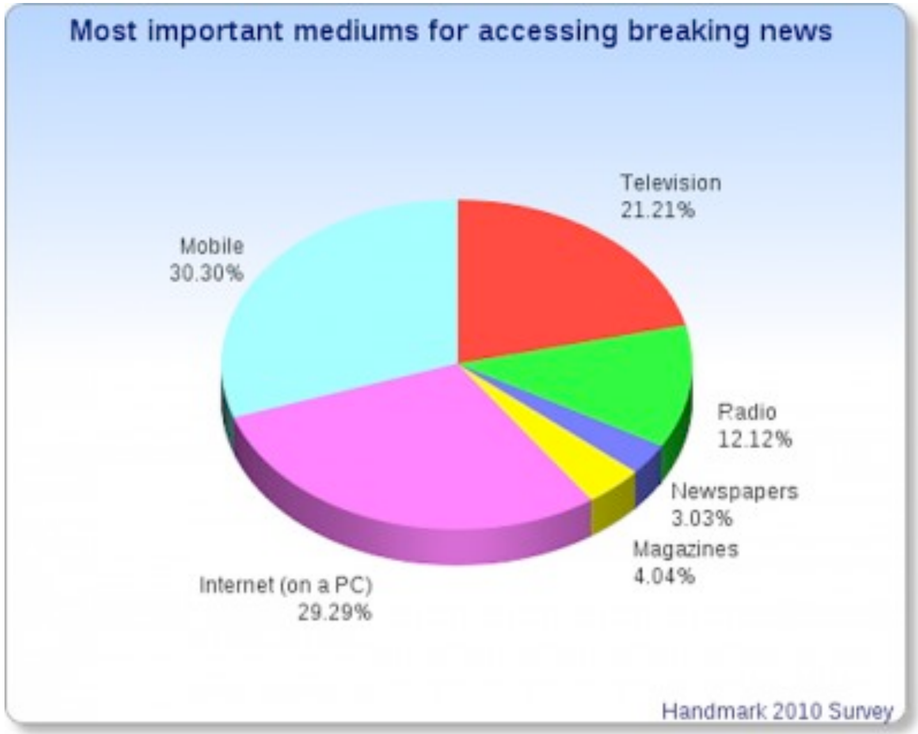

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Weight constraint for control

- B_1 and B_2 can represent the amount of money expended over a finite period, or the perceived risk.

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Adjoint equations

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$$\frac{d\lambda_2}{dt} = B_1 + (\lambda_1 - \lambda_2)\left[\left(\beta_1 - \beta_2 \frac{I}{(1-u_m)m_I + I}\right)S - \beta_2 \frac{(1-u_m)m_I}{((1-u_m)m_I + I)^2} IS\right]$$
$$+ (\lambda_3 - \lambda_2)\left[\left(\beta_1 - \beta_3 \frac{I}{(1-u_m)m_I + I}\right)(1-\gamma)V - \beta_3 \frac{(1-u_m)m_I}{((1-u_m)m_I + I)^2}(1-\gamma)VI\right]$$
$$+ \lambda_2(\alpha + \mu + \lambda) - \lambda_4\lambda$$

$$\frac{d\lambda_3}{dt} = -1 + (\lambda_3 - \lambda_2)(\beta_1 - \beta_3 \frac{I}{(1-u_m)m_I + I})(1-\gamma)I + \lambda_3\mu + (\lambda_3 - \lambda_1)\omega$$

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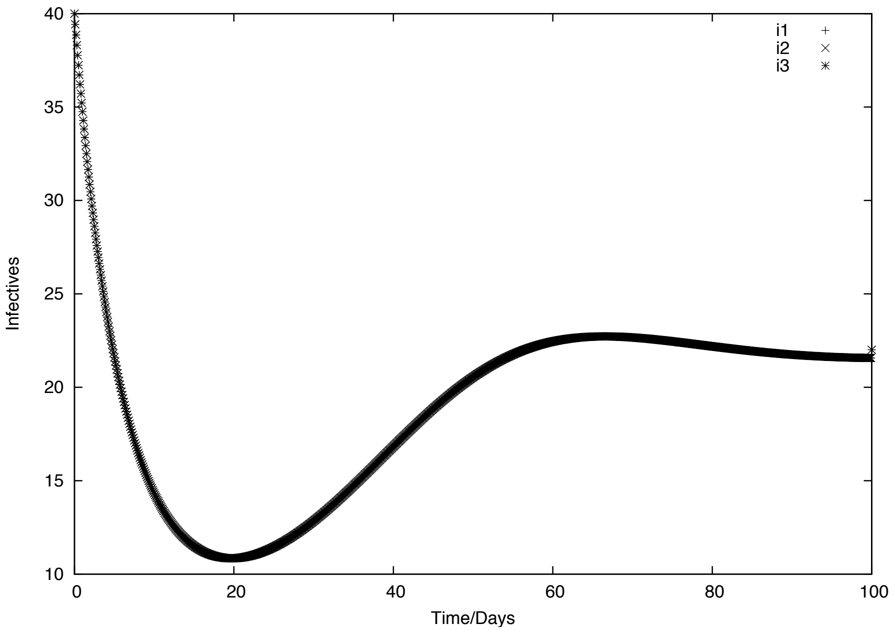
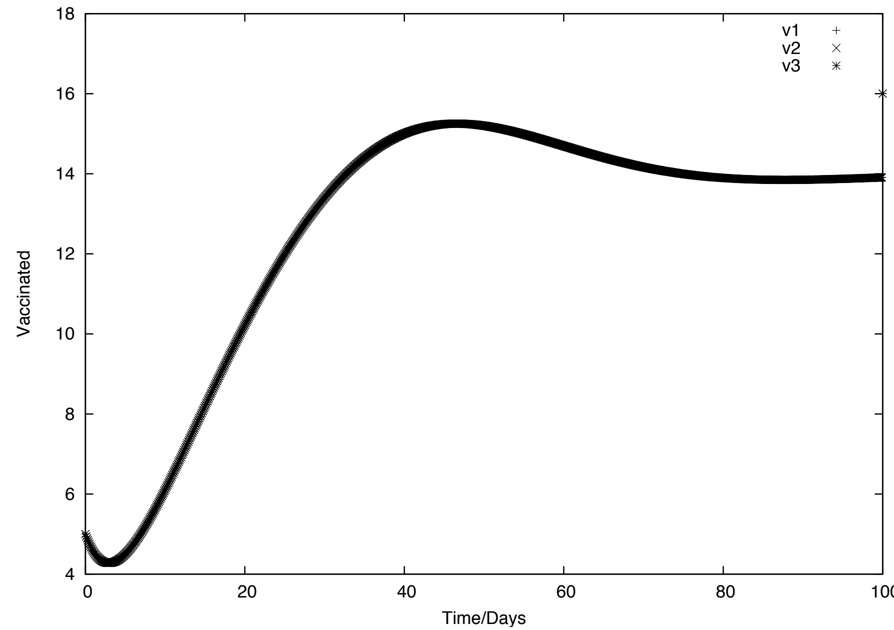
Media has beneficial effect on vaccine





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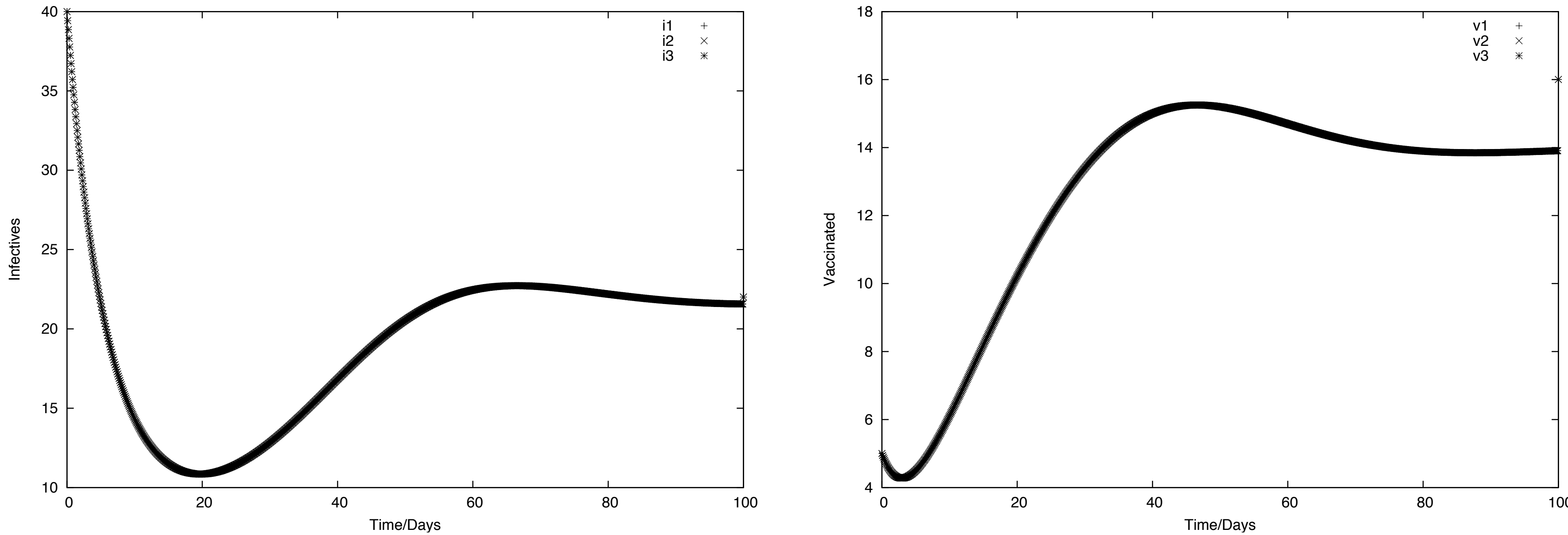

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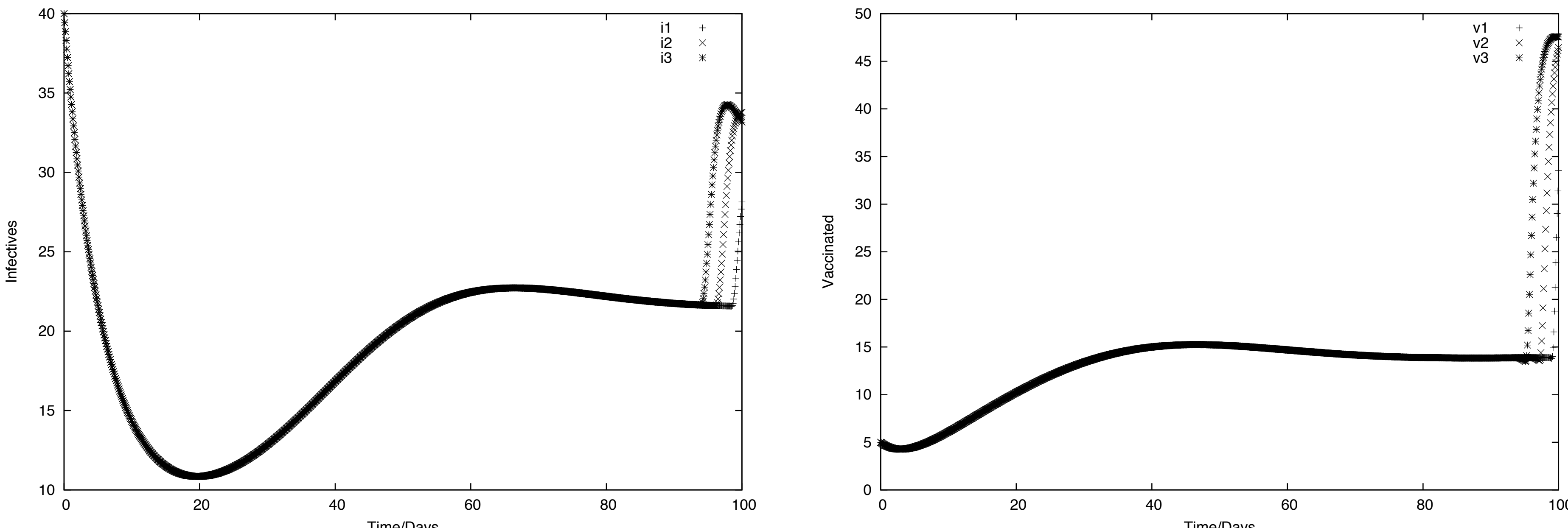

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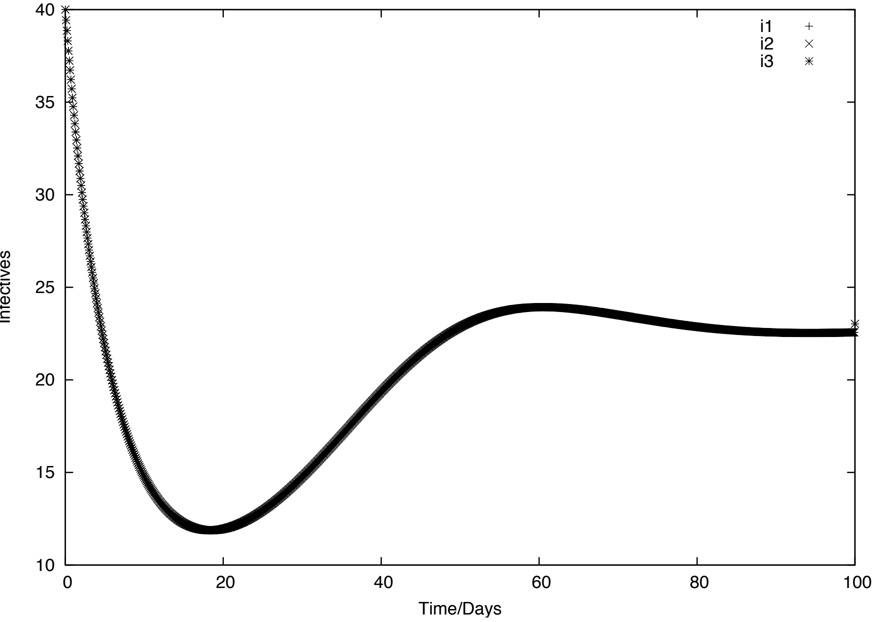
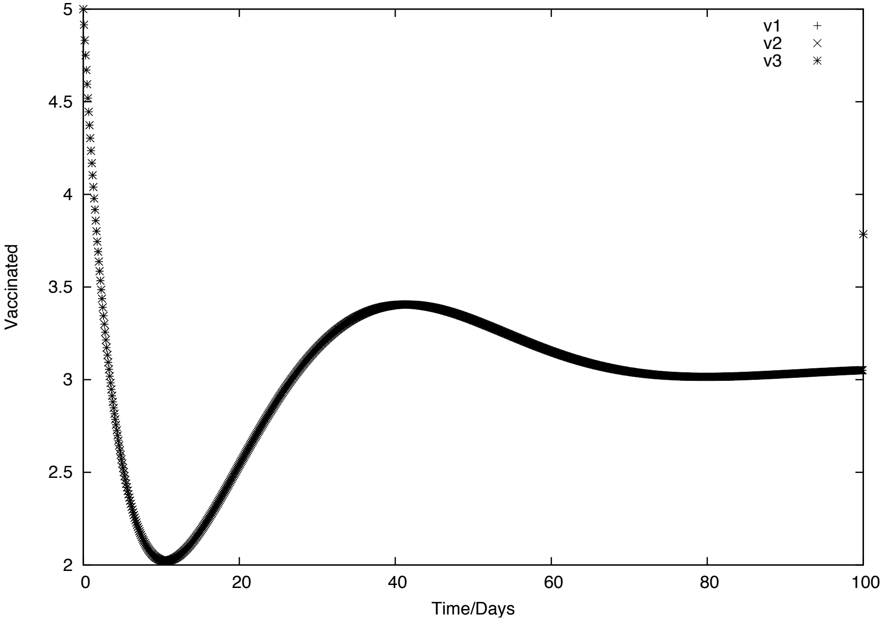
Media has negative effect on vaccine





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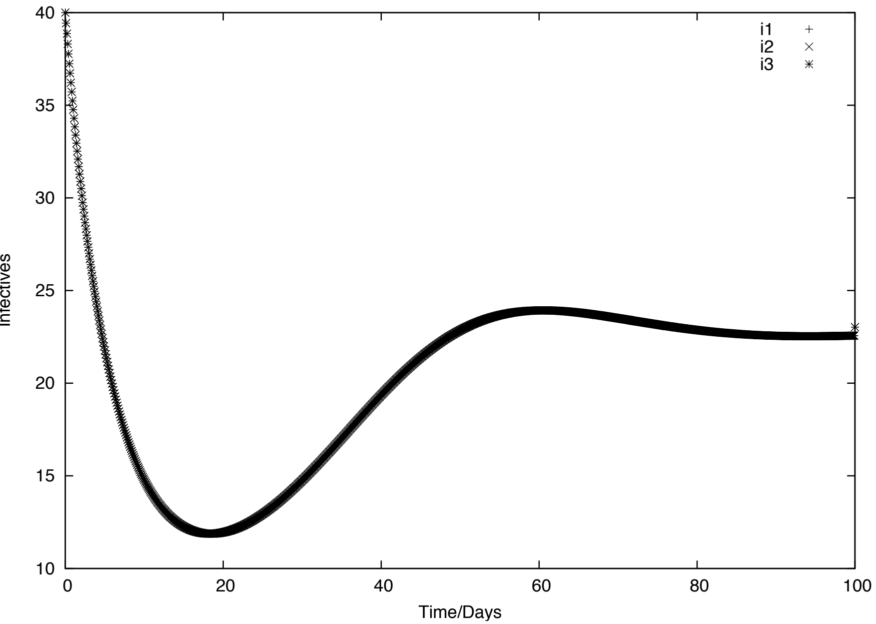

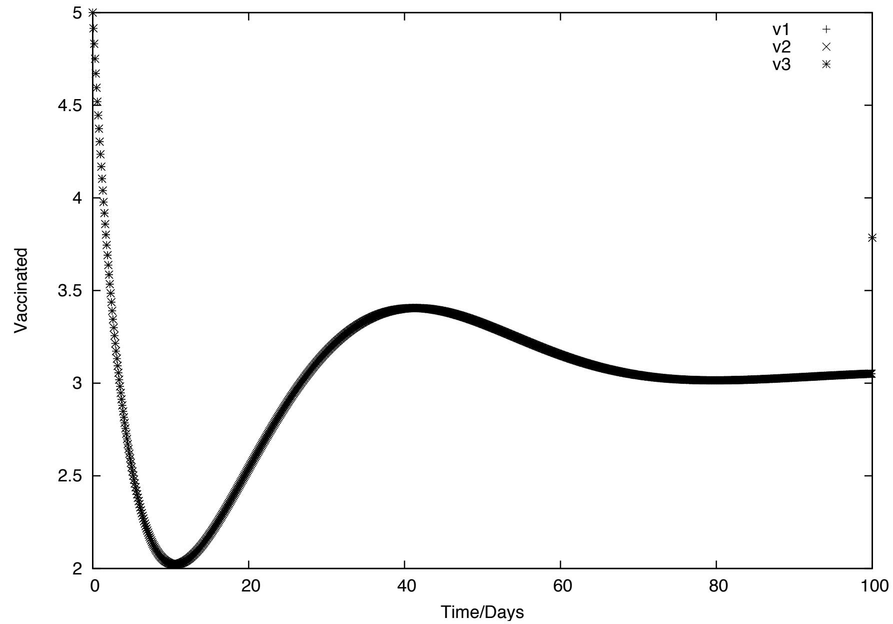

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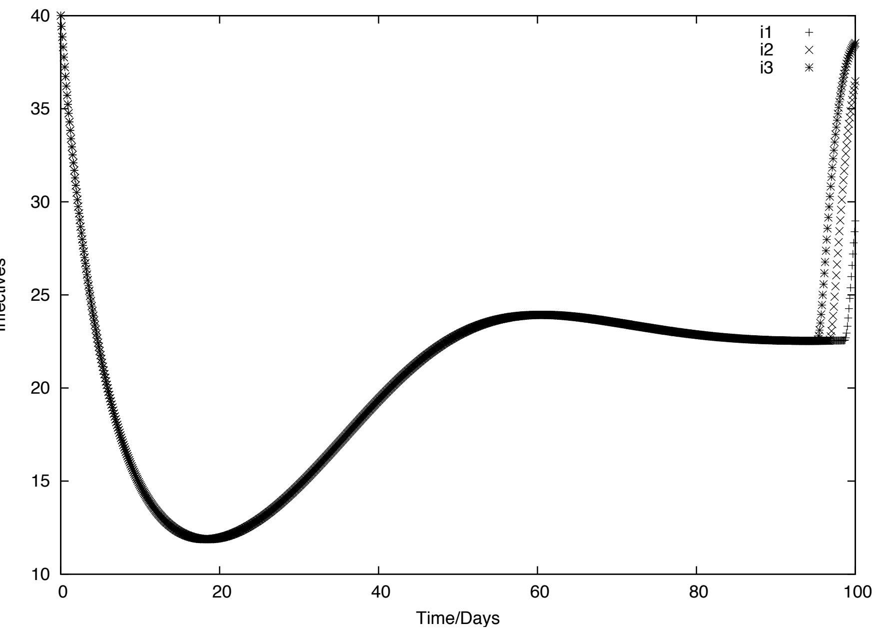

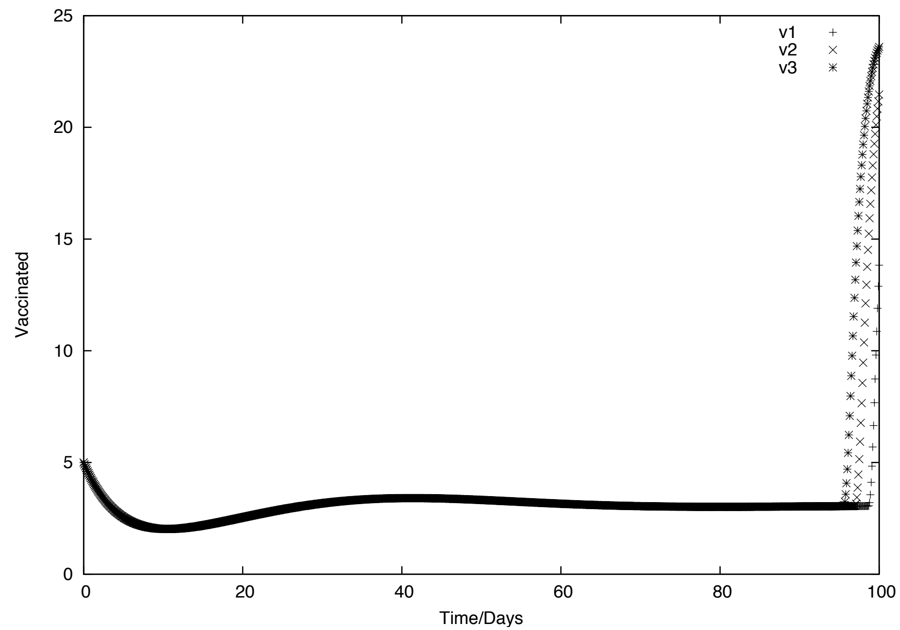

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- Suppose, initially, the media and the general population are unaware of the disease
- Thus, nobody gets vaccinated, allowing the disease to spread initially
- New infected individuals arrive at fixed times
- We will ignore recovery in this simple model.

Media awareness threshold

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- Above this threshold, susceptibles do not mix with infecteds
- However, vaccinated individuals mix significantly with infecteds
- Even though they may still potentially contract the virus.

Simplified model - lower region

- For $I<I_{crit}$, the model is

S=susceptible I=infected V=vaccinated Λ=birth rate μ=background death rate α=disease death rate ω=waning rate λ=recovery rate I_{crit}=vaccination panic threshold

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$$\frac{dS}{dt} = \Lambda + \omega V - \mu S \qquad t \neq t_k$$

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- If arrival times are not fixed, the results are broadly unchanged.

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Simplified model - upper region

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$$\frac{dV}{dt} = \theta S - (\mu + \omega)V - \beta_5(1-\gamma)VI$$

- No mixing of susceptibles and infecteds

S=susceptible I=infected V=vaccinated Λ=birth rate μ=background death rate θ=vaccination rate α=disease death rate ω=waning rate γ=vaccine efficacy λ=recovery rate I_{crit}=vaccination panic threshold

Simplified model - upper region

- For $I > I_{crit}$, the model is

$$\frac{dS}{dt} = \Lambda + \omega V - (\theta + \mu)S$$
$$\frac{dI}{dt} = \beta_5(1-\gamma)VI - (\alpha + \mu + \lambda)I$$
$$\frac{dV}{dt} = \theta S - (\mu + \omega)V - \beta_5(1-\gamma)VI$$

- No mixing of susceptibles and infecteds
- The vaccinated mix with infecteds, allowing them to be infected

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  (at low rates).

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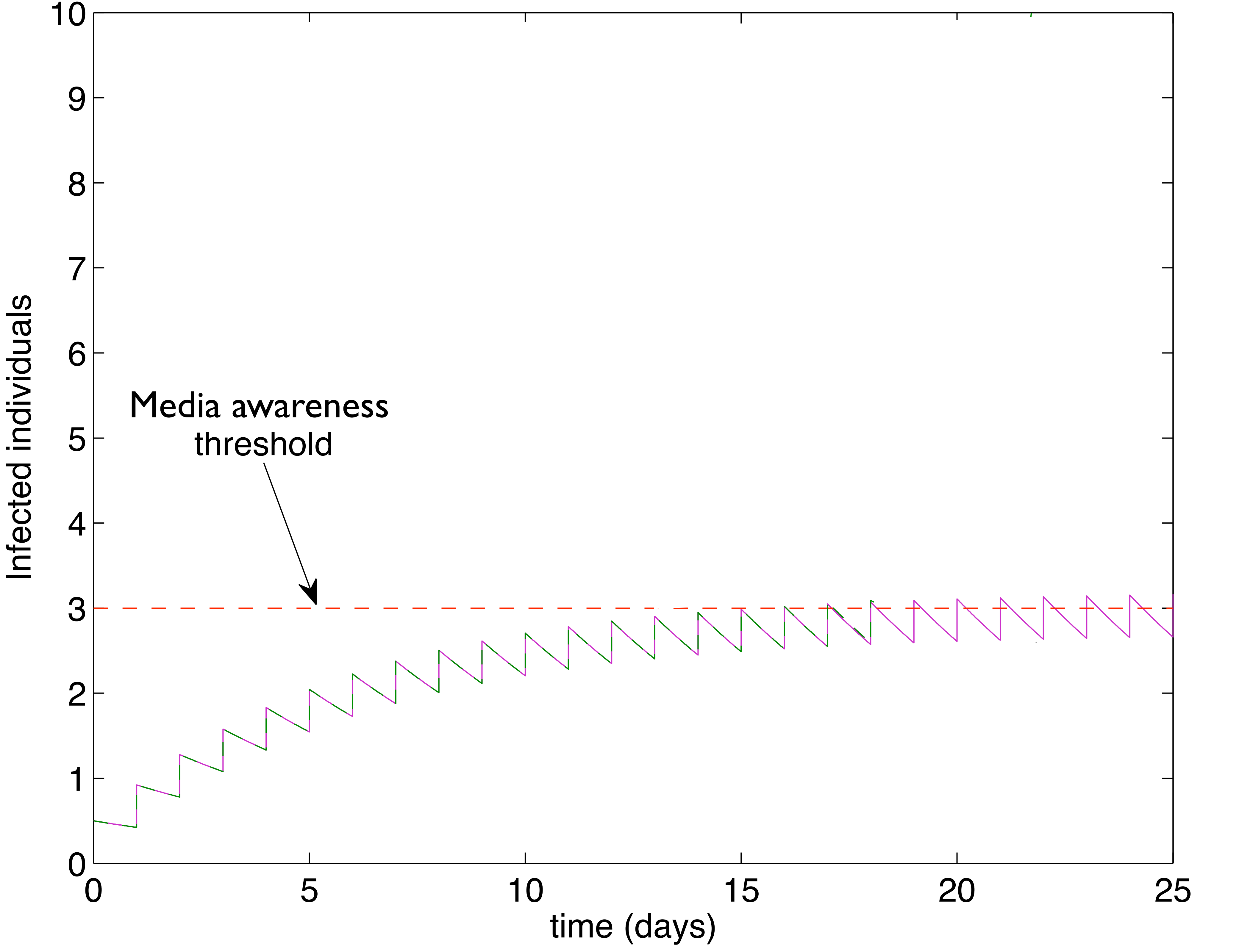
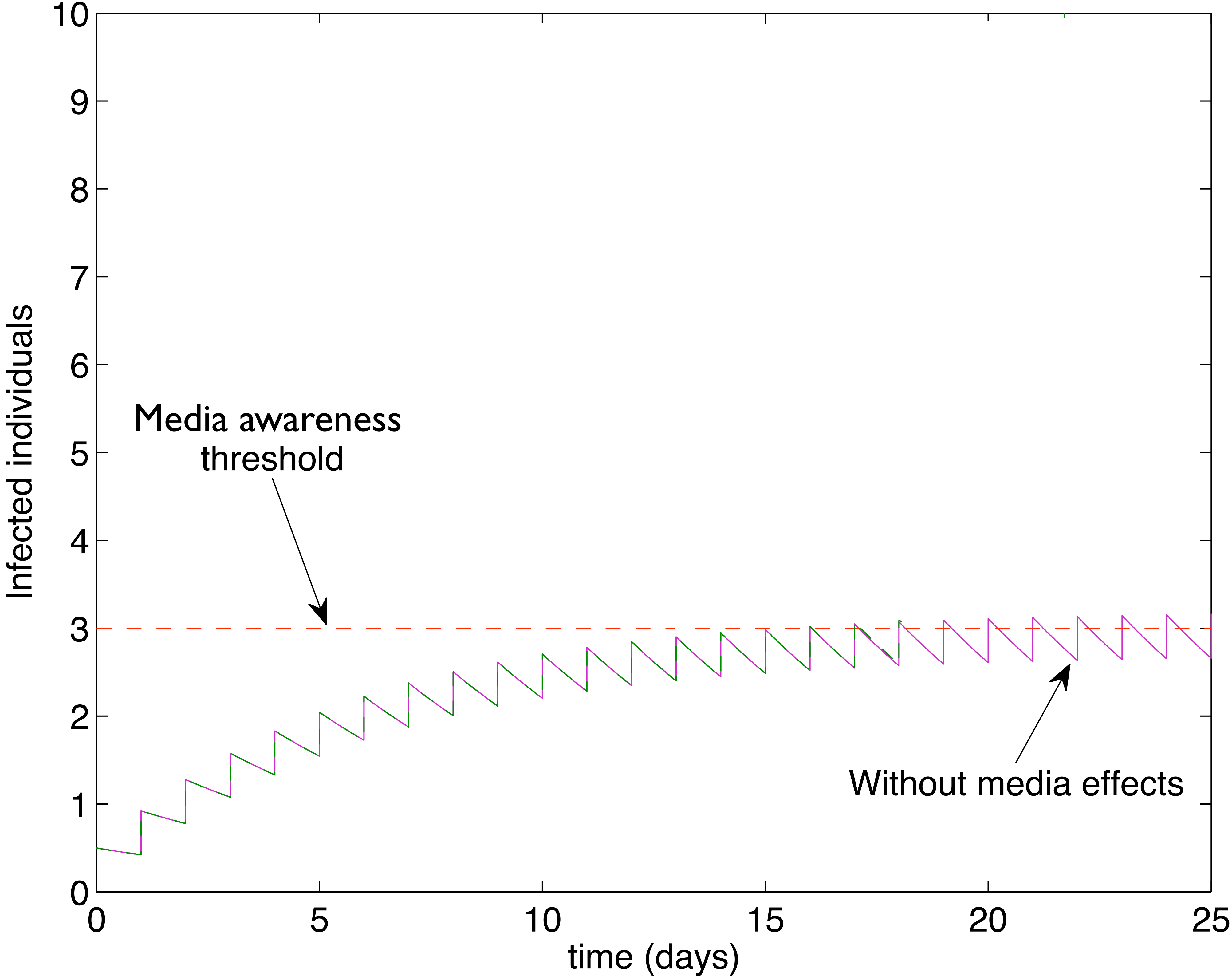
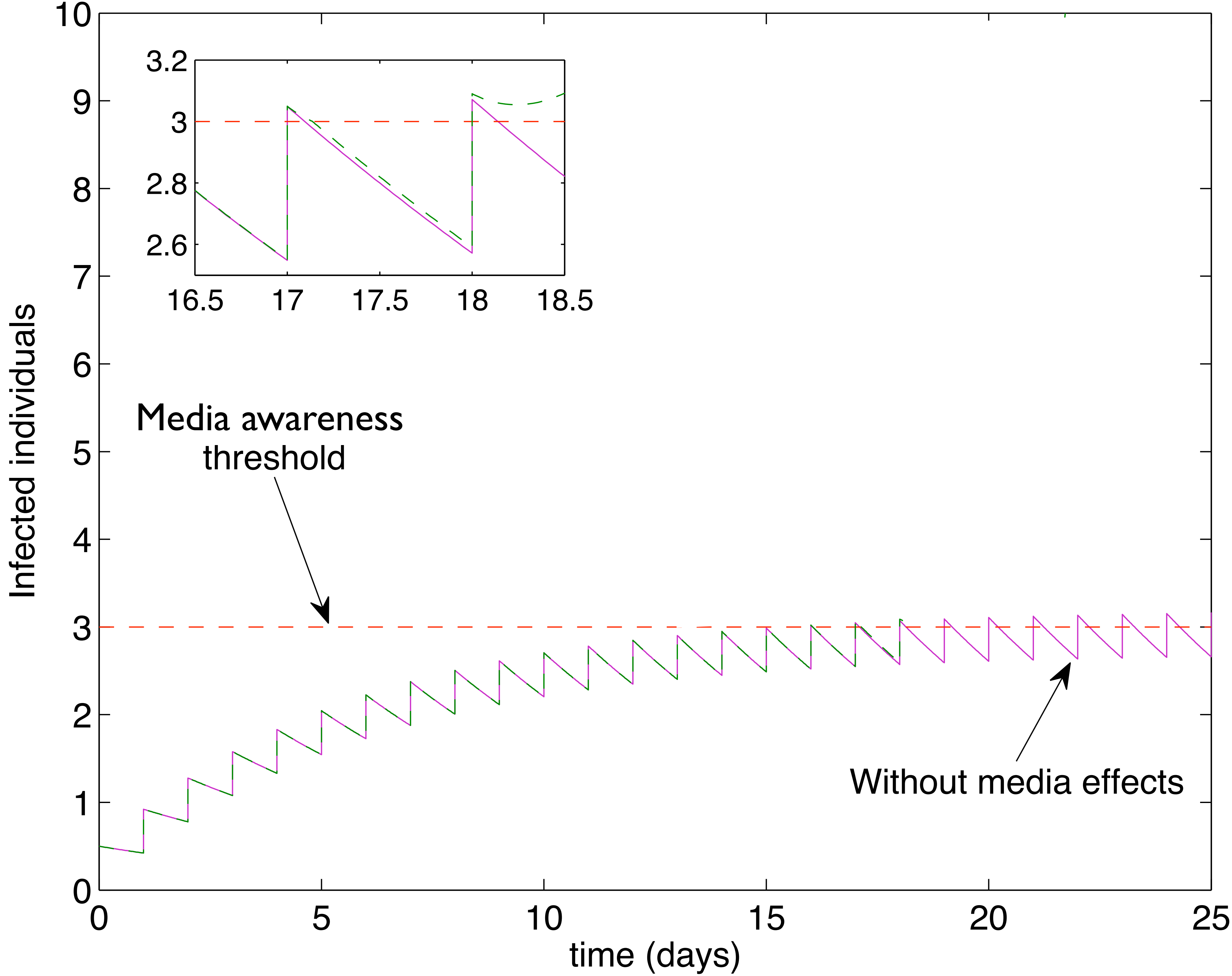


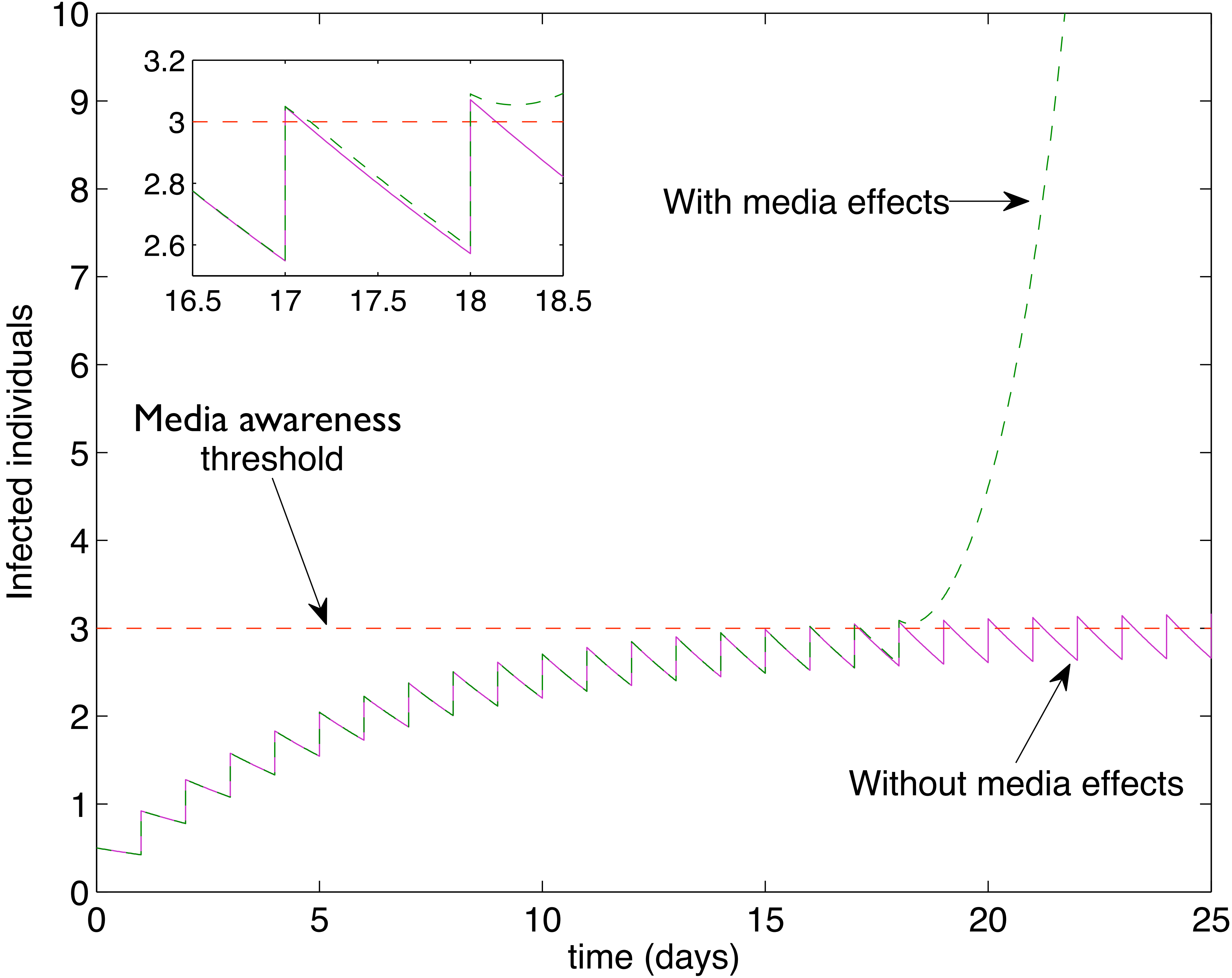
Media awareness threshold
Infected individuals
time (days)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25



Media awareness threshold
Without media effects
Infected individuals
time (days)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25



Infected individuals
time (days)
Media awareness threshold
Without media effects
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
2.6
2.8
3
3.2
16.5
17
17.5
18
18.5



With media effects
Media awareness
threshold
Without media effects
Infected individuals
time (days)

Lower region

- If $I<I_{crit}$,we can prove that

μ=background death rate α=disease death rate
λ=recovery rate I_{crit}=vaccination panic threshold

Lower region

- If $I < I_{crit}$, we can prove that

$$I^{+} \to \frac{I^{i}}{1 - e^{-(\alpha+\mu+\lambda)\tau}} \equiv m^{+}$$

μ=*background death rate* α=*disease death rate*
λ=*recovery rate* I_{crit}=*vaccination panic threshold*

Lower region

- If $I < I_{crit}$, we can prove that

$$I^+ \rightarrow \frac{I^i}{1 - e^{-(\alpha+\mu+\lambda)\tau}} \equiv m^+$$

where $\tau = t_{k+1} - t_k$

μ=background death rate α=disease death rate
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- If $I < I_{crit}$, we can prove that

$$I^{+} \to \frac{I^{i}}{1 - e^{-(\alpha+\mu+\lambda)\tau}} \equiv m^{+}$$

where $\tau = t_{k+1} - t_k$

- If $m^{+} > I_{crit}$, then the system will eventually switch from the lower region to the upper region.

μ=background death rate α=disease death rate
λ=recovery rate I_{crit}=vaccination panic threshold

Upper region

- If $I > I_{crit}$, there is an endemic equilibrium (S^*, I^*, V^*)

S=susceptible I=infected V=vaccinated m^+=non-media equilibrium I_{crit}=vaccination panic threshold

Upper region

- If $I > I_{crit}$, there is an endemic equilibrium (S^*, I^*, V^*)
- This equilibrium is stable if $I^* > I_{crit}$

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- This equilibrium is stable if $I^* > I_{crit}$
- ie once trajectories enter the upper region, they will stabilise there
- If $I^* > m^+$, then the outcome will be worse than without media effects
- Thus, even in this extremely simplified model, the media may make things significantly worse.

S=susceptible I=infected V=vaccinated m^+=non-media equilibrium I_{crit}=vaccination panic threshold

Low-level mixing of susceptibles

- Low-level mixing may apply to the upper region as well

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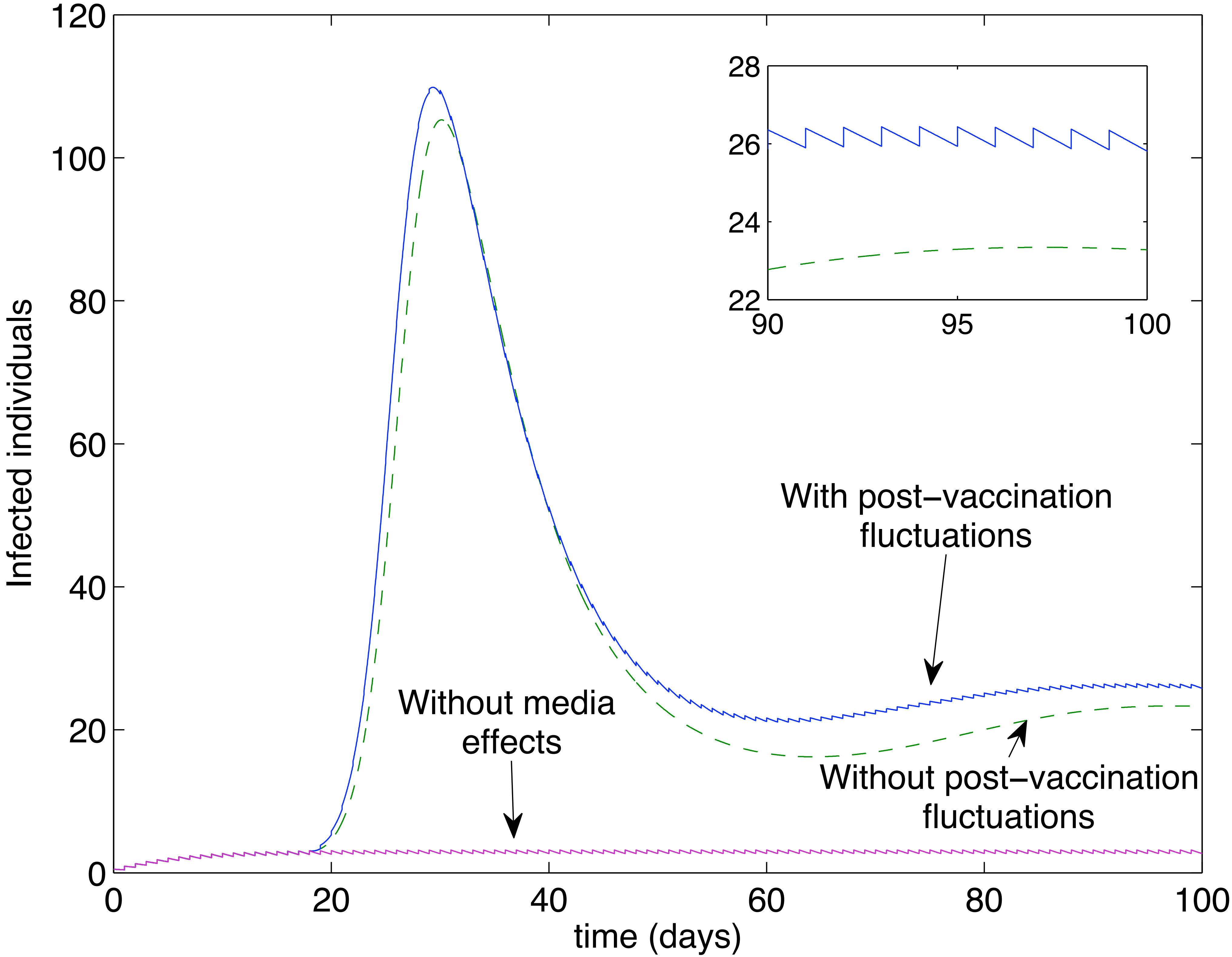
- Low-level mixing may apply to the upper region as well
- Including these will increase the long-term number of infecteds
- It will also increase the peak of the epidemic wave.



Infected individuals
time (days)
120
100
80
60
40
20
0
0
20
40
60
80
100
28
26
24
22
90
95
100
With post−vaccination fluctuations
Without media effects
Without post−vaccination fluctuations

High-level mixing of susceptibles

- What if susceptibles mix with infecteds in more significant numbers?

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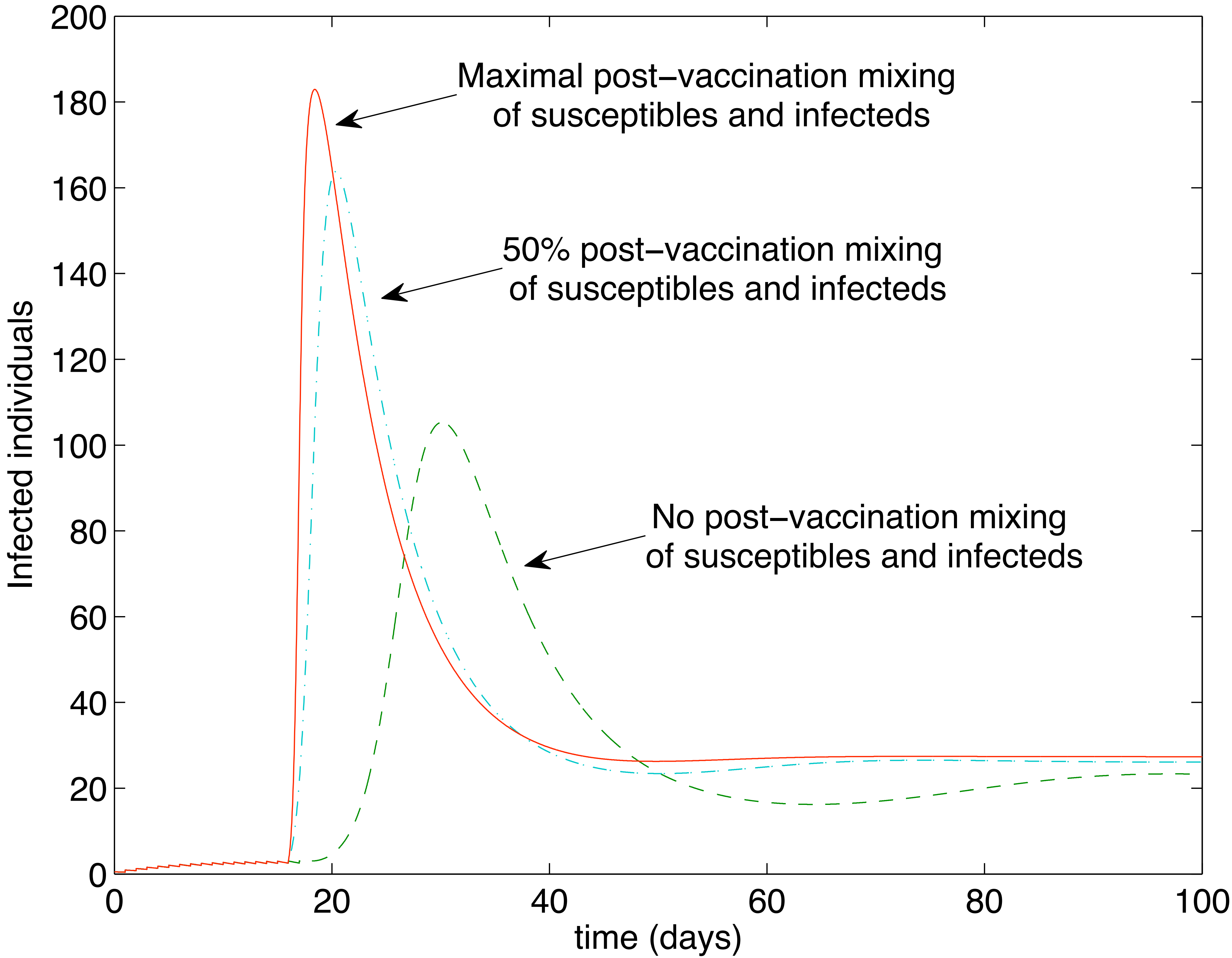
- If these effects are included in the upper region, then the wave peak occurs earlier

High-level mixing of susceptibles

- What if susceptibles mix with infecteds in more significant numbers?
- If these effects are included in the upper region, then the wave peak occurs earlier
- The long-term number of infecteds will also increase.



Maximal post–vaccination mixing
of susceptibles and infecteds
50% post–vaccination mixing
of susceptibles and infecteds
No post–vaccination mixing
of susceptibles and infecteds
Infected individuals
time (days)
0
20
40
60
80
100
120
140
160
180
200
0
20
40
60
80
100

Adverse outcome

- Thus, a small series of outbreaks that would equilibrate at some maximal level $m^+ > I_{crit}$ may, as a result of the media, instead equilibrate at a much larger value $I^* > m^+$

m^+=non-media equilibrium I_{crit}=vaccination panic threshold

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- The driving factor here is overconfidence in an imperfect vaccine
- ie vaccinated people mix significantly more with infecteds than susceptibles do
- This may happen if people feel invulnerable, due to media simplifications around vaccines.

m^+=non-media equilibrium I_{crit}=vaccination panic threshold


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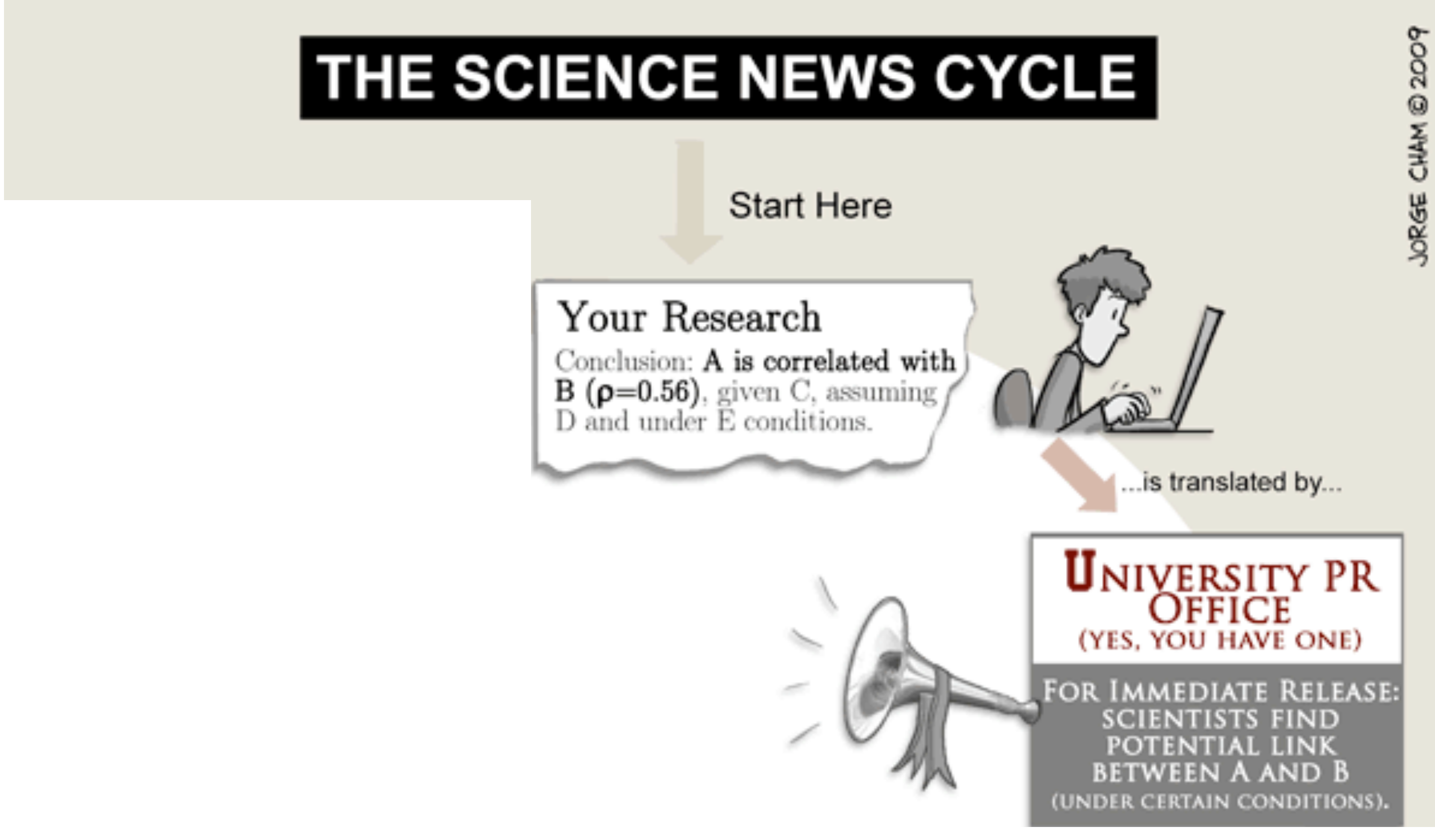
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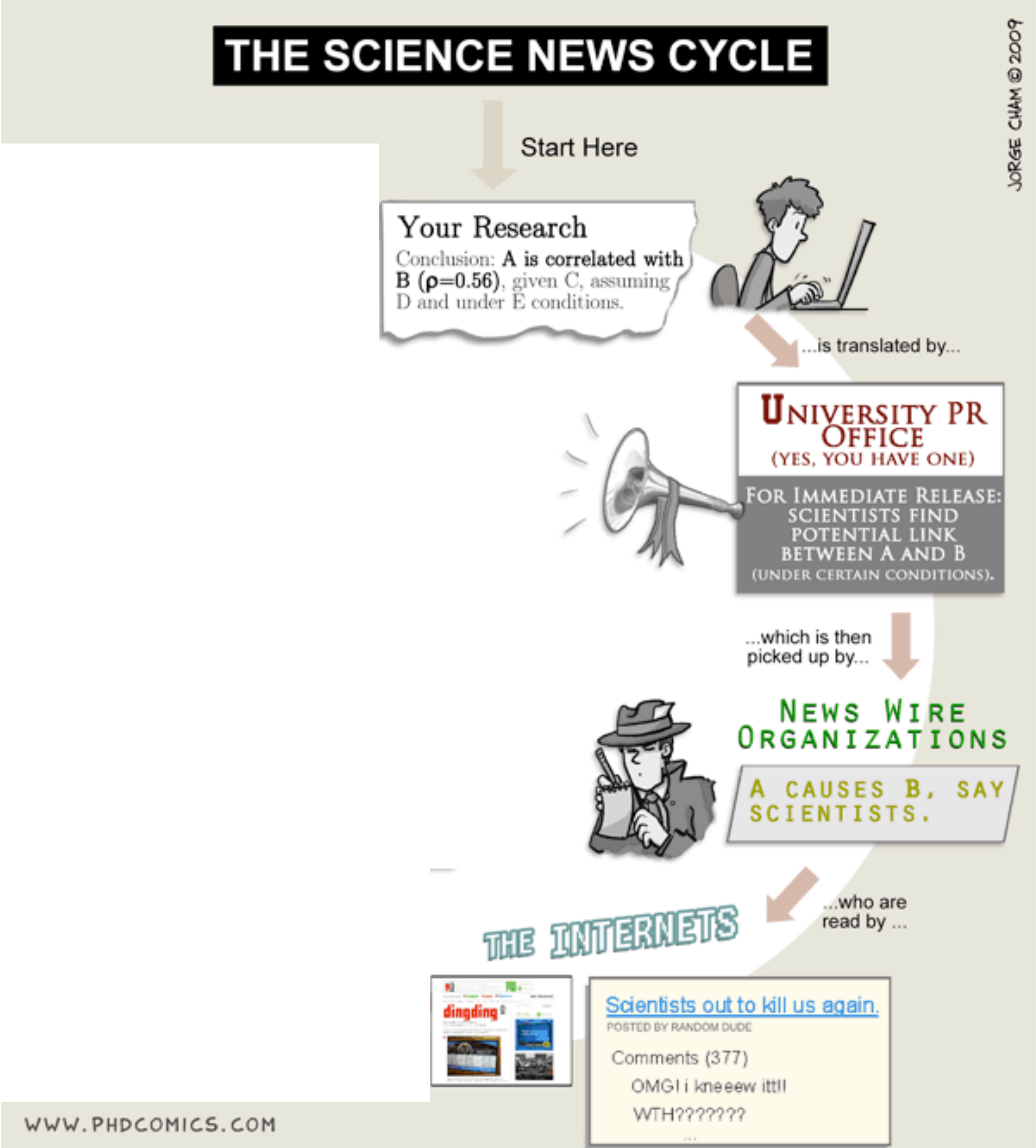

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A CAUSES B, SAY SCIENTISTS.
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THE INTERNETS
dingding
Scientists out to kill us again.
POSTED BY RANDOM DUDE
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...
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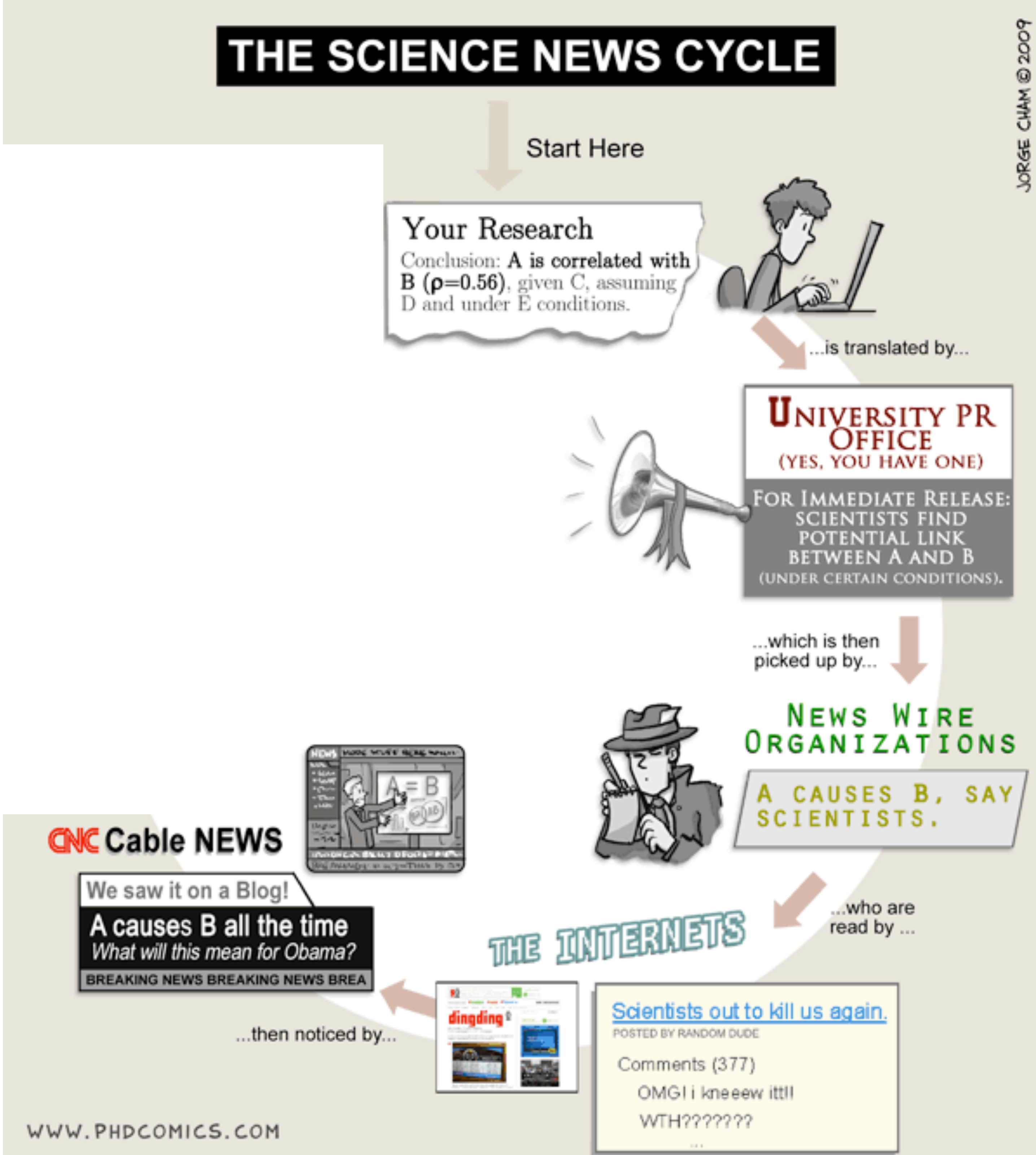
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A=B
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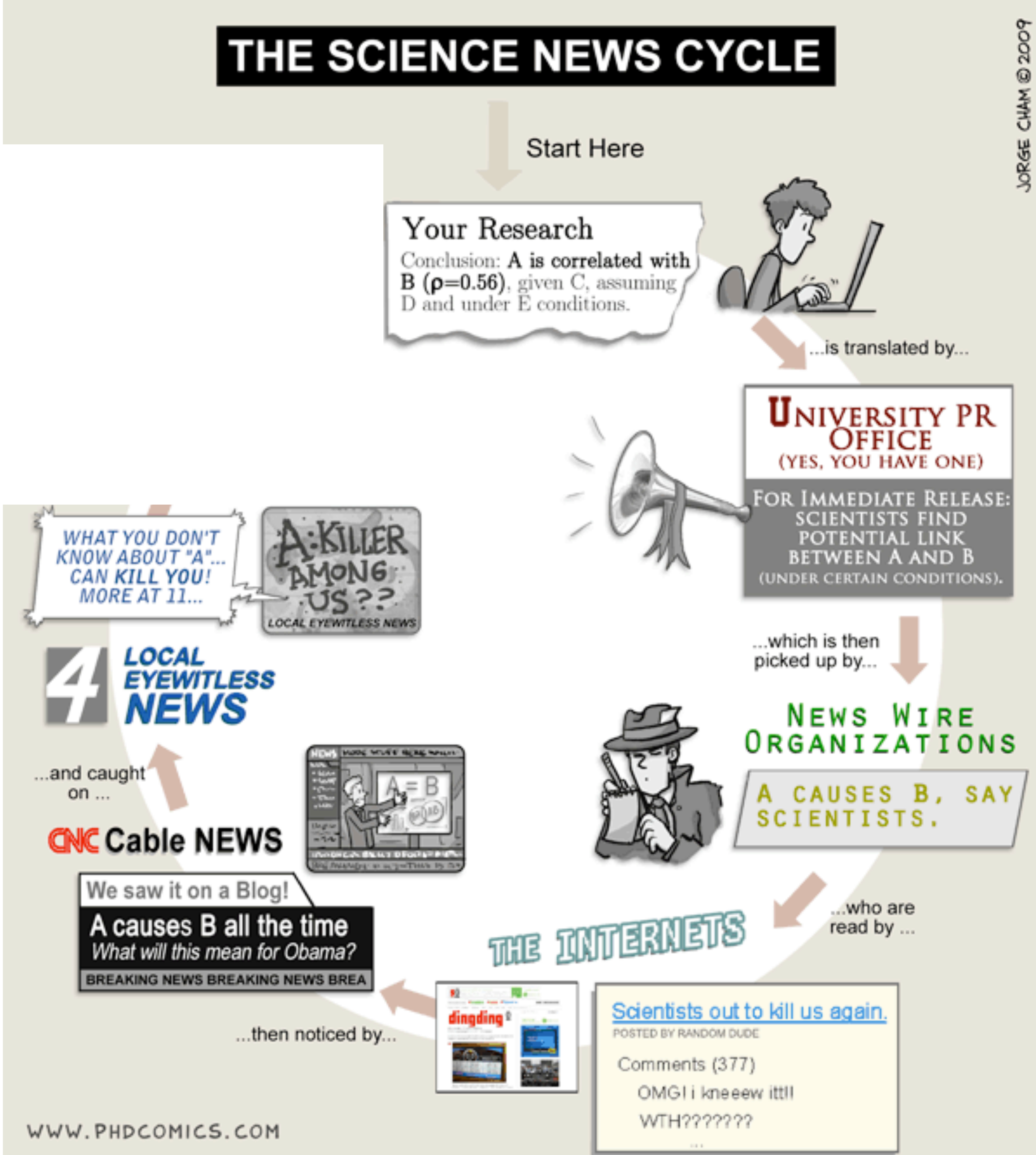
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Recommendations

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  ...you didn't do it.

Summary

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- The result is a vaccinating panic and a net increase in the number of long-term infected
- Thus, media coverage of an emerging epidemic can have dire consequences
- It can also implicitly reinforce an imperfect solution as the only answer.

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- eg people may ignore the media, de-linking the vaccination rate from the control.

Conclusions

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- The media are responsible for treating risk as spectacle, panic in the face of fear and oversimplifications in the absence of data
- While the media may encourage more people to get vaccinated, they may also trigger a vaccinating panic
- Or promote overconfidence in the ability of a vaccine to fully protect against the disease
- When the next pandemic arrives, the outcome is likely to be significantly worse as a result of the media.

Key References

- J.M. Tchuenche, N. Dube, C.P. Bhunu, R.J. Smith? and C.T. Bauch (2011). The impact of media coverage on the transmission dynamics of human influenza. BMC Public Health 11(Suppl 1):S5.

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