EnKFseir

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1 Seir model

1.1 Model variables

All model variables are dimensionless normalized by the total initial population N.

Variable	Numerical	Description	Variable in html
$\mathbf{S}$	$y(0) = (N - I_0)/N$	Susceptible (Population not immune to disease)	`(S         )`
$\mathbf{E}$	$y(1) = 0.0$	Exposed (Population currently in incubation)	`(E         )`
$\mathbf{I}$	$y(2) = I_0/N$	Infected (Number of infections actively circulating)	`(I         )`
$\mathbf{Q}_\mathrm{m}$	$y(3) = 0.0$	Sick Mild (Number of mild cases)	`(Mild      )`
$\mathbf{Q}_\mathrm{s}$	$y(4) = 0.0$	Sick Severe (Number of sever cases at home)	`(Severe    )`
$\mathbf{Q}_\mathrm{h}$	$y(5) = 0.0$	Sick Hospital (Number of sever cases at hospital)	`(Severe_H)`
$\mathbf{Q}_\mathrm{f}$	$y(6) = 0.0$	Sick Fatal (Severe at hospital that will die)	`(Fatal     )`
$\mathbf{R}_\mathrm{m}$	$y(7) = 0.0$	Removed mild (recovered)	`(R_Mild    )`
$\mathbf{R}_\mathrm{s}$	$y(8) = 0.0$	Removed severe (recovered)	`(R_Severe)`
$\mathbf{D}$	$y(9) = 0.0$	Removed fatal (Dead)	`(R_Fatal )`

1.2 Model equations

$$\mathbf{S} \rightarrow \mathbf{E} \rightarrow \mathbf{I} \rightarrow \begin{cases} \mathbf{Q}_\mathrm{m} & \rightarrow \mathbf{R}_\mathrm{m} \\ \mathbf{Q}_\mathrm{s} \rightarrow \mathbf{Q}_\mathrm{h} & \rightarrow \mathbf{R}_\mathrm{s} \\ \mathbf{Q}_\mathrm{f} & \rightarrow \mathbf{D} \end{cases} \tag{1}$$

The model starts with a non-immune population $\mathbf{S}$ and a number of infectious persons $\mathbf{I}$. people in $\mathbf{S}$ gets in contact with people in $\mathbf{I}$ and are exposed $\mathbf{E}$. After some time they become infectious and move to $\mathbf{I}$. The infectious people then develop desease and are moved to $\mathbf{Q}_\mathrm{m}$ for mild cases, $\mathbf{Q}_\mathrm{s}$ for severe cases, and $\mathbf{Q}_\mathrm{f}$ for fatal cases. The severe cases are all going to the hospital after some time $\mathbf{Q}_h$. (The fatal cases are also assumed being hospitelized.) Then $\mathbf{Q}_\mathrm{m}$ recovers and are moved to $\mathbf{R}_\mathrm{m}$, the severe hospitelized $\mathbf{Q}_\mathrm{h}$ recovers and move to $\mathbf{R}_\mathrm{s}$, and the fatally ill $\mathbf{Q}_\mathrm{f}$ ends up dead in $\mathbf{D}$.

The model assumes that as soon as you get sick you are moved to one of the $\mathbf{Q}$ categories and you don't infect anyone anymore, in other words you are **Q**arantined. We know this is not the case since doctors and nurses are getting infected at the hospitals.

Note that the dimensional equations includes a division by N in the quadratic terms which disappears from the non-dimensional equations below.

$$\frac{\partial \mathbf{S}}{\partial t} = -(R(t)/\tau_{\mathrm{inf}})\, \mathbf{I}\, \mathbf{S} \tag{2}$$

$$\frac{\partial \mathbf{E}}{\partial t} = (R(t)/\tau_{\mathrm{inf}})\, \mathbf{I}\, \mathbf{S} - (1/\tau_{\mathrm{inc}})\, \mathbf{E} \tag{3}$$

$$\frac{\partial \mathbf{I}}{\partial t} = (1/\tau_{\mathrm{inc}})\, \mathbf{E} - (1/\tau_{\mathrm{inf}})\, \mathbf{I} \tag{4}$$

$$\frac{\partial \mathbf{Q}_{\mathrm{m}}}{\partial t} = (p_{\mathrm{m}}/\tau_{\mathrm{inf}})\, \mathbf{I} - (1/\tau_{\mathrm{recm}})\, \mathbf{Q}_{\mathrm{m}} \tag{5}$$

$$\frac{\partial \mathbf{Q}_{\mathrm{s}}}{\partial t} = (p_{\mathrm{s}}/\tau_{\mathrm{inf}})\, \mathbf{I} - (1/\tau_{\mathrm{hosp}})\, \mathbf{Q}_{\mathrm{s}} \tag{6}$$

$$\frac{\partial \mathbf{Q}_{\mathrm{h}}}{\partial t} = (1/\tau_{\mathrm{hosp}})\, \mathbf{Q}_{\mathrm{s}} - (1/\tau_{\mathrm{recs}})\, \mathbf{Q}_{\mathrm{h}} \tag{7}$$

$$\frac{\partial \mathbf{Q}_{\mathrm{f}}}{\partial t} = (p_{\mathrm{f}}/\tau_{\mathrm{inf}})\, \mathbf{I} - (1/\tau_{\mathrm{death}})\, \mathbf{Q}_{\mathrm{f}} \tag{8}$$

$$\frac{\partial \mathbf{R}_{\mathrm{m}}}{\partial t} = (1/\tau_{\mathrm{recm}})\, \mathbf{Q}_{\mathrm{m}} \tag{9}$$

$$\frac{\partial \mathbf{R}_{\mathrm{s}}}{\partial t} = (1/\tau_{\mathrm{recs}})\, \mathbf{Q}_{\mathrm{h}} \tag{10}$$

$$\frac{\partial \mathbf{D}}{\partial t} = (1/\tau_{\mathrm{death}})\, \mathbf{Q}_{\mathrm{f}} \tag{11}$$

1.3 Model paramters

τ_{2death}	$P(1)$	`Time_to_death`	`= 32.0`	Days to death
N	$P(2)$	`N`	`= 5000000.0`	Initial population
I_0	$P(3)$	`I0`	`= 50.0`	Initial infectious (19 cases 1st march)
R_0	$P(4)$	`R0`	`= 2.2`	Basic Reproduction Number
τ_{inc}	$P(5)$	`D_incbation`	`= 5.2`	Incubation period (Tinc)
τ_{inf}	$P(6)$	`D_infectious`	`= 2.9`	Duration patient is infectious (Tinf)
τ_{recm}	$P(7)$	`D_recovery_mild`	`= 14.0 - D_infectious`	Recovery time mild cases (11.1)
τ_{recs}	$P(8)$	`D_recovery_severe`	`= 31.5 - D_infectious`	Recovery time severe cases Length of hosp
τ_{hosp}	$P(9)$	`D_hospital_lag`	`= 5.0`	Time to hospitalization.
p_{f}	$P(10)$	`CFR`	`= 0.02`	Case fatality rate
p_{s}	$P(11)$	`p_severe`	`= 0.2`	Hospitalization rate % for severe cases
$R(t)$	$P(12)$	`Rt`	`= 0.9`	Basic Reproduction Number during interve
$\tau_{\mathrm{intervention}}$	$P(13)$	`InterventionTime`	`= 30.0`	Interventions start here (15th march)
$p_{\mathrm{m}} = 1 - p_{\mathrm{s}} - p_{\mathrm{f}}$				
$\tau_{\mathrm{death}} = \tau_{\mathrm{2death}} - \tau_{\mathrm{inf}}$				

1.4 Diagnostic variables

Number of hospitelized	$N(\mathbf{Q}_{\mathrm{f}} + \mathbf{Q}_{\mathrm{h}})$
Number of recovered	$N(\mathbf{R}_{\mathrm{m}} + \mathbf{R}_{\mathrm{s}})$
Number of deaths	$N\mathbf{D}$
Number of exposed	$N\mathbf{E}$
Number of infectious	$N\mathbf{I}$
Number of susceptible	$N\mathbf{S}$