

**Modified SEIR Model – System of differential equations, which describe the evolution of some key features of COVID19 pandemic over the time**

$$\frac{dS}{dt} = -\beta \cdot I \cdot S$$

$$\frac{dE}{dt} = \beta \cdot I \cdot S - \sigma \cdot E$$

$$\frac{dI}{dt} = \sigma \cdot E - \gamma \cdot I$$

$$\frac{dM}{dt} = P_{vac} \cdot N_{vac} \cdot P_M \cdot \gamma \cdot I - \frac{1}{T_M} \cdot M$$

$$\frac{dR_M}{dt} = \frac{1}{T_M} \cdot M$$

$$\frac{dV}{dt} = (1 - P_{vac}) \cdot (1 - N_{vac}) \cdot P_V \cdot \gamma \cdot I - \frac{1}{T_V} \cdot V$$

$$\frac{dR_V}{dt} = \frac{1}{T_V} \cdot V$$

$$\frac{dH}{dt} = (1 - P_{vac}) \cdot (1 - N_{vac}) \cdot P_H \cdot \gamma \cdot I - \frac{1}{T_H} \cdot H$$

$$\frac{dR_H}{dt} = \frac{1}{T_H} \cdot H$$

$$\frac{dF}{dt} = (1 - P_{vac}) \cdot (1 - N_{vac}) \cdot P_F \cdot \gamma \cdot I - \frac{1}{T_F} \cdot F$$

$$\frac{dR_F}{dt} = \frac{1}{T_F} \cdot F$$

$$\beta = \frac{(1 - P_{vac}) \cdot (1 - N_{vac}) \cdot R_0}{T_{vac}}$$

$$\sigma = \frac{1}{T_{inc}}$$

$$\gamma = \frac{1}{T_{inf}}$$

We are searching for the parameters:  $\theta = \{R_0, T_{vac}, T_{inc}, T_M, T_V, T_H, T_F, P_M, P_V, P_H, P_F\}$ , considering the number of fatalities ( $R_F$ ) as the only real variable that could be measured correctly and we find the best parameters  $\theta^*$  according to it.

Starting time: **1 July 2021** (Initial number of infections: ~1mil from ~19mil)

Stats: <https://www.worldometers.info/coronavirus/country/romania/>

*Table of Modified SEIR Model Parameters*

Name	Description	Initial value	Range
N	Total number of population		[19084460]
I <sub>0</sub>	Initial number of infections		[1080910]
S	Susceptible population	$N - I_0$	Deduced
E	Exposed population	0	Deduced
I	Infectious population	I <sub>0</sub>	Deduced
M	Recovering at home with mild symptoms	0	Deduced
V	Recovering at home with severe symptoms	0	Deduced
H	Recovering at hospital with severe symptoms	0	Deduced
F	Dying	0	Deduced
R <sub>M</sub>	Recovered at home from mild symptoms	0	Deduced
R <sub>V</sub>	Recovered at home from sever symptoms	0	Deduced
R <sub>H</sub>	Recovered at hospital from sever symptoms	0	Deduced
R <sub>F</sub>	Dead	0	Deduced
β	Transmission rate		Deduced
N <sub>vac</sub>	Vaccinated population rate		[0.4]
P <sub>vac</sub>	Decrease transmission after vaccinating population rate		[0.9]
T <sub>vac</sub>	Length of vaccine until immunity (days)		[7 – 14]
R <sub>0</sub>	Basic reproduction number		[1.5 – 2.5]
σ	Rate of getting infectious from being expose		Deduced
T <sub>inc</sub>	Length of incubation period (days)		[2 – 14]
γ	Recovery rate (from M, V, H)		Deduced
T <sub>inf</sub>	Length of infectiousness to death (days)		[3 – 14]
P <sub>M</sub>	Mild symptoms rate		Deduced
P <sub>V</sub>	Sever home symptoms rate		[0.05 – 0.15]
P <sub>H</sub>	Sever hospital symptoms rate		[0.05 – 0.15]
P <sub>F</sub>	Case fatality rate		[0.001 – 0.001]
T <sub>M</sub>	Recovery time for mild symptoms (days)		[5 – 14]
T <sub>V</sub>	Recovery time for sever symptoms at home (days)		[7 – 40]
T <sub>H</sub>	Recovery time for sever symptoms at hospital (days)		[7 – 40]
T <sub>F</sub>	Time from end of infectiousness to death (days)		[15 – 35]