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

$$\frac{dS}{dt} = -\beta \cdot I \cdot S \qquad \frac{dE}{dt} = \beta \cdot I \cdot S - \sigma \cdot E \qquad \frac{dI}{dt} = \sigma \cdot E - \gamma \cdot I$$

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

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

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

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

$$\beta = \frac{(1 - P_{vac}) \cdot (1 - N_{vac}) \cdot R_0}{T_{vac}} \qquad \sigma = \frac{1}{T_{inc}} \qquad \gamma = \frac{1}{T_{inf}}$$

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 fatilities (R_F) as the only real variable that could be measured correctly and we find the best parameters θ^* according to it.

Starting time: ***1 July 2021*** *(Initial number of infections: ~1mil from ~19mil)*
Stats: [*https://www.worldometers.info/coronavirus/country/romania/*](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_0	Initial number of infections		[1080910]
S	Susceptible population	$N - I_0$	Deduced
E	Exposed population	0	Deduced
I	Infectious population	I_0	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_M	Recovered at home from mild symptoms	845351	Deduced
R_V	Recovered at home from sever symptoms	100000	Deduced
R_H	Recovered at hospital from sever symptoms	100000	Deduced
R_F	Dead	33785	Deduced
β	Transmission rate		Deduced
N_{vac}	Vaccinated population rate		[0.4]
P_{vac}	Decrease transmission after vaccinating population rate		[0.9]
T_{vac}	Length of vaccine until immunity (days)		[7 – 14]
R_0	Basic reproduction number		[1.5 – 2.5]
σ	Rate of getting infectious from being expose		Deduced
T_{inc}	Length of incubation period (days)		[2 – 14]
γ	Recovery rate (from M, V, H)		Deduced
T_{inf}	Length of infectiousness to death (days)		[3 – 14]
P_M	Mild symptoms rate		Deduced
P_V	Sever home symptoms rate		[0.05 – 0.15]
P_H	Sever hospital symptoms rate		[0.05 – 0.15]
P_F	Case fatility rate		[0.001 – 0.001]
T_M	Recovery time for mild symptoms (days)		[5 – 14]
T_V	Recovery time for sever symptoms at home (days)		[7 – 40]
T_H	Recovery time for sever symptoms at hospital (days)		[7 – 40]
T_F	Time from end of infectiousness to death (days)		[15 – 35]