

Some estimates of Covid 19 in México.

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Grupo de emergencia sanitaria Covid 19 UNAM

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Background:

- ✓ December 31, 2019: China reported an outbreak of pneumonia cases of unknown etiology to the WHO Country Office.
- ✓ December 31, 2019 to January 3, 2020: 44 cases of pneumonia of unknown origin are reported to the WHO in Wuhan City, Hubei province.
- ✓ January 7: Chinese authorities announce that it is a new coronavirus (nCoV-2019) - now called SARS-CoV-2.
- ✓ Phylogenetic analyzes were performed showing that the new coronavirus is closer to SARS coronavirus (2002), than to MERS-CoV (2013).
- ✓ January 30: WHO declares Coronavirus a Public Health Emergency of International Importance
- ✓ On March 11, the WHO declares the Coronavirus as a Pandemic.

Throughout history

- Plague of Athens, 430 BC. the epidemic kills Pericles and a third of the population of Athens, causing his defeat by Sparta (Thucydides, History of the Peloponnesian Wars)
- War of the Elephant, Mecca 568 AD smallpox kills the Ethiopian army
- Plague in Europe, 14th century, kills about 15 million people in Europe (and between 40 and 60 in Asia)
- Conquest of Tenochtitlan, 1521, smallpox kills Emperor Cuitlahuac and decimates the Aztec army and population.
- Conquest of Inca Empire, 1524, smallpox kills the emperor Huayna Capac and provokes a civil war among the Incas.
- Spanish Influenza, 1918 – 1920, kills between 50 and 100 million people worldwide



**Three Egyptian
Mummies**
1570-1085 BC

Ramses the Vth
Died 1157 BC

Propagation of the infectious
front of the plague in Europe.
XIV century.

*... But at length it came to Gloucester,
yea even to Oxford and to London, and
finally it spread over all England and
so wasted the people that scarce the
tenth person of any sort was left alive.*

Geoffrey the Baker, Chronicon
Angliae



Mathematical models in Epidemiology

Classic Approach

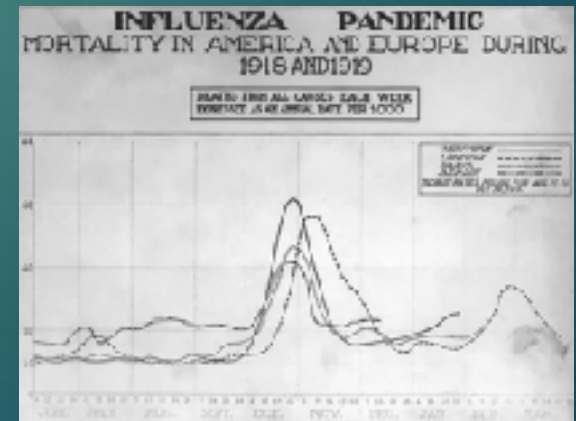
Same time as: Chemical kinetics and the Volterra model for predator-prey.

First motivation: Epidemic of Spanish Influenza 1918-1919, between 30 and 60 million deaths.

First hypothesis: There is no spatial dependency.

In chemical kinetics, only concentrations matter.

Constant population is assumed.



Kermack y McKendrick (1927)



$$\frac{ds}{dt} = -\lambda N s i$$

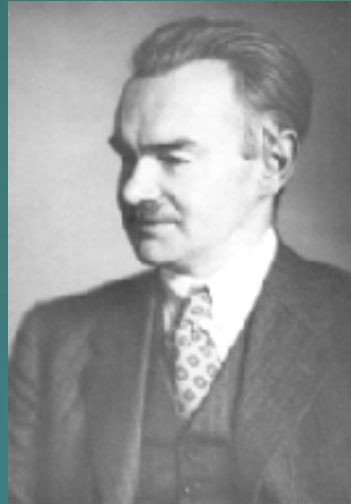
$$\frac{di}{dt} = \lambda N s i - \gamma i$$

$$\frac{dr}{dt} = \gamma i$$

$$S + I + R = N = \text{constant}$$

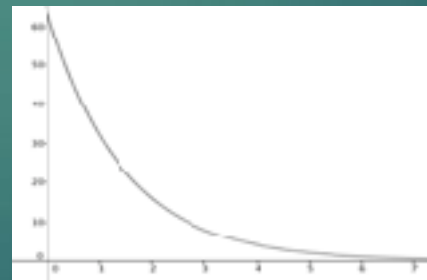


John McKendrick
1841 - 1926

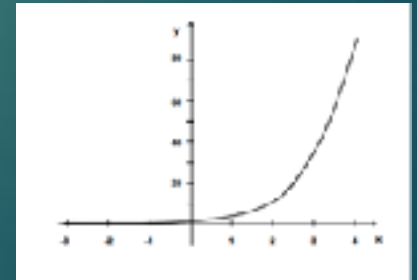


William Kermack
1898 - 1970

$$\lambda N s - \gamma < 0$$



$$\lambda N s - \gamma > 0$$



Thresholds

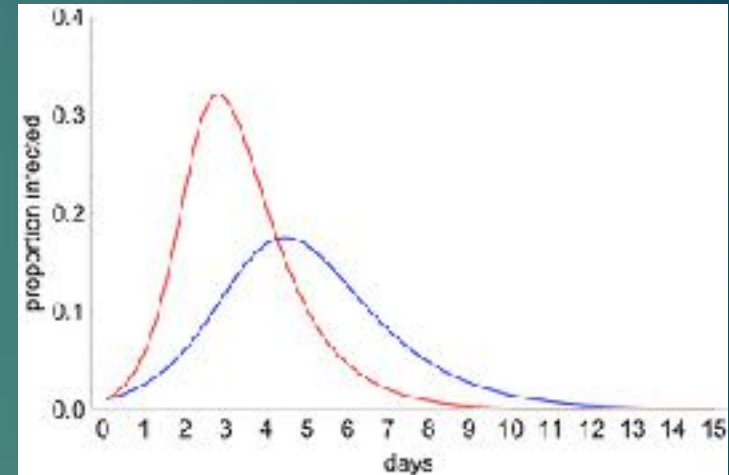
Critical values of the parameters that must be exceeded for an epidemic outbreak to occur

Critical proportion of susceptibles for an epidemic outbreak

$$s_c = \frac{\gamma}{\lambda}$$

$S_0 < S_c$ the disease does not progress

$S_0 > S_c$ epidemic outbreak



Basic Reproductive Number R_0

$$R_0 = \frac{\lambda N}{\gamma}$$

Average Secondary Infections produced
by a primary case in a community
where everyone is susceptible

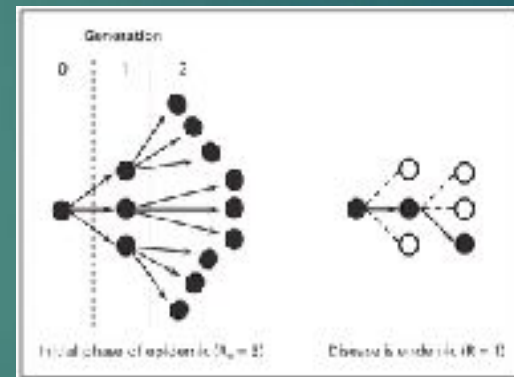
$R_0 s_0 < 1 \rightarrow$ *no epidemic*

$R_0 s_0 > 1 \rightarrow$ *epidemic*



Ronald Ross
1857 – 1932

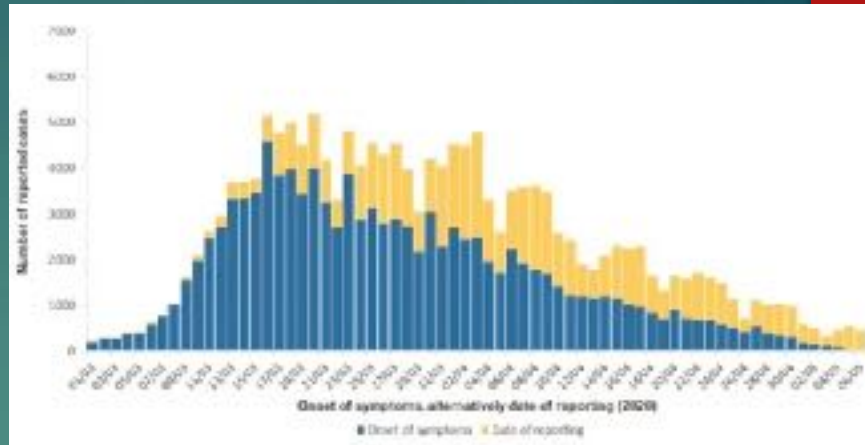
Ross number 1915



$$R_0 \approx \frac{\ln s_0 - \ln s_\infty}{s_0 - s_\infty}$$

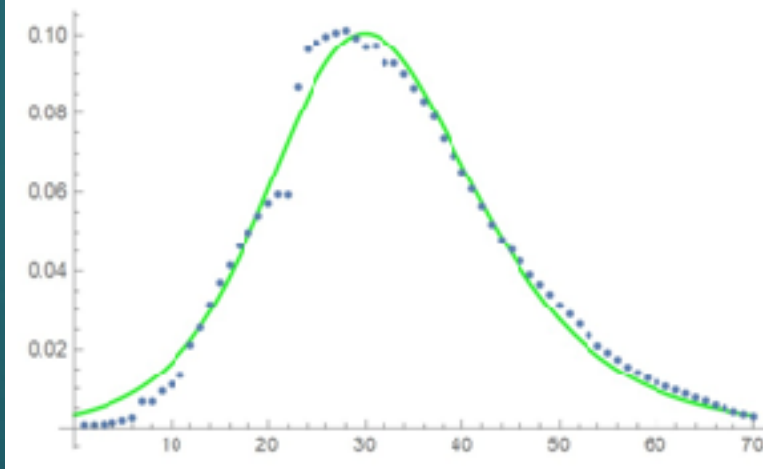
Are the data reliable?

Is it useful?

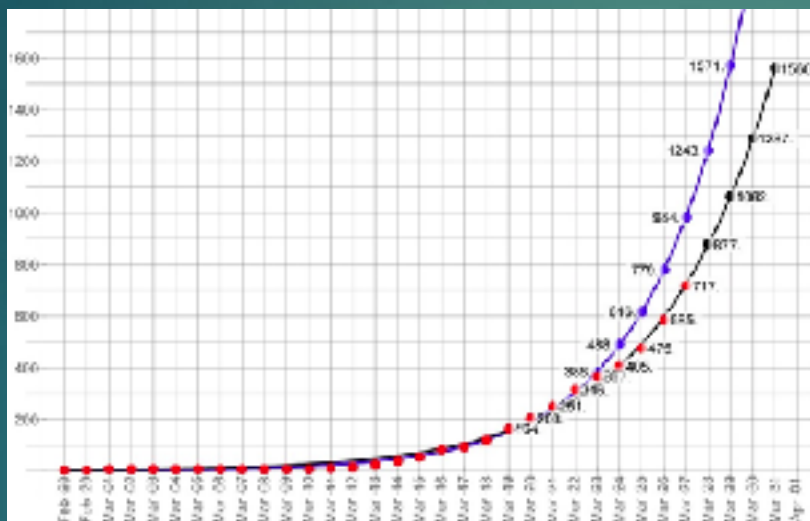


The classic model can not adjust a plateau!

Hubei. $\alpha=0.405785$, $\beta=0.239505$,
 $R_0=1.69427$, $\gamma=4.18$



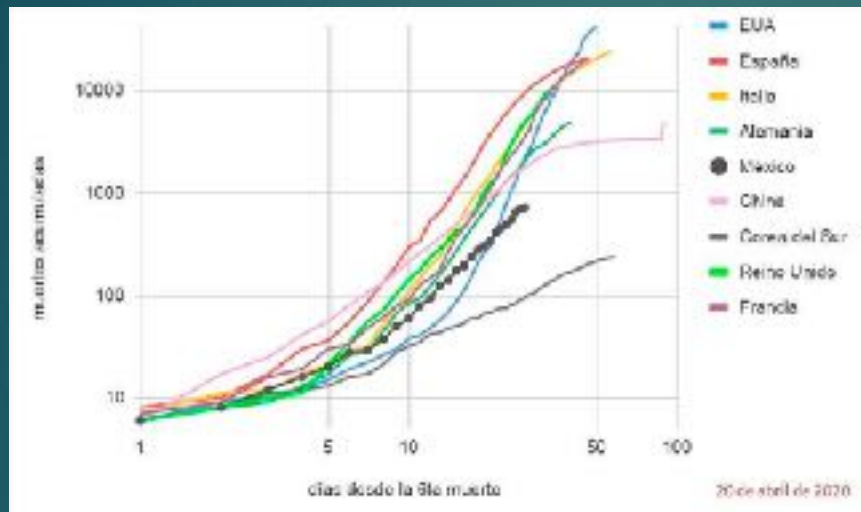
What are mathematical models really useful for?



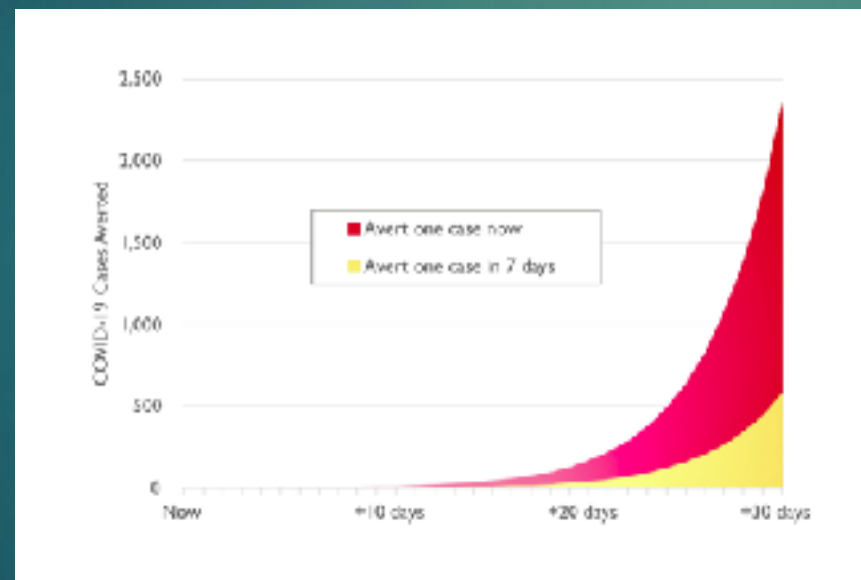
What is the factor of positives to number of infected?

8.2, 10, 7.3, 30, 85, 1300,... ??

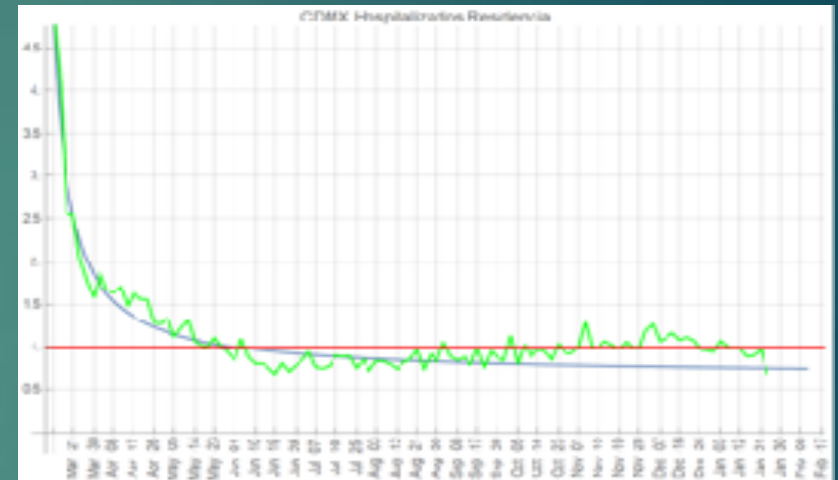
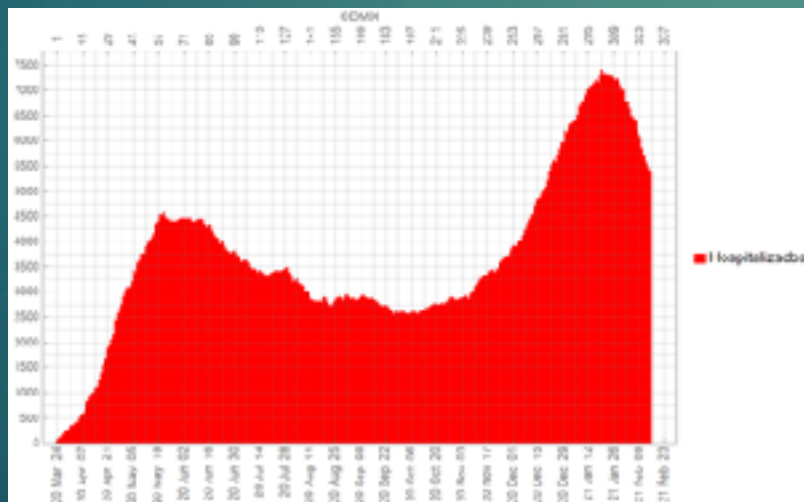
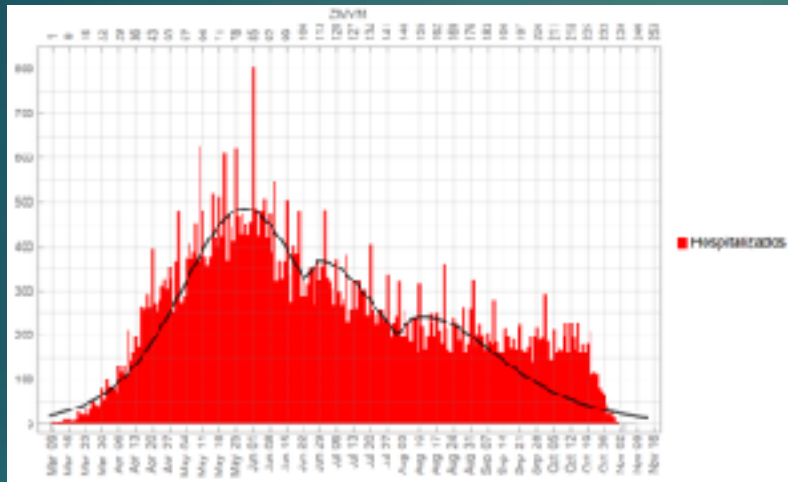
The factor does not matter!



It is very important the moment
That a quarantine is declared.

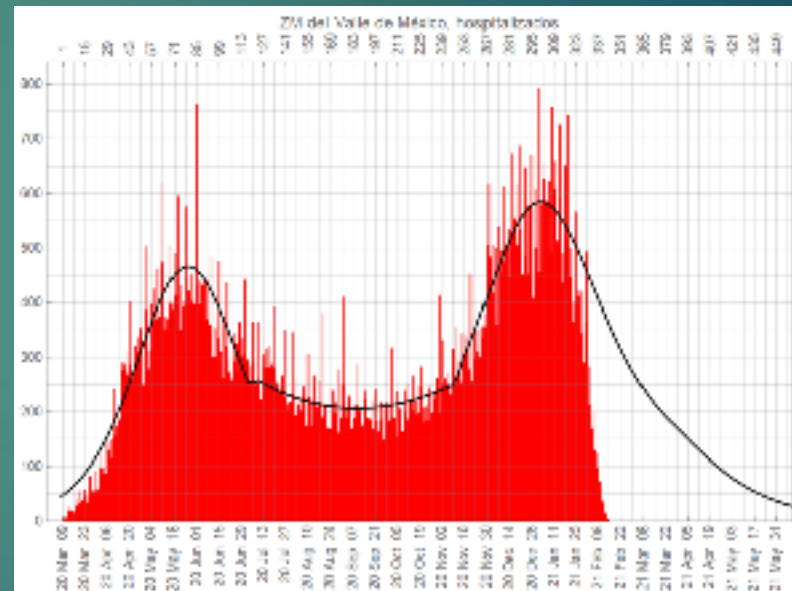
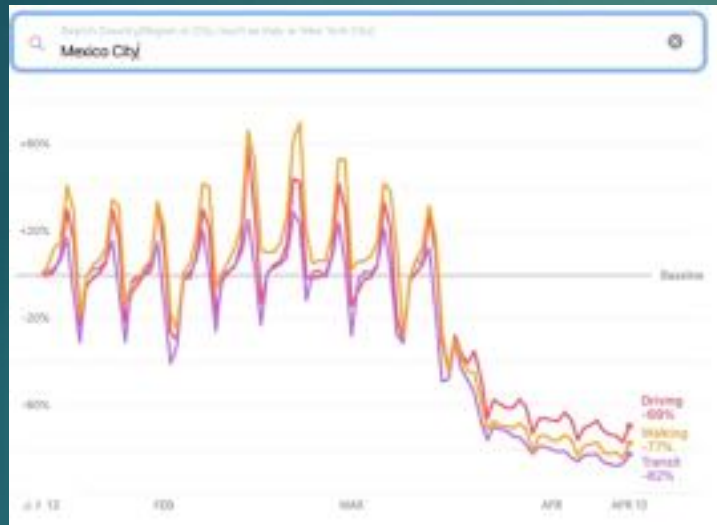


More complex behaviors due to the social factor



Kermack-McKendrick + increased mobility

(Source of Susceptibles)



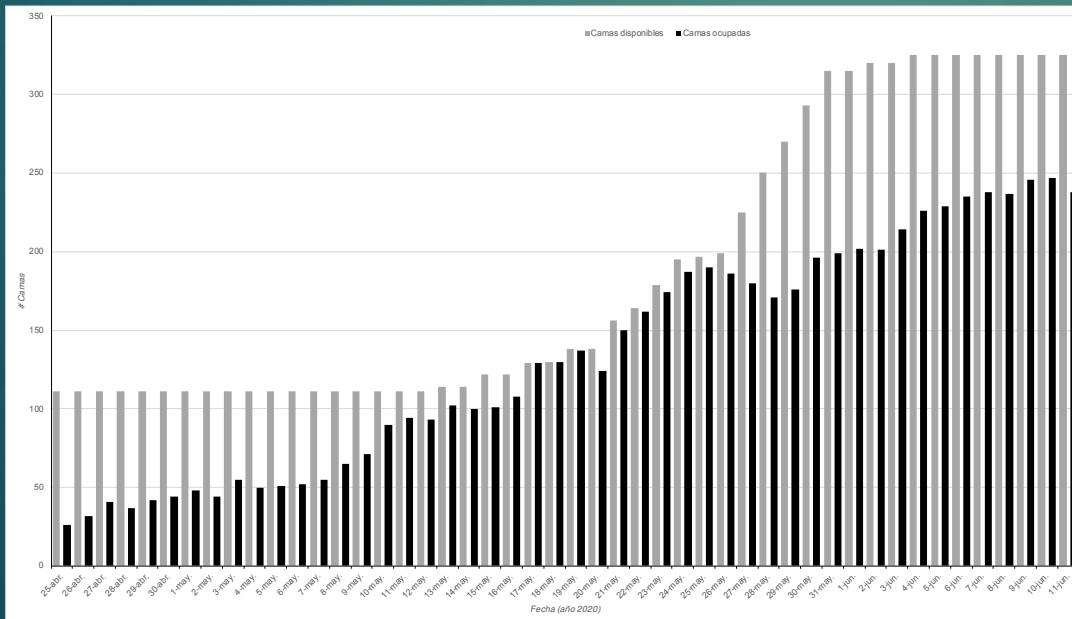
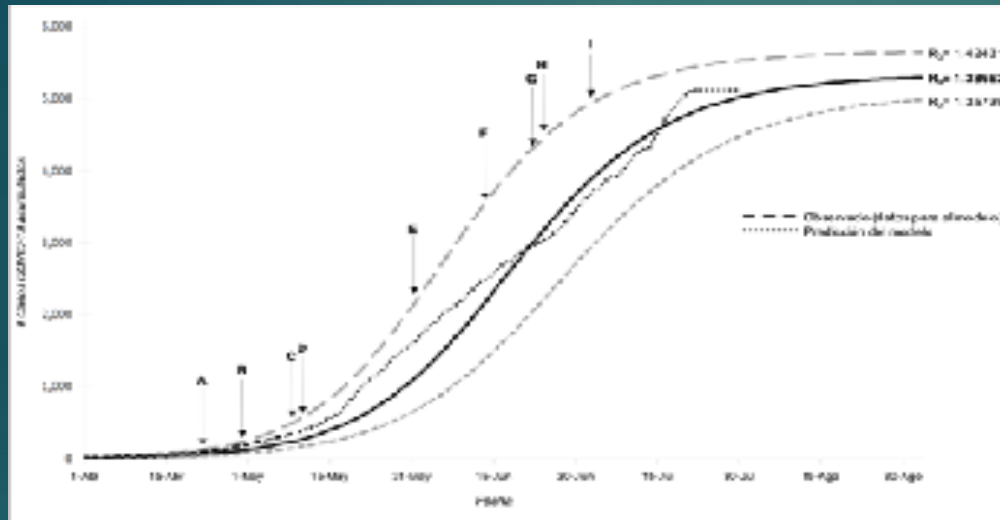
Covid 19 en Acapulco Guerrero, México

660000
inhabitants.

Until the beginning of May only 100 covid be

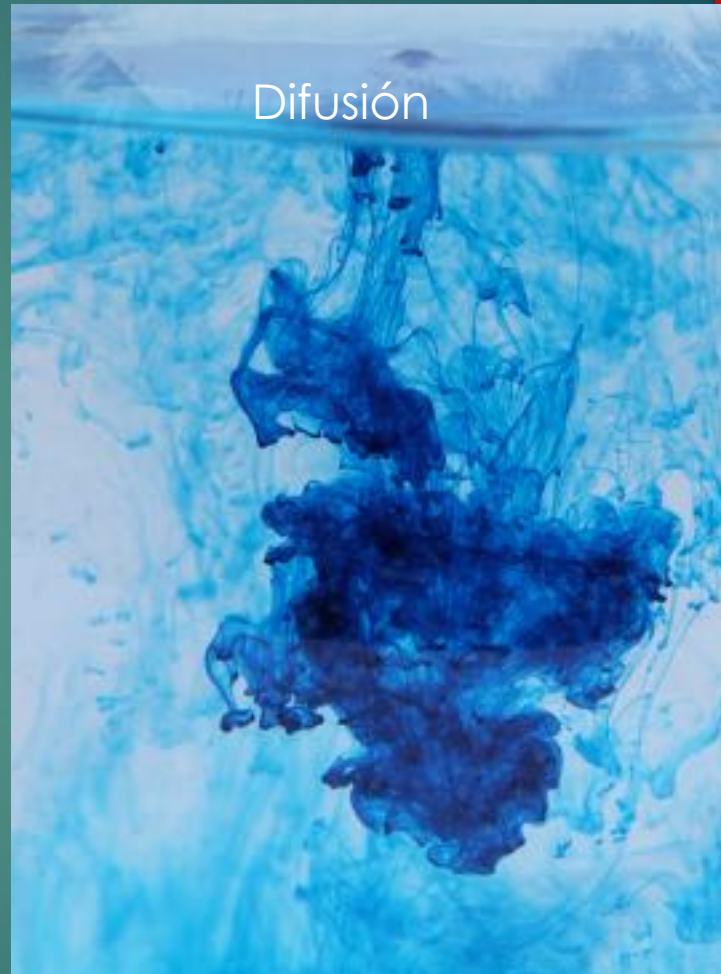


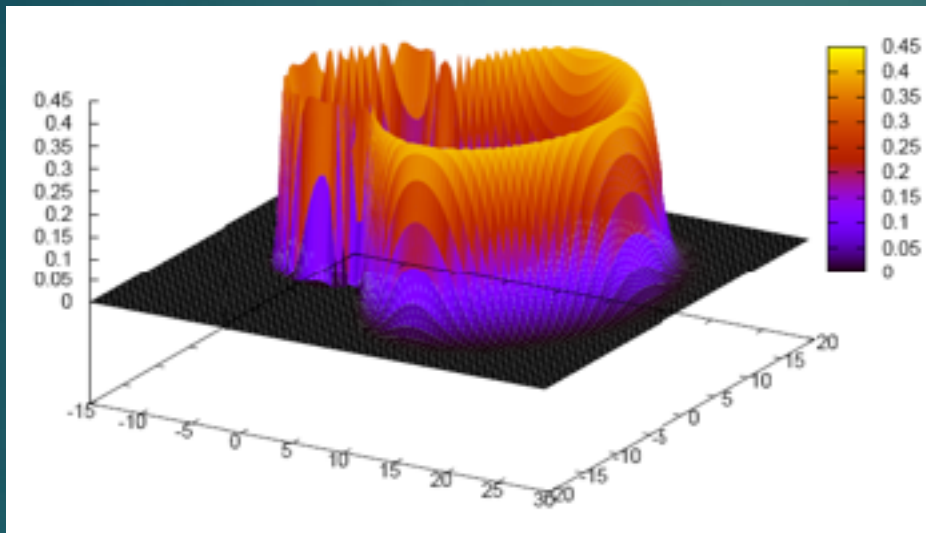
Epidemiological model of COVID-19 for decision making in the municipality of Acapulco, Guerrero.



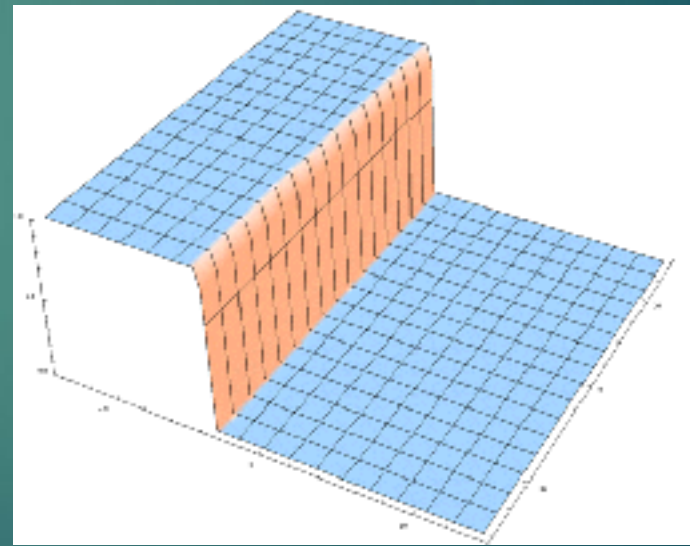
Cómo se extendió por el mundo el Covid-19?

Kermack & McKendrick +





Diffusion and new outbreaks
generated by nonlinear effects

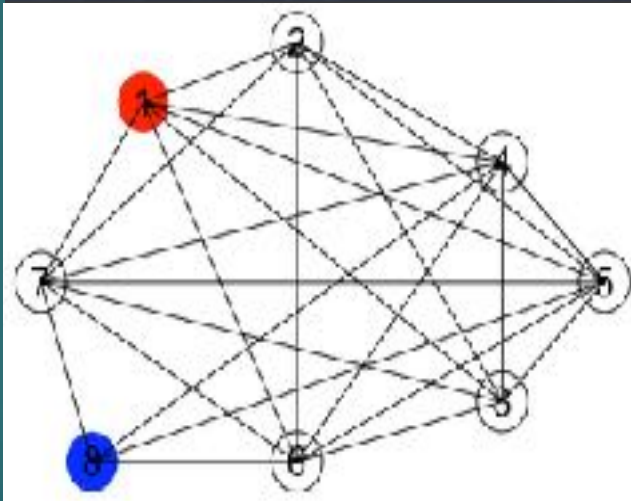


Covid 19 travels by airlines



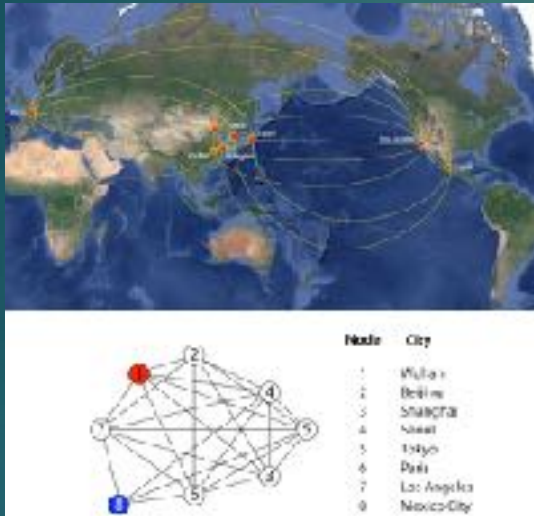
... and the Colleges of Cartographers drew up a Map of the Empire, which was the size of the Empire and exactly coincided with it.

J.L.B.



Nodo	Ciudad
1	Wuhan
2	Beinjing
3	Shanghai
4	Seoul
5	Tokyo
6	París
7	Los Ángeles
8	CDMX

Covid-19 spread mainly by airlines

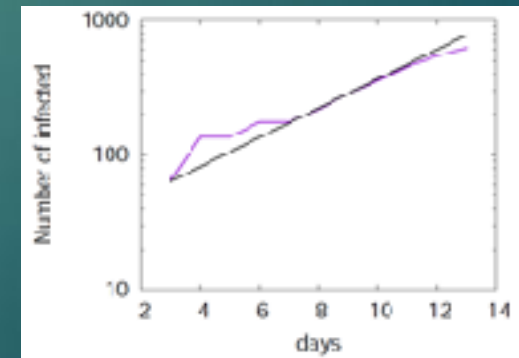
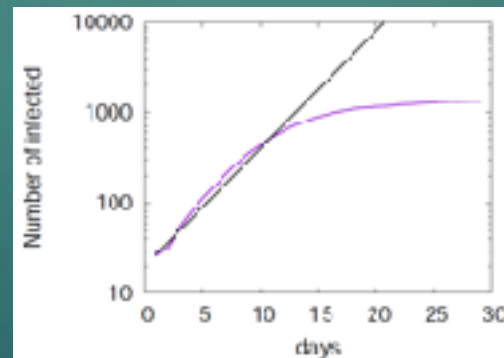
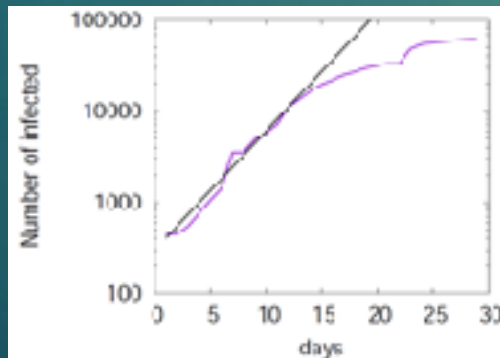


$$\begin{aligned}\dot{S} &= \epsilon \Delta S - \beta S I, \\ \dot{I} &= \epsilon \Delta I + \beta S I - \gamma I.\end{aligned}$$

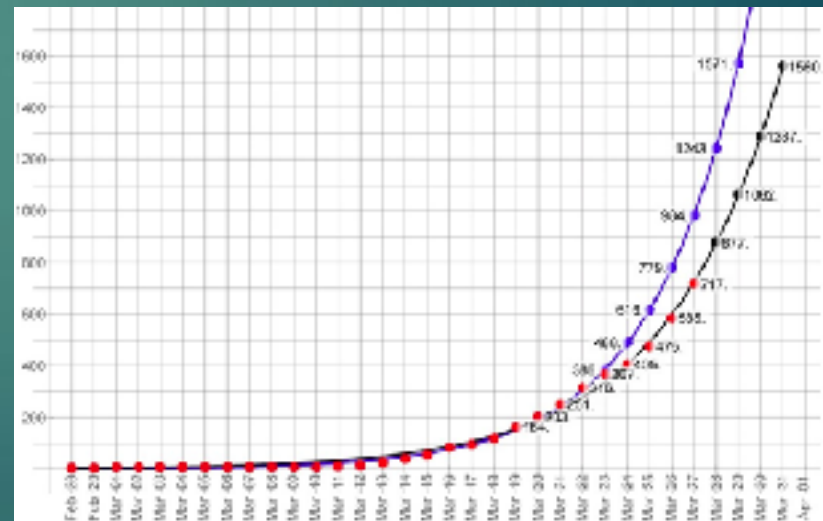
Δ is the graph Laplacian matrix

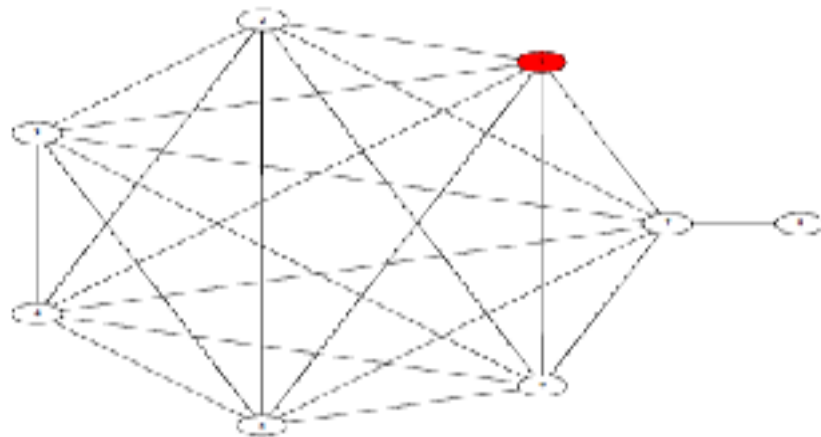
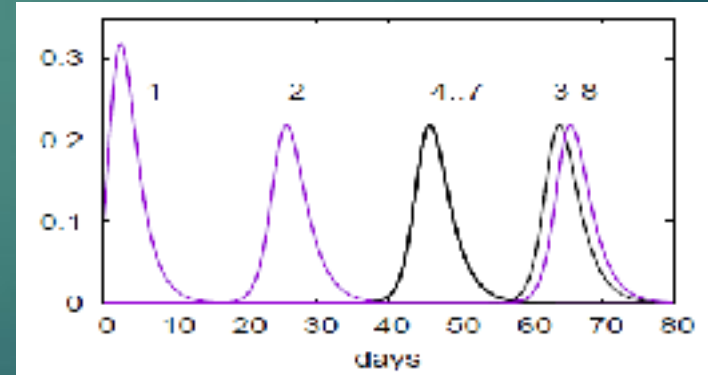
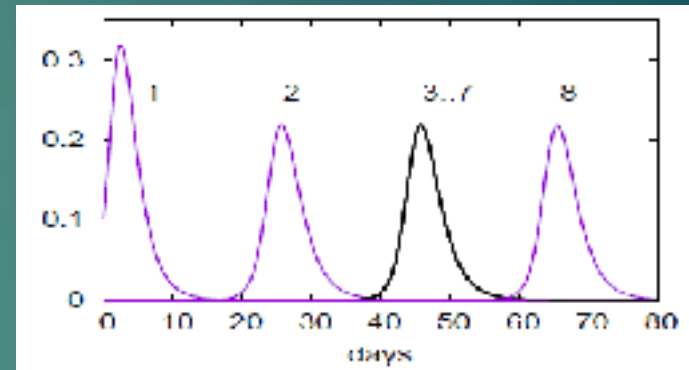
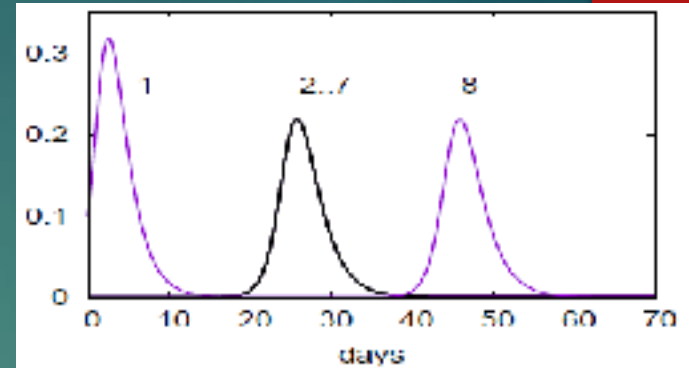
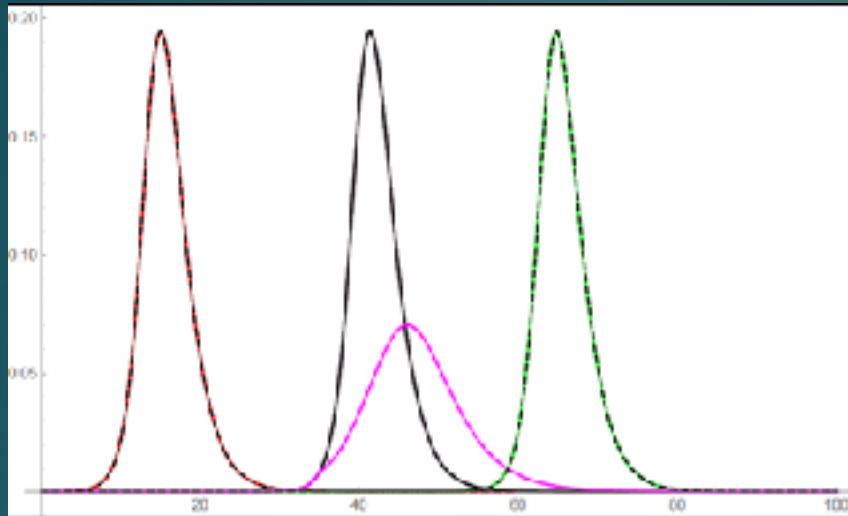
γ is associated with the average lifespan of the virus. For this type of virus, between 3 and 7 days

β is the transmission rate. At the beginning of the pandemic, the R_0 was estimated between 1.5 and 5.



These results were communicated to the Mexican Ministry of Health on February 24. The criterion was to see a clear exponential rise and between 200 and 400 infections.







Introduction of new variants

$$S' = -(\lambda_1 I_1 + \lambda_2 I_2)S$$

$$I_1' = \lambda_1 I_1 S - \gamma_1 I_1$$

$$I_2' = \lambda_2 I_2 S - \gamma_2 I_2$$

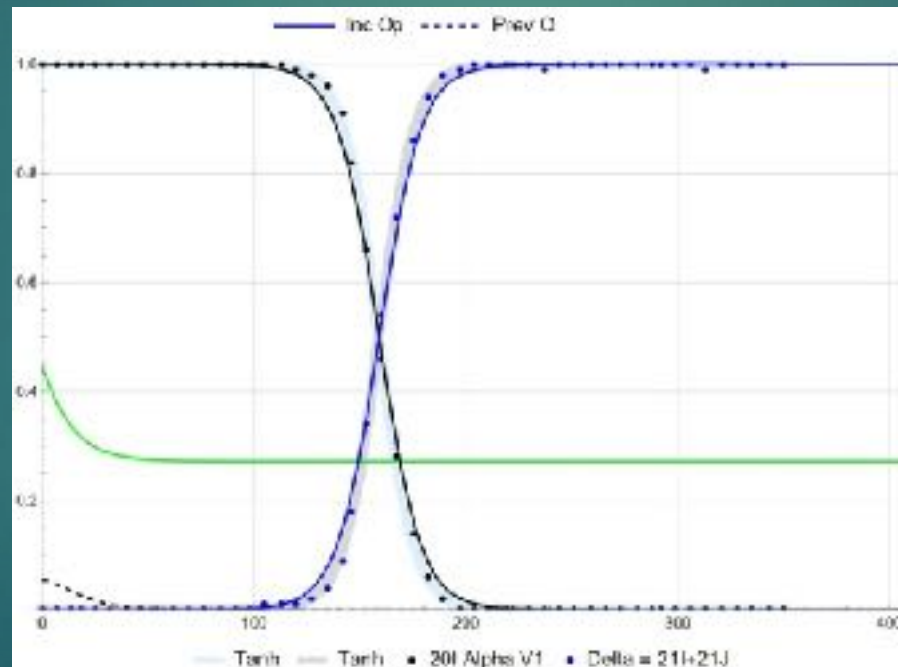
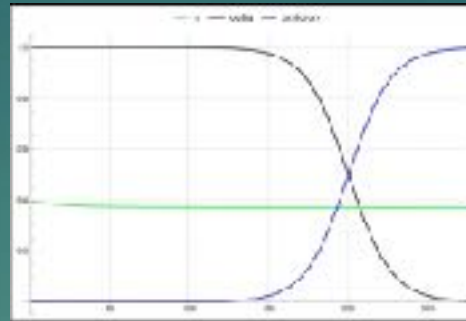
$$R_1' = \gamma_1 I_1 - \delta_2 \lambda_2 I_2 R_1$$

$$R_2' = \gamma_2 I_2 - \delta_1 \lambda_1 I_1 R_2$$

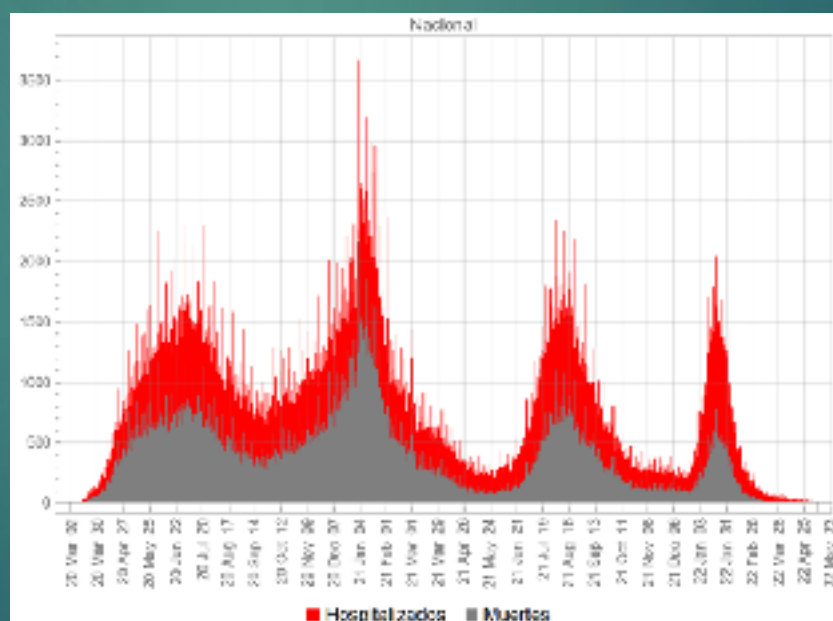
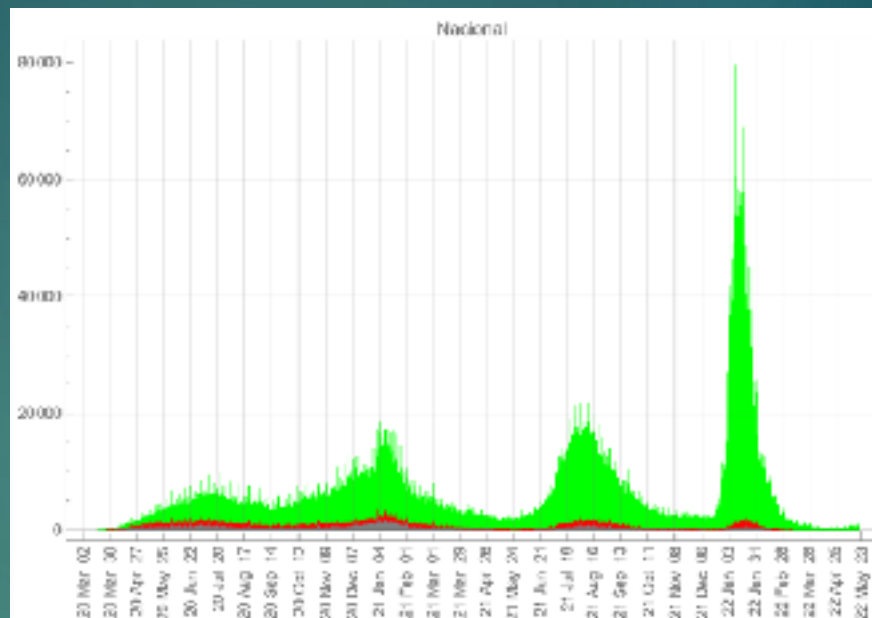
$$Y_1' = \delta_1 \lambda_1 I_1 R_2 - \gamma_1 Y_1$$

$$Y_2' = \delta_2 \lambda_2 I_2 R_1 - \gamma_2 Y_2$$

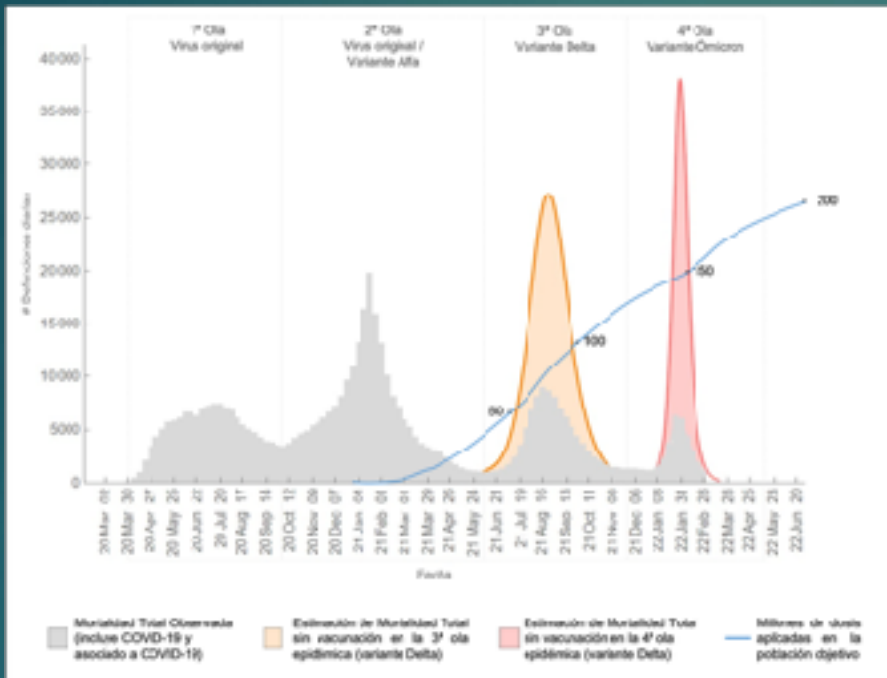
$$P' = \gamma_1 Y_1 + \gamma_2 Y_2$$



Omicron



Omicron with no vaccination



147000 additional deaths third outbreak

93000 additional deaths fourth outbreak

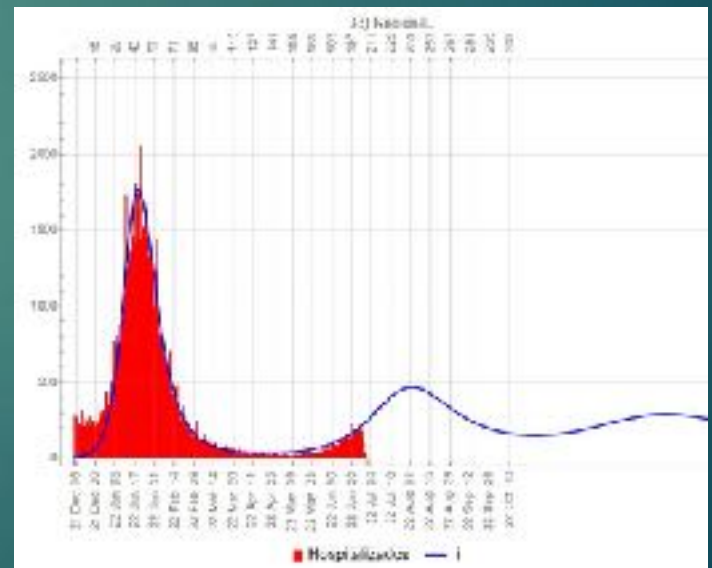
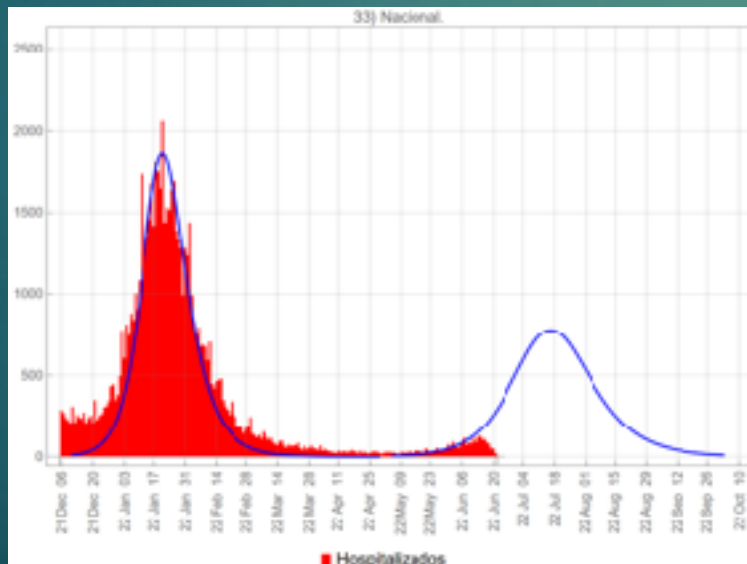
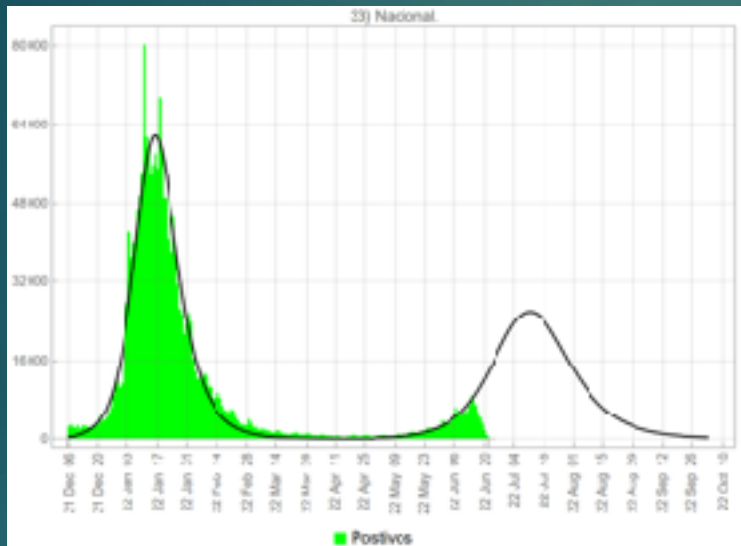
Omicron fifth outbreak

Loss of immunity and formation of endemic state

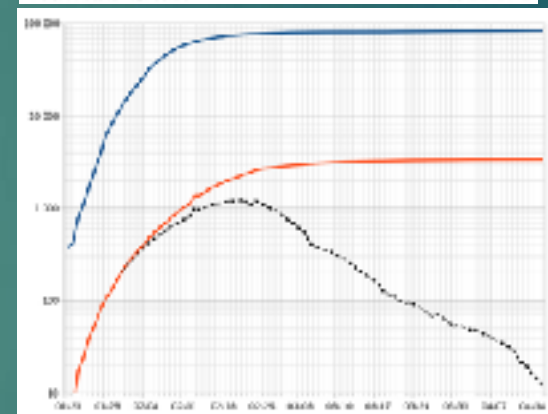
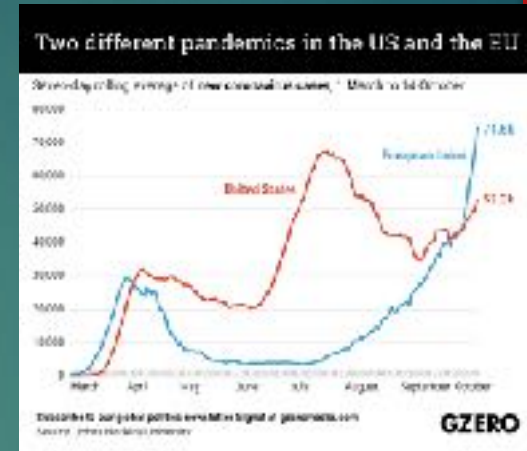
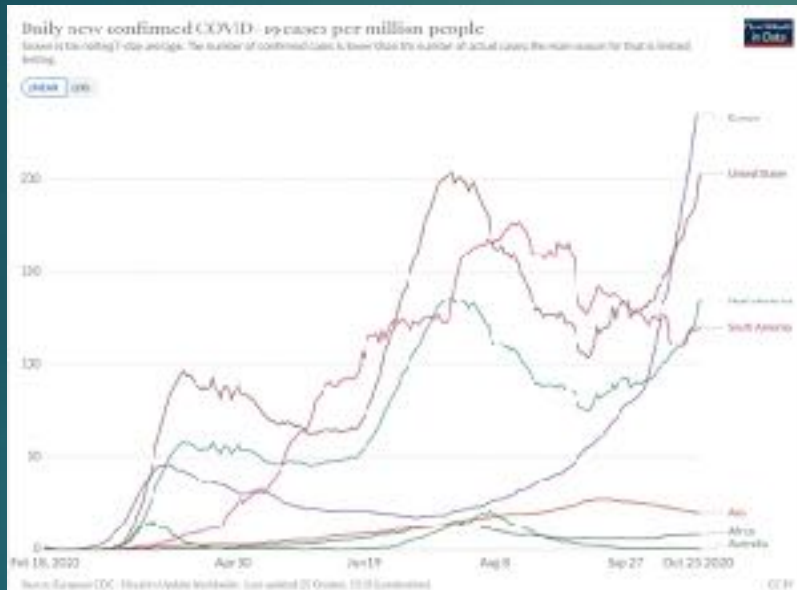
$$\frac{dS}{dt} = -\lambda SI + \alpha R$$

$$\frac{dI}{dt} = \lambda SI - \gamma I$$

$$\frac{dR}{dt} = \gamma I - \alpha R$$

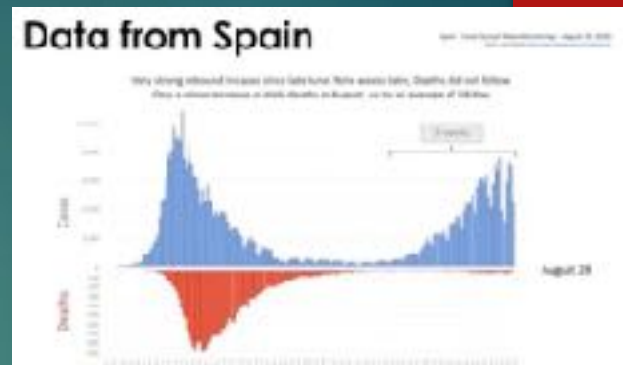


How efficient have governments been?



Progression on a logarithmic scale of number of cases and number of deaths (red) in China

Comparativa: COVID-19 - Crisis del corona/virus 25/05/2021						
Países	Incremento Muertos	Muertos	Muertos / millón	Incremento Confirmados	Confirmados	Confirmados / 100.000 - 14 días
Hangria (+)	41	29.632	3.032,08	213	802.733	91,60
República Checa (+)	13	38.054	2.816,38	555	1.659.433	102,67
Bosnia y Herzegovina (+)	16	9.184	2.782,10	146	203.688	65,41
San Marino (+)	0	96	2.643,05	0	5.689	17,65
Wacodonía del Norte (+)	14	5.356	2.575,64	46	155.117	35,88
Montenegro (+)	1	1.576	2.537,50	67	99.425	141,35
Bulgaria (+)	36	17.617	2.534,28	353	417.526	67,78
Wicloria (+)	4	6.088	2.295,50	54	254.905	64,69
Eslovaquia (+)	11	12.312	2.255,82	150	389.176	43,30
Dinast (+)	2.990	454.429	2.182,40	60.466	19.274.695	495,55
Belgica (+)	16	24.889	2.166,13	1.935	1.052.622	252,39
Perú []	164	68.634	2.111,14	4.950	1.937.246	225,26
Italia (+)	121	125.622	2.106,29	3.955	4.201.827	113,62
Eslovenia (+)	6	4.363	2.081,68	368	262.486	243,31
Ucrania (+)	21	1.971	1.964,19	538	354.921	192,87
Polonia (+)	269	73.506	1.691,21	1.263	2.468.150	63,79
Reino Unido (+)	9	128.010	1.505,87	2.991	4.485.168	42,41
Estados Unidos (+)	1.009	691.950	1.801,19	54.062	33.190.470	114,38
Wéxico (+)	212	222.232	1.735,01	2.952	2.402.122	28,45
Calcomia (+)	514	86.180	1.716,80	23.467	3.794.161	487,12
España (+)	33	79.686	1.687,80	5.291	3.663.176	125,49
Argentina (+)	532	75.588	1.682,01	55.359	3.622.135	504,70
Portugal (+)	1	17.022	1.604,71	554	645.434	87,75
Austria (+)	0	127	1.637,80	7	13.671	259,31
Francia (+)	145	109.105	1.621,00	12.057	5.600.140	299,70
Rumania (+)	52	38.092	1.556,84	379	1.075.933	39,92
Lituania (+)	11	4.320	1.516,00	640	272.521	207,87
China (+)	39	28.624	1.488,09	5.117	1.344.676	442,52
Liechtenstein []	0	68	1.486,89	0	3.902	61,94
Armenia (+)	11	4.411	1.480,35	130	222.269	73,35
Panamá (+)	4	6.257	1.484,63	663	375.600	155,88
Suecia (+)	40	14.436	1.397,81	2.732	1.067.167	379,30



60 Israel 707
62 Canadá 665

112 Japón 99
135 Corea del Sur 37
154 Tailandia 12.5
171 Singapur 5.6
174 China 4.8
177 Taiwan 1.9
180 Vietnam 0.5

What influences the spread of Covid 19?

Distancing measures, social responsibility,
trust in institutions, etc.

+

Vaccination, new strains,

+

Climatic effects

+

Possible Immuno-Genetic effects

