Effect of current and counterfactual non-pharmaceutical intervention scenarios on COVID-19 epidemic in Iran

In collaboration with the CoMo Consortium

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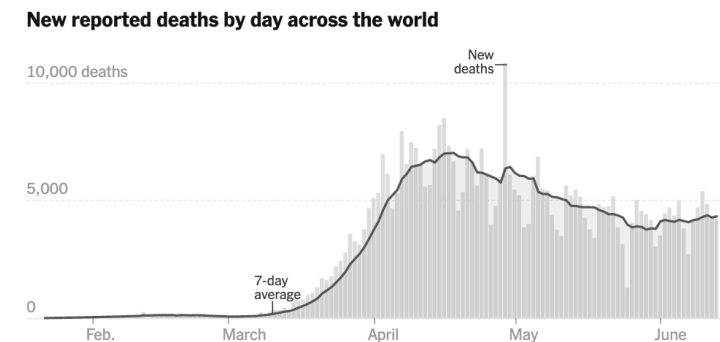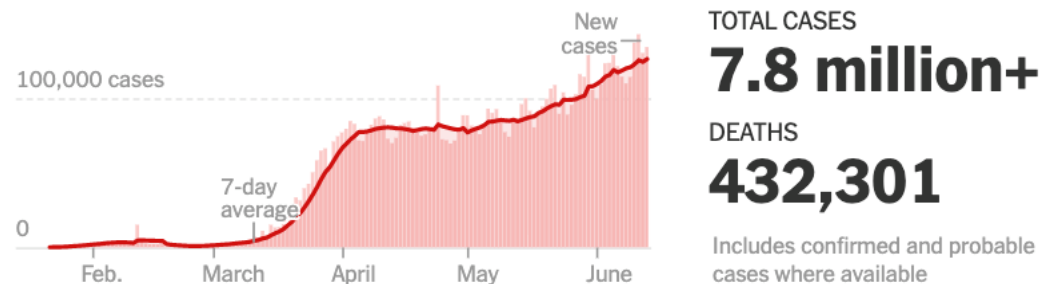
June 15, 2020

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Topics

- Background and study objective
- Working groups
- CoMo Model
- Model Inputs / Parameters
- Non-pharmaceutical interventions in Iran
- Baseline and counterfactual scenarios
- Conclusion

Background and study aim

- **COVID-19 pandemic continues to spread around the world** with 7.8 million+ cases as of June 14.

- **With no vaccine**, non-pharmaceutical interventions (NPI) play a key role in mitigating the pandemic.

- In **Iran**, the daily number of cases declined for a few weeks in April, but now we see a second wave of the epidemic.

- **Our study aimed** to model COVID-19 infections and deaths under the current NPI and two counterfactual scenarios.

TOTAL CASES

7.8 million+

DEATHS

432,301

Includes confirmed and probable cases where available

New reported deaths by day across the world

By The New York Times   Updated June 14, 2020, 10:37 A.M. E.T.

24 people in 8 working groups

- **Country Team (22):** Ali Mirzazadeh, Sana Eybpoosh, Ali Ahmadi, Mohsen Shati, Ali Alami, Mohammad Hassan Emamian, Farid Najafi, Seyedeh Mahdieh Namayandeh, Alireza Ansari-Moghaddam, Soodabeh Navadeh, Mostafa Vahedian, Homayoun Sadeghi-Bazargani, Maryam Shakiba, Mohammad Heidari, Ebrahim Ghaderi, Mohsan Arabi, Elham Ahmad Nejad, Akabr Fotouhi, Ali Akbar Haghdoost, Hamid Heidarian Miri, Shadi Sirous, Hamid Sharifi

- **CoMo Team (2):** Penny Hancock, Lisa J White

CoMo model

- Age structured SEIR model
- Infected compartments stratified by symptoms, severity, treatment seeking and access

Source: CoMo Consortium
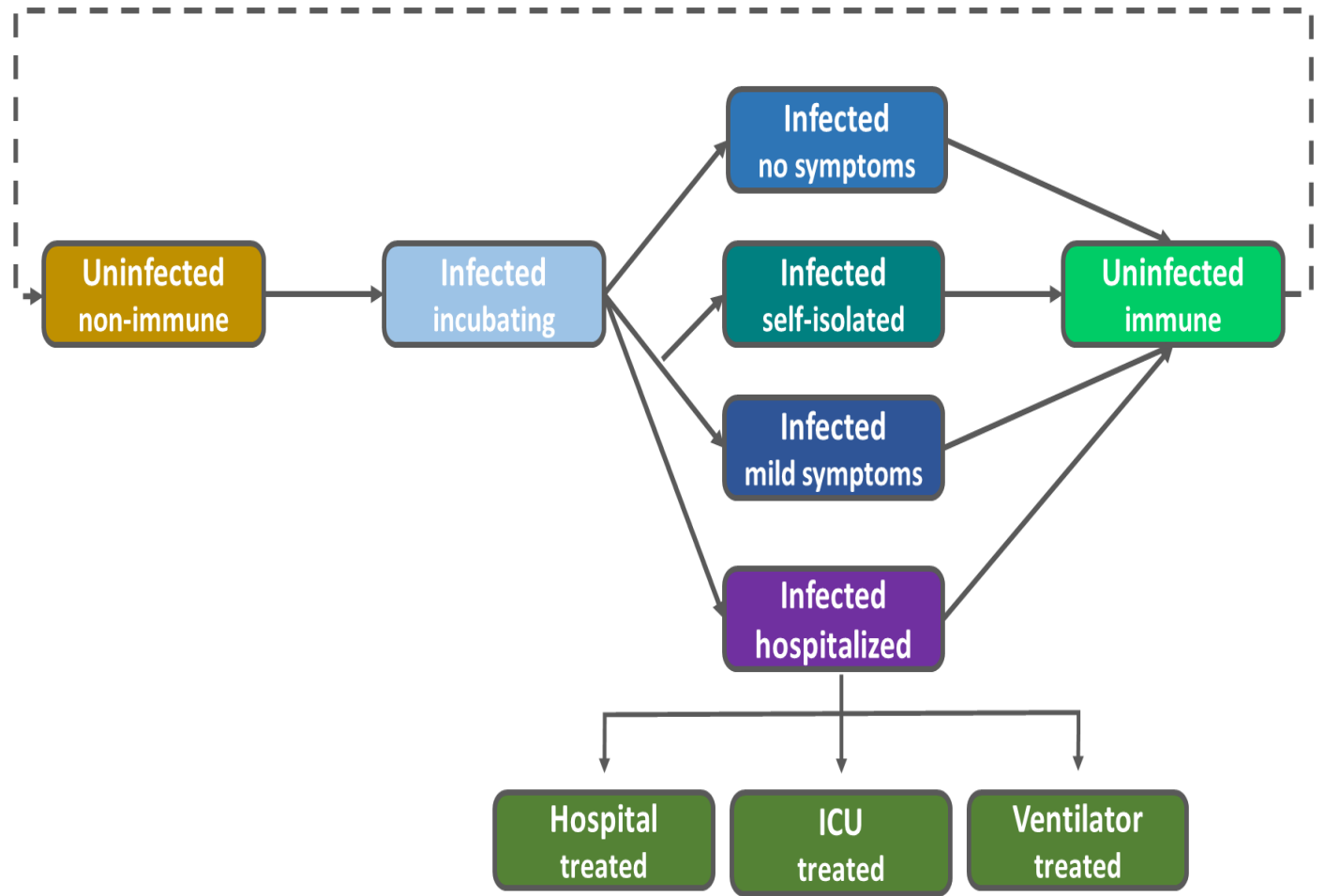
CoMo model: main features

Tailor the model assumptions to individual country's context

Simulation of different intervention scenarios that changes in coverage over time

Possible impact of epidemics to hospital capacity (hospital beds, ICU beds, Ventilators)

Source: CoMo Consortium

Model Inputs / Parameters

- Cases/Deaths

- Severity-Mortality

- Population

- Country Area Parameters

- Virus Parameters

- Hospitalization Parameters

- Interventions

- Social Contacts data (Prem K et al PLOS Computational Biology 2017)

Model Inputs / Parameters

- Iran Cases (up to June 14)

Overall deaths =
8,837/186,476 = **4.74%**

Source:
Iran MOH

Number of reported cases per day

Number of deaths per day
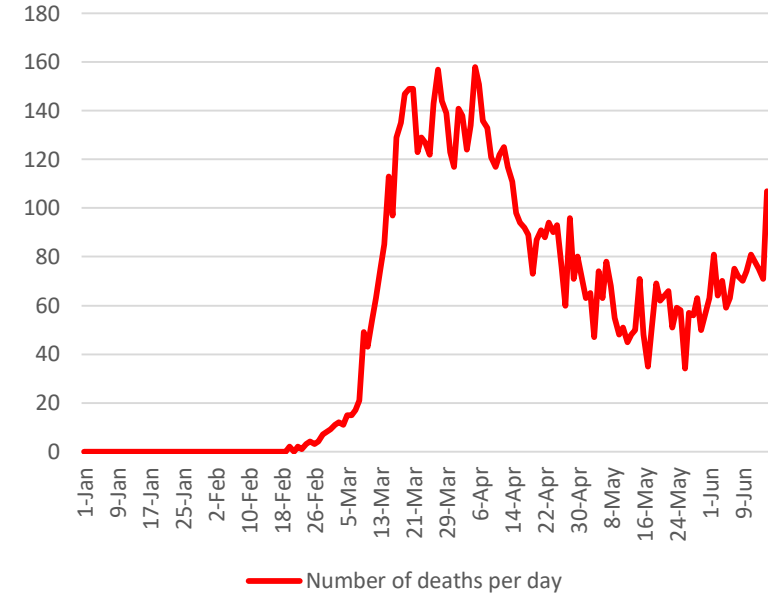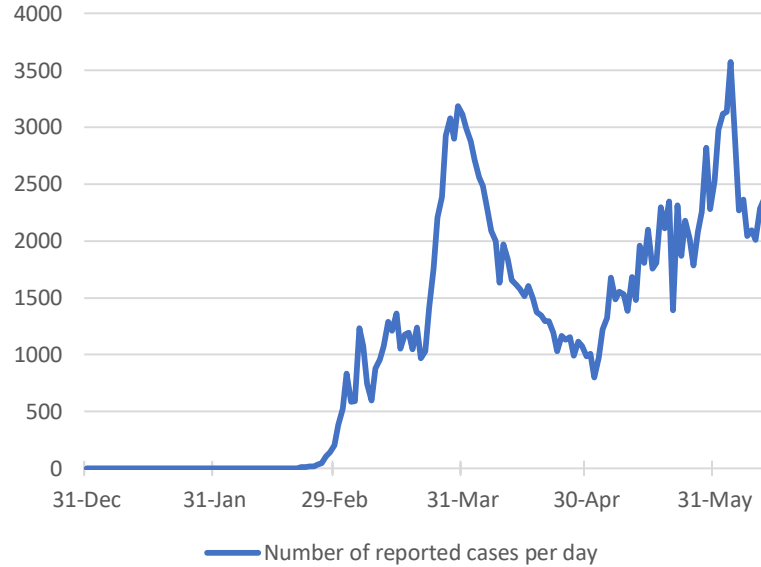
- US Cases (up to June 14)

Overall deaths =
115,271/2,063,812 = **5.58%**

Source:
US CDC

New reported cases by day in the United States

30,000 cases

New cases

7-day average

20,000

10,000

0

March April May June
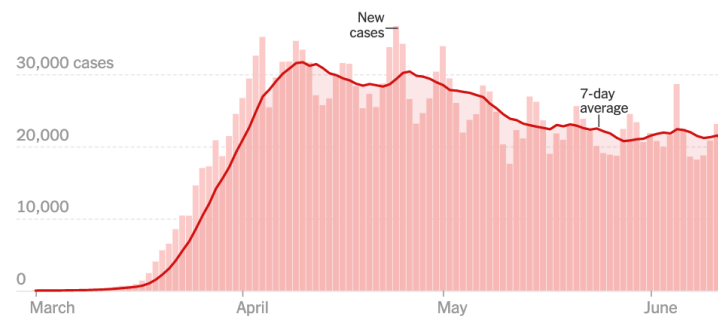
New reported deaths by day in the United States

New deaths

2,000 deaths

7-day average

1,000

0

March April May June
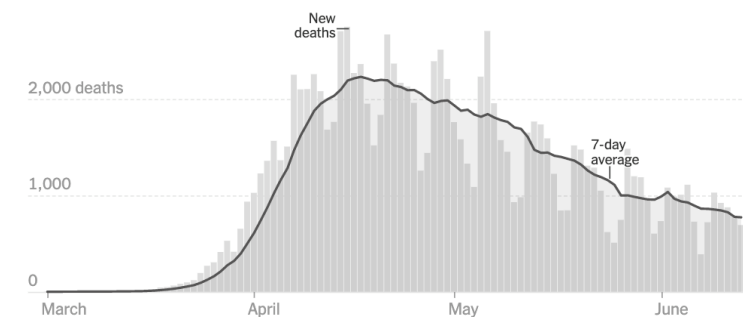
By The New York Times   Updated June 14, 2020, 10:37 A.M. E.T.

Testing for SARS-CoV-2 in Iran

Iran; Daily New Tests
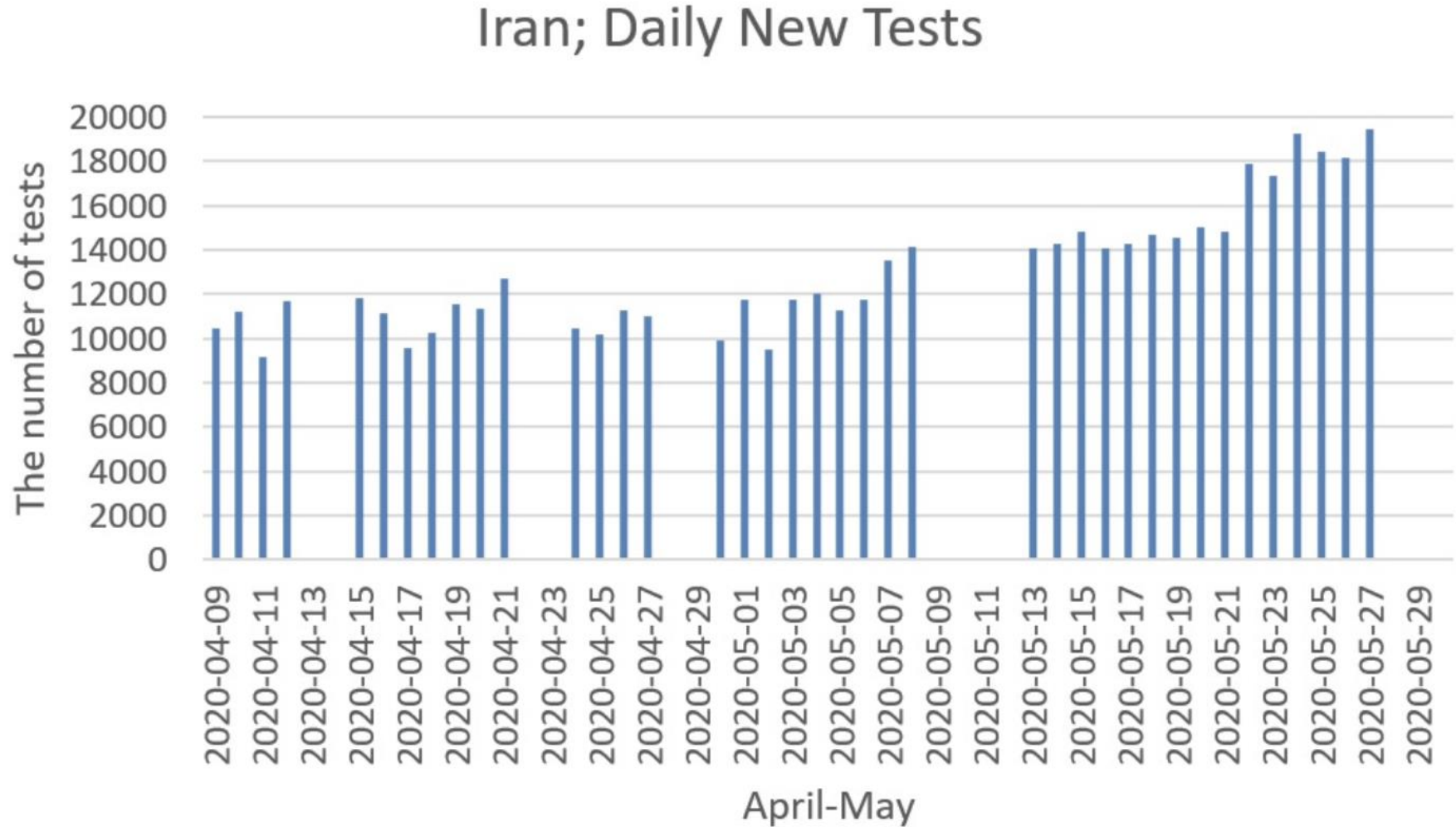
Model Inputs / Parameters

- ## Severity-Mortality

Severity/Mortality by Age Category:

- Vital Surveillances: The Epidemiological Characteristics of an Outbreak of 2019 Novel Coronavirus Diseases (COVID-19) — China, 2020
- Adjusted Age-Specific Case Fatality Ratio During The COVID-19 Epidemic In Hubei, China, January And February 2020

age_category	Our Value		Original V.	
	Fatality rate (%) * Normalized	Proportion of all infections that lead to hospitalisation) (%)	Fatality rate (%)	Proportion of all infections that lead to hospitalisation) (%)
0-5 y.o.	0.16	0.02	0.0016	0
5-10 y.o.	0.19	0.01	0.0016	0
10-15 y.o.	0.13	0.01	0.007	0.04
15-20 y.o.	0.11	0.07	0.007	0.04
20-25 y.o.	0.09	0.07	0.031	1.1
25-30 y.o.	0.07	0.06	0.031	1.1
30-35 y.o.	0.08	0.10	0.26	0.084
35-40 y.o.	0.10	0.16	0.26	0.084
40-45 y.o.	0.14	0.33	0.48	0.16
45-50 y.o.	0.18	0.45	0.48	0.16
50-55 y.o.	0.24	0.58	0.6	8.2
55-60 y.o.	0.33	0.71	0.6	8.2
60-65 y.o.	0.38	0.84	1.9	11.8
65-70 y.o.	0.48	1.00	1.9	11.8
70-75 y.o.	0.57	1.16	4.3	16.6
75-80 y.o.	0.67	1.19	4.3	16.6
80-85 y.o.	0.78	1.22	7.8	18.4
85-90 y.o.	0.80	1.25	7.8	18.4
90-95 y.o.	1.00	1.28	7.8	18.4
95-100 y.o.	1.00	1.31	7.8	18.4
100+ y.o.	1.00	1.34	7.8	18.4

* Normalized

Normalized Fatality Rate

— Iran (HFR) — Original

Infection Hospitalization Rate

■ Iran ■ Original
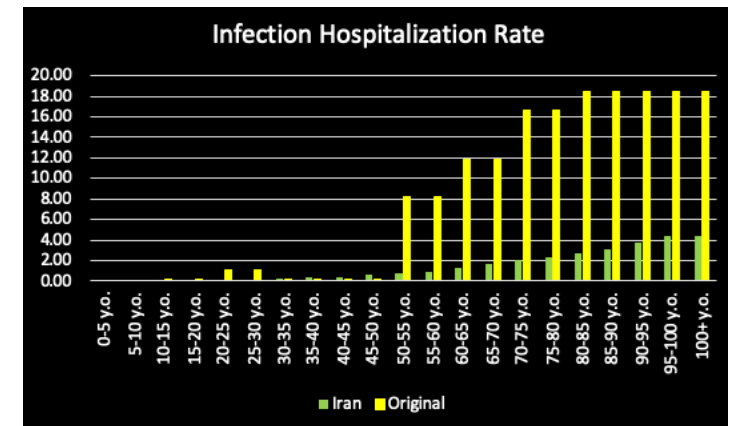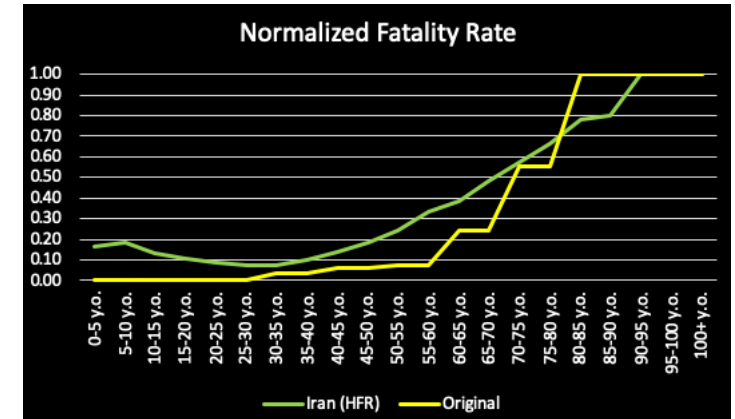
MOH COVID19 data (up to May 15,2020)
Seroprevalence – Sys. Review: 16%

Model Inputs / Parameters

• Population

Age - Cumm %
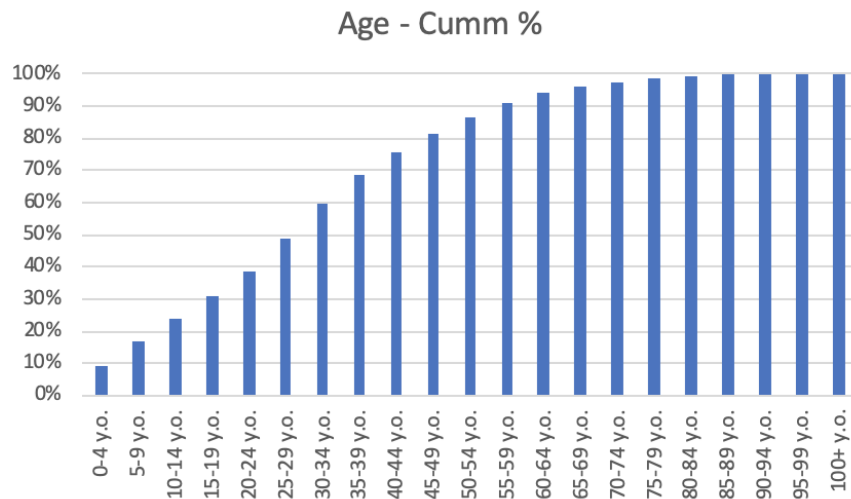
Source:
Statistical Centre of Iran
Population projected to 2019

Age category	Population	Number of births per person per day	Deaths per person per day
0-4 y.o.	7365780	0.000000	0.000062
5-9 y.o.	6657836	0.000000	0.000003
10-14 y.o.	5907143	0.000000	0.000003
15-19 y.o.	5668934	0.000050	0.000007
20-24 y.o.	6638730	0.000138	0.000013
25-29 y.o.	8516525	0.000162	0.000013
30-34 y.o.	8931679	0.000134	0.000015
35-39 y.o.	7308243	0.000080	0.000014
40-44 y.o.	5730525	0.000023	0.000016
45-49 y.o.	5018991	0.000023	0.000024
50-54 y.o.	4076952	0.000000	0.000037
55-59 y.o.	3479447	0.000000	0.000046
60-64 y.o.	2640353	0.000000	0.000068
65-69 y.o.	1777282	0.000000	0.000090
70-74 y.o.	1222913	0.000000	0.000125
75-79 y.o.	920480	0.000000	0.000187
80-84 y.o.	671604	0.000000	0.000190
85-89 y.o.	324501	0.000000	0.000121
90-94 y.o.	115866	0.000000	0.000043
95-99 y.o.	19395	0.000000	0.000009
100+ y.o.	6821	0.000000	0.000009
	83,000,000		

Model Inputs / Parameters

- Parameters

Label	Value Date	Original Value	Unit	Our Value
Date range of simulation / Start	1/1/20			12/22/19
Date range of simulation / End	09/1/20			09/30/20
Probability of infection given contact		0.049		0.043
Percentage of all asymptomatic infections that are reported		2.5	%	0
Percentage of all symptomatic infections that are reported		5	%	1.4
Percentage of all hospitalisations that are reported		100	%	70

Model Inputs / Parameters

- Country Area Parameters

Label	Value_Country	Value	Unit
Social Contacts Data	Iran (Islamic Republic of)		
Mean Household size		3.3	Individuals
Mean number of infectious migrants per day		0	Individuals

Source:
Social Contacts Data: Prem K et al PLOS Computational Biology 2017)
Mean Household: Statistical Centre of Iran Population project 2019

Iran - contact rates matrix (all locations = home + work + school + other)
Contact rate = the number of other people that a person encounters per day

	Age group of individual															
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	2.13	1.15	0.62	0.40	0.74	1.22	1.33	1.02	0.54	0.29	0.31	0.24	0.14	0.09	0.05	0.04
10	0.98	7.76	1.49	0.47	0.35	0.87	1.15	1.10	0.83	0.34	0.21	0.18	0.13	0.08	0.04	0.03
15	0.41	2.41	9.42	1.18	0.58	0.56	0.68	0.90	0.95	0.51	0.25	0.12	0.07	0.07	0.05	0.04
20	0.25	0.62	3.88	13.57	2.14	1.08	0.68	0.86	0.95	0.83	0.41	0.16	0.08	0.05	0.03	0.02
25	0.54	0.44	0.57	4.25	7.10	2.91	1.47	0.96	0.82	1.00	0.63	0.34	0.11	0.05	0.05	0.04
30	1.16	0.67	0.34	1.28	3.52	5.04	2.29	1.32	0.91	0.74	0.71	0.39	0.16	0.06	0.03	0.02
35	1.08	1.52	1.07	0.64	1.33	2.23	2.86	1.62	1.00	0.62	0.52	0.38	0.19	0.07	0.04	0.03
40	0.84	1.39	1.14	0.71	0.72	1.32	1.54	2.10	1.23	0.64	0.41	0.25	0.18	0.10	0.05	0.02
45	0.51	0.94	1.15	1.19	0.79	0.93	1.13	1.16	1.53	0.75	0.46	0.17	0.13	0.08	0.05	0.02
50	0.29	0.64	0.73	1.32	0.70	0.69	0.71	0.74	0.73	0.87	0.46	0.19	0.08	0.04	0.04	0.04
55	0.33	0.63	0.83	1.03	0.84	0.96	0.70	0.57	0.67	0.67	0.69	0.35	0.12	0.05	0.03	0.04
60	0.53	0.73	0.56	0.69	0.58	0.91	0.81	0.53	0.49	0.40	0.47	0.53	0.21	0.09	0.04	0.03
65	0.43	0.45	0.30	0.39	0.33	0.49	0.52	0.50	0.34	0.24	0.23	0.27	0.30	0.13	0.05	0.02
70	0.26	0.42	0.34	0.18	0.23	0.31	0.41	0.39	0.31	0.15	0.15	0.18	0.16	0.26	0.08	0.03
75	0.13	0.38	0.35	0.32	0.13	0.24	0.21	0.34	0.34	0.25	0.19	0.14	0.17	0.16	0.21	0.09
80	0.23	0.32	0.48	0.40	0.14	0.15	0.21	0.29	0.30	0.29	0.28	0.14	0.08	0.12	0.09	0.13

Age group of contact (row labels)

RED color intensities indicate more likely events

Prem K et al PLOS Computational Biology 2017)

Iran - contact rates matrix
home, school, work, other

Home

Age group of contact \ Age group of individual	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	0.5	0.6	0.4	0.2	0.3	0.5	0.6	0.5	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0
10	0.4	0.8	0.5	0.2	0.1	0.3	0.5	0.5	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0
15	0.2	0.5	1.2	0.4	0.1	0.1	0.2	0.4	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
20	0.1	0.2	0.6	1.1	0.3	0.1	0.1	0.2	0.4	0.4	0.2	0.1	0.0	0.0	0.0	0.0
25	0.3	0.2	0.2	0.6	1.2	0.4	0.1	0.1	0.2	0.4	0.3	0.1	0.0	0.0	0.0	0.0
30	0.8	0.3	0.1	0.2	0.5	1.1	0.3	0.1	0.0	0.1	0.3	0.2	0.1	0.0	0.0	0.0
35	0.8	0.9	0.5	0.1	0.1	0.4	0.8	0.3	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0
40	0.6	0.9	0.8	0.3	0.1	0.1	0.2	0.7	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0
45	0.4	0.7	0.8	0.5	0.2	0.1	0.1	0.2	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
50	0.2	0.4	0.5	0.6	0.3	0.1	0.0	0.1	0.1	0.4	0.1	0.0	0.0	0.0	0.0	0.0
55	0.3	0.2	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.3	0.1	0.0	0.0	0.0	0.0
60	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.2	0.3	0.1	0.0	0.0	0.0	0.0
65	0.4	0.4	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.0
70	0.2	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.1	0.2	0.0	0.0
75	0.1	0.4	0.3	0.2	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0
80	0.2	0.3	0.4	0.4	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.0	0.1	0.1	0.1

School

Age group of contact \ Age group of individual	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.1	5.0	0.2	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	1.0	5.0	0.2	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	1.8	7.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.2	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.1	0.1	0.4	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0
50	0.1	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
60	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

All locations

Age group of contact \ Age group of individual	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	2.1	1.1	0.6	0.4	0.7	1.2	1.3	1.0	0.5	0.3	0.3	0.2	0.1	0.1	0.1	0.0
10	1.0	7.8	1.5	0.5	0.3	0.9	1.1	1.1	0.8	0.3	0.2	0.2	0.1	0.1	0.0	0.0
15	0.4	2.4	9.4	1.2	0.6	0.6	0.7	0.9	0.6	0.3	0.1	0.1	0.1	0.0	0.0	0.0
20	0.3	0.6	3.9	13.6	2.1	1.1	0.7	0.9	0.4	0.8	0.4	0.2	0.1	0.0	0.0	0.0
25	0.5	0.4	0.6	4.2	7.1	2.9	1.5	1.0	0.8	1.0	0.6	0.3	0.1	0.0	0.0	0.0
30	1.2	0.7	0.3	1.3	3.5	5.0	2.3	1.3	0.9	0.7	0.7	0.4	0.2	0.1	0.0	0.0
35	1.1	1.5	1.1	0.6	1.3	2.2	2.9	1.6	1.0	0.6	0.5	0.4	0.2	0.1	0.0	0.0
40	0.8	1.4	1.1	0.7	0.7	1.3	1.5	2.1	1.2	0.6	0.4	0.3	0.2	0.1	0.1	0.0
45	0.5	0.9	1.2	1.2	0.8	0.8	1.1	1.2	1.5	0.8	0.5	0.3	0.1	0.1	0.1	0.0
50	0.3	0.6	0.7	1.3	0.7	0.7	0.7	0.7	0.7	0.9	0.5	0.3	0.1	0.1	0.0	0.0
55	0.3	0.6	0.8	1.0	0.8	1.0	0.7	0.6	0.7	0.7	0.7	0.3	0.1	0.1	0.0	0.0
60	0.5	0.7	0.6	0.7	0.6	0.9	0.8	0.5	0.5	0.4	0.5	0.5	0.2	0.1	0.0	0.0
65	0.4	0.4	0.3	0.4	0.3	0.5	0.5	0.5	0.3	0.2	0.2	0.3	0.3	0.1	0.1	0.0
70	0.3	0.4	0.3	0.2	0.2	0.3	0.4	0.4	0.3	0.2	0.1	0.2	0.2	0.3	0.1	0.0
75	0.1	0.4	0.4	0.3	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.1	0.2	0.2	0.2	0.1
80	0.2	0.3	0.5	0.4	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1

Work

Age group of contact \ Age group of individual	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.2	0.4	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.1	0.3	0.6	0.4	0.4	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.1	0.2	0.4	0.5	0.4	0.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.1	0.2	0.4	0.4	0.5	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.4	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
55	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0
60	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Other

Age group of contact \ Age group of individual	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	1.3	0.5	0.3	0.2	0.5	0.7	0.7	0.5	0.3	0.2	0.2	0.2	0.1	0.1	0.0	0.0
10	0.6	2.0	0.7	0.2	0.2	0.5	0.5	0.5	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0
15	0.2	0.9	3.2	0.6	0.5	0.4	0.4	0.4	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0
20	0.1	0.3	1.5	5.3	1.6	0.8	0.4	0.4	0.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0
25	0.2	0.2	0.3	2.5	5.1	2.1	1.0	0.6	0.4	0.4	0.2	0.1	0.0	0.0	0.0	0.0
30	0.3	0.2	0.2	0.7	2.3	3.1	1.5	0.8	0.5	0.4	0.3	0.2	0.1	0.1	0.0	0.0
35	0.3	0.2	0.3	0.3	0.9	1.4	1.4	0.8	0.5	0.3	0.3	0.2	0.1	0.1	0.0	0.0
40	0.2	0.2	0.2	0.2	0.5	0.8	0.9	0.9	0.5	0.3	0.2	0.1	0.1	0.0	0.0	0.0
45	0.1	0.2	0.3	0.2	0.4	0.5	0.6	0.5	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0
50	0.0	0.1	0.1	0.1	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0
55	0.1	0.1	0.1	0.2	0.4	0.5	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
60	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0

RED color intensities indicate more likely events

Prem K et al PLOS Computational Biology 2017)

Model Inputs / Parameters

- Virus Parameters
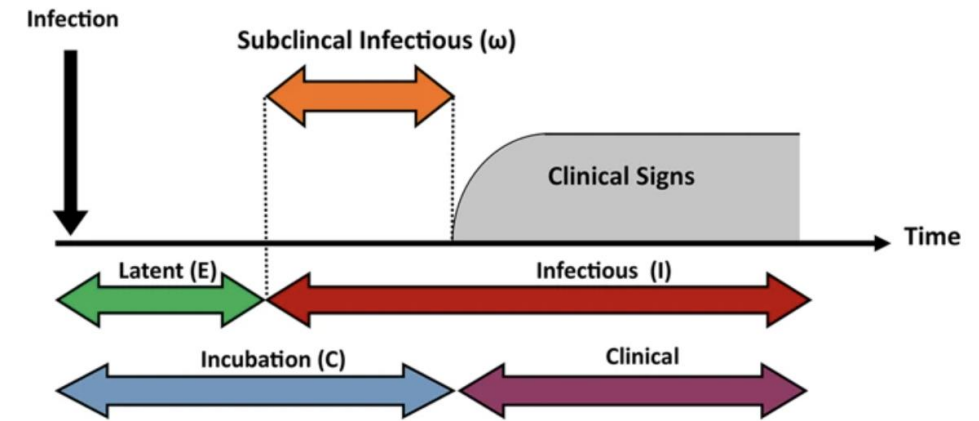
Label	Unit	Our Value	Source	Original V.
Relative infectiousness of incubation phase:	%	10	CoMo	10
Average incubation period:	Days	5.68	Sys. Rev.	3.5
Average duration of symptomatic infection period:	Days	4.5	CoMo	4.5
Month of peak infectivity of the virus:		Jan.	CoMo	Jan.
Annual variation in infectivity of the virus:	%	0	CoMo	0
Average duration of immunity:	Years	150	CoMo	150
Probability upon infection of developing clinical symptoms:	%	45	Gilan.IR	55
Probability upon hospitalisation of requiring ICU admission:	%	13	MOH.IR	50
Probability upon admission to the ICU of requiring a ventilator:	%	28	MOH.IR	75

Incubation Period
Average = 5.68 days
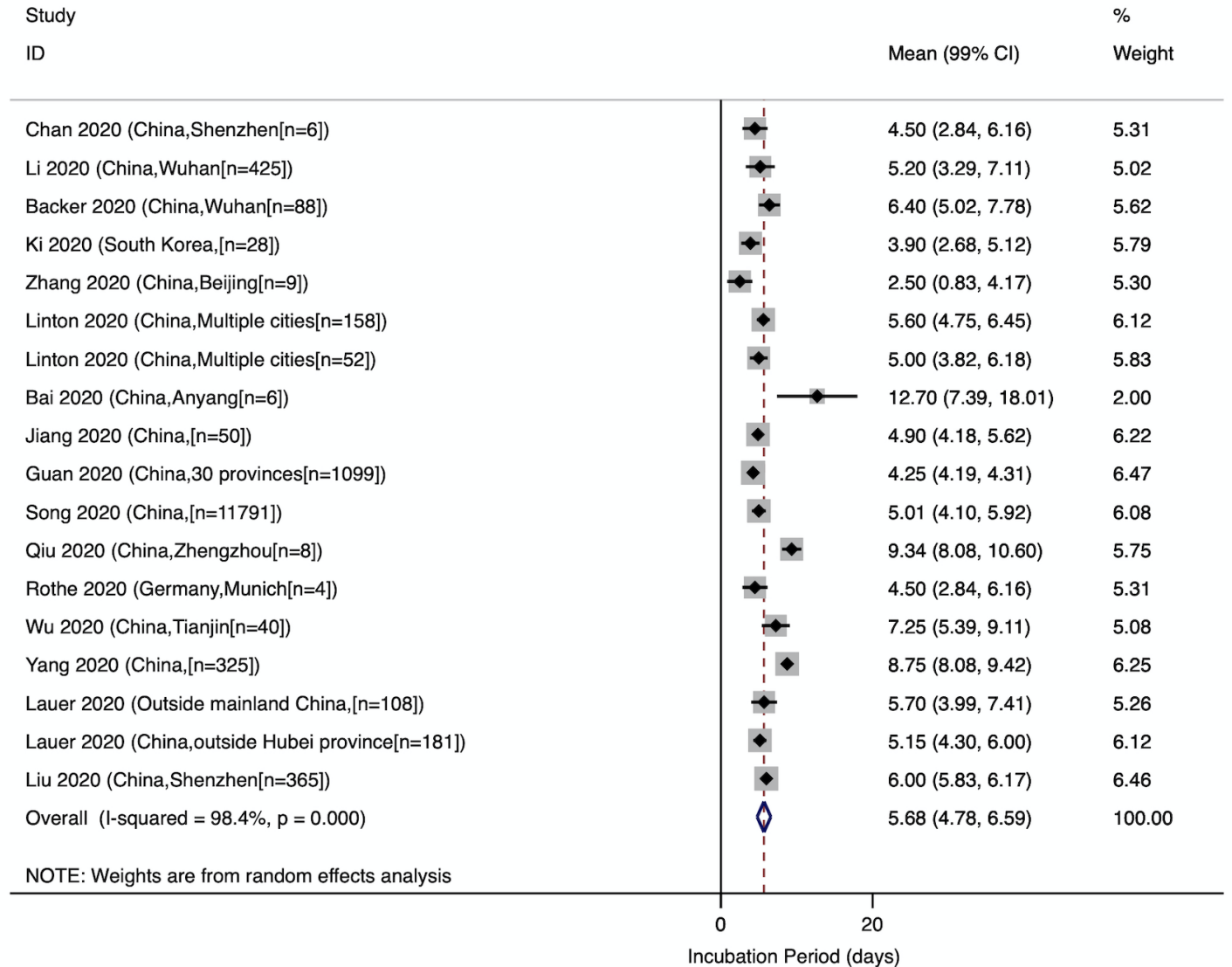
Malahat Khalili, et al. Epidemiology
and Infection (Accepted)

Study ID	Mean (99% CI)	% Weight
Chan 2020 (China,Shenzhen[n=6])	4.50 (2.84, 6.16)	5.31
Li 2020 (China,Wuhan[n=425])	5.20 (3.29, 7.11)	5.02
Backer 2020 (China,Wuhan[n=88])	6.40 (5.02, 7.78)	5.62
Ki 2020 (South Korea,[n=28])	3.90 (2.68, 5.12)	5.79
Zhang 2020 (China,Beijing[n=9])	2.50 (0.83, 4.17)	5.30
Linton 2020 (China,Multiple cities[n=158])	5.60 (4.75, 6.45)	6.12
Linton 2020 (China,Multiple cities[n=52])	5.00 (3.82, 6.18)	5.83
Bai 2020 (China,Anyang[n=6])	12.70 (7.39, 18.01)	2.00
Jiang 2020 (China,[n=50])	4.90 (4.18, 5.62)	6.22
Guan 2020 (China,30 provinces[n=1099])	4.25 (4.19, 4.31)	6.47
Song 2020 (China,[n=11791])	5.01 (4.10, 5.92)	6.08
Qiu 2020 (China,Zhengzhou[n=8])	9.34 (8.08, 10.60)	5.75
Rothe 2020 (Germany,Munich[n=4])	4.50 (2.84, 6.16)	5.31
Wu 2020 (China,Tianjin[n=40])	7.25 (5.39, 9.11)	5.08
Yang 2020 (China,[n=325])	8.75 (8.08, 9.42)	6.25
Lauer 2020 (Outside mainland China,[n=108])	5.70 (3.99, 7.41)	5.26
Lauer 2020 (China,outside Hubei province[n=181])	5.15 (4.30, 6.00)	6.12
Liu 2020 (China,Shenzhen[n=365])	6.00 (5.83, 6.17)	6.46
Overall (I-squared = 98.4%, p = 0.000)	5.68 (4.78, 6.59)	100.00

NOTE: Weights are from random effects analysis

Incubation Period (days)

Model Inputs / Parameters

- Hospitalization Parameters

Label	Unit	Our Value	Source	Original V.
Maximum number of hospital beds	Beds	100,437	MOH.lr	160,000
Maximum number of ICU beds	Beds	5,790	MOH.lr	8,000
Maximum number of ventilators	Ventilators	4,650	MOH.lr	8,000
Relative percentage of regular daily contacts when hospitalised	%	30	Exp. Opi	15
Probability of dying when hospitalized (oldest age class)	%	42	MOH.lr	35
Probability of dying when denied hospitalization (oldest age class)	%	45	CoMo	45
Probability of dying when admitted to ICU (oldest age class)	%	60	MOH.lr	55
Probability of dying when admission to ICU denied (oldest age class)	%	80	CoMo	80
Probability of dying when ventilated (oldest age class)	%	86	MOH.lr	80
Probability of dying when ventilator denied (oldest age class)	%	95	CoMo	95
Duration of hospitalised infection	Days	4	MOH.lr	3
Duration of ICU infection	Days	5	MOH.lr	3
Duration of ventilated infection	Days	3	MOH.lr	3

Non-pharmaceutical interventions	Start date	Duration	Coverage	Adherence	Efficacy	Home contacts inflation	Out-home contacts deflation
Lockdown, Mid	3/20/20 (۱ فروردین)	5w					
Self-Isolation if Symptomatic	2/24/20 (۵ اسفند)	32w (۱۹ مهر)	90%	80%	---	---	---
Screening/Contact-Tracing (Overdisp.=2, Contacts = 4)	2/24/20 (۵ اسفند)	32w (۱۹ مهر)	75%	---	---	---	---
Social Distancing	2/25/20 (۶ اسفند)	8w (۲ اردیبهشت)	40%	50%	---	---	---
Handwashing	2/20/20 (۱ اسفند)	45w (۳۰ بهمن)	---	---	5%	---	---
Working at Home	2/26/20 (۷ اسفند)	8w (۶ خرداد)	60%	---	50%	10%	---
School Closures	2/25/20 (۶ اسفند)	28w (۱۷ شهریور)	---	---	85%	20%	---
Shielding the Elderly (age = 60+)	2/26/20 (۷ اسفند)	10w (۱۷ اردیبهشت)	80%	---	82%	---	---
Travel Ban	2/29/20 (۱۰ اسفند)	8w (۶ اردیبهشت)	---	---	50%	---	---
Voluntary home quarantine (Avr. Days = 14, Days with Max Coverage = 2)	2/24/20 (۵ اسفند)	32w (۱۹ مهر)	50%	---	---	20%	60%

Persian New Year Effect

- Mid Lockdown
- 20 March (5 weeks)

Choose One Lockdown:

	Low	Medium	High
Self-isolation coverage	50	75	95
Social distancing coverage	25	75	95
Hand hygiene coverage	5	5	5
Work from home coverage	25	50	75
School closure efficacy	0	85	85
Cocoon coverage	90	90	90
Travel ban efficacy	0	0	95
Quarantine coverage	0	25	90

🔒 Mid Lockdown

Start Date:

2020-03-20

Duration of Lockdown:

5 weeks   52 weeks

Non-pharmaceutical interventions

Timeline

Range of simulation	*2019-12-22 to 2020-09-30*
Working at Home	*2020-02-26 to 2020-04-22*
Travel Ban	*2020-02-29 to 2020-04-25*
Social Distancing	*2020-02-25 to 2020-04-21*
Shielding the Elderly	*2020-02-26 to 2020-05-06*
Self Isolation if Symptomatic	*2020-02-24 to 2020-10-05*
School Closures	*2020-02-25 to 2020-09-08*
Quarantine	*2020-02-24 to 2020-10-05*
Mid Lockdown	*2020-03-20 to 2020-04-24*
Handwashing	*2020-02-20 to 2020-12-31*

Today: 2020-06-15

Jan 2020   Apr 2020   Jul 2020   Oct 2020   Jan 2021

Model calibration

- % Asymptomatic reported: 2.5% -> 0%
- % Symptomatic reported = 1.4%
  - 83 million
  - 16% seroprevalence
  - 45% developing symptoms
  - Reported cases minus hospitalization: 186,476 – 85,358 = 101,118
- Epi. start date : 25 Dec -> 22 Dec [~2 months before the first case reported]
- Hospitalization that reported: 70%
- Probability of infection given contact = 0.043 -> 0.042

Baseline Visual Fit

Date range of simulation:

2019-12-22 to 2020-09-30

⚙ Country

⚙ Virus

⚙ Hospital

Probability of infection given contact:

0 | 0.042 | 0.2

Percentage of all asymptomatic infections that are reported:

0% | 100%

Percentage of all symptomatic infections that are reported:

1.3% | 100%

Percentage of all hospitalisations that are reported:

0% | 70% | 100%

Available:

🔒 Lockdown ⚙▾

Self-isolation if Symptomatic ⚙▾

Social Distancing ⚙▾

✋ Handwashing ⚙▾

Working at Home ⚙▾

🏫 School Closures ⚙▾

Shielding the Elderly ⚙▾

✈ Travel Ban ⚙▾

Voluntary home quarantine ⚙▴

Not Yet Available:

💉 Vaccination

Selected Inputs: Cases/Deaths: -- Own Value --- , demographics: -- Own Value --- , social contacts: Iran (Islamic Republic of)

Run Baseline | 👍 Validate Baseline

Focus on:
○ Observed ● Predicted Reported ○ Predicted Reported + Unreported

18,185
Covid-19 **attributable** deaths during the range of simulation.

3.7 days
to double the number of infections at inception.

18,209
Covid-19 **reported** deaths during the range of simulation.

Baseline Cases

Baseline Cumulative Deaths
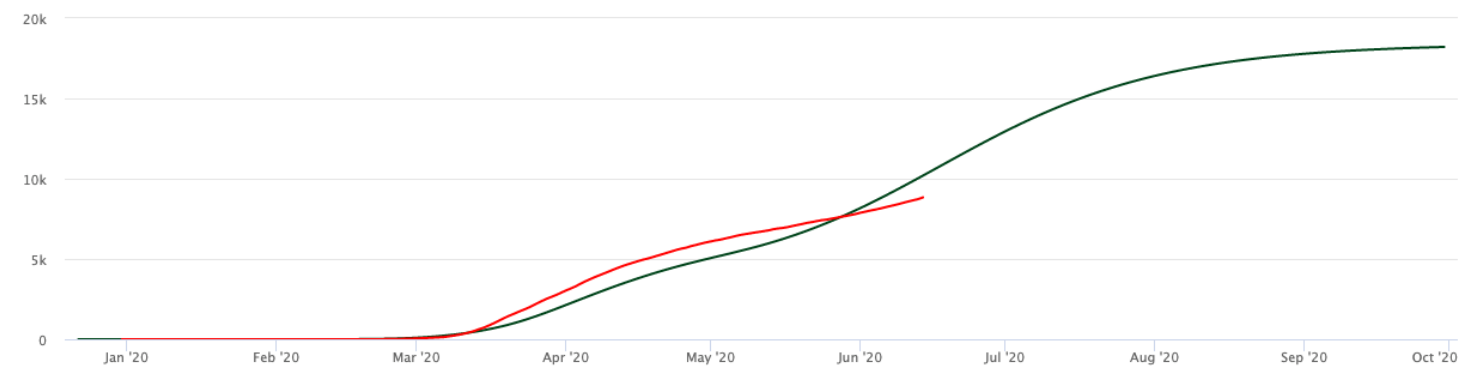
Baseline

55.2%
of the population infected during the range of simulation.

18,185
Covid-19 **attributable** deaths during the range of simulation.

18,209
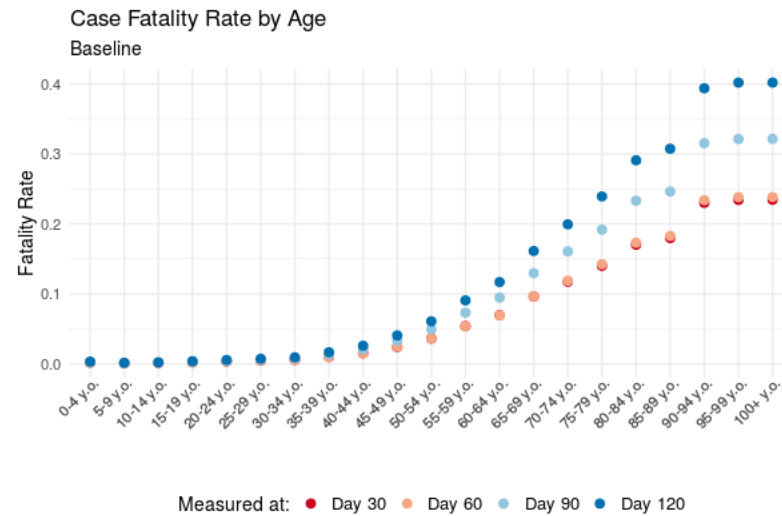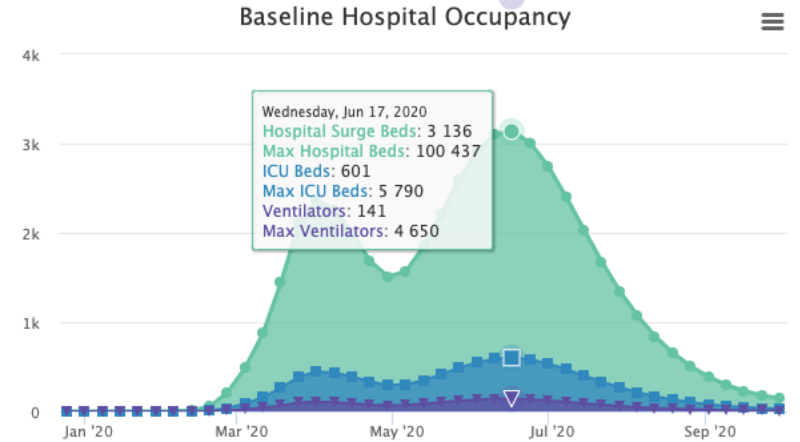Covid-19 **reported** deaths during the range of simulation.

Baseline Cases

Wednesday, Jun 10, 2020
Reported: 3 721
Reported + Unreported: 432 689
Observed: 2 011
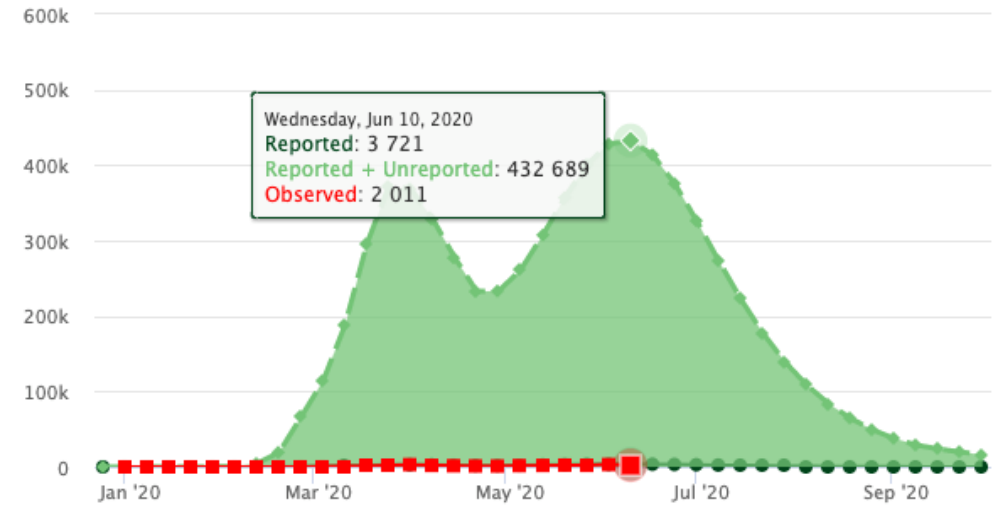
Focus on:
○ No Focus   ● COVID-19 Deaths

Baseline Cumulative Deaths

Wednesday, Sep 30, 2020
Natural Death, Non Exposed: 482 283 deaths
Natural Death, Exposed: 183 600 deaths
Death Treated ICU no Ventilator: 2 216 deaths
Death Treated ICU and Ventilator: 1 236 deaths
Death Treated Hospital: 10 111 deaths
Death Untreated Hospital: 4 621 deaths
Death Untreated ICU no Ventilator: 0 deaths
Death Untreated ICU and Ventilator: 0 deaths
Total COVID-19 Death: 18 184 deaths

Baseline

Proportion of Covid-19 Deaths per Age Category
Baseline

Legend: ≥ 70 y.o., 60-70 y.o., 50-60 y.o., 40-50 y.o., 30-40 y.o., ≤ 30 y.o.

Baseline Hospital Occupancy

Wednesday, Jun 17, 2020
Hospital Surge Beds: 3 136
Max Hospital Beds: 100 437
ICU Beds: 601
Max ICU Beds: 5 790
Ventilators: 141
Max Ventilators: 4 650

Case Fatality Rate by Age
Baseline

Measured at: Day 30, Day 60, Day 90, Day 120

Baseline Rt

Counterfactual Scenarios

Interventions	Baseline	Scenario 1	Scenario 2
lockdown	Med. 20March-24April	X	X
Self-isolation if symptomatic	✓	✓	
Coverage	90%	90%	
Adherence	80%	80%	X
Duration of intervention	24Feb-5Oct	24Feb-5Oct	
Additional to self-isolation: Screening	✓	✓	
Coverage	75%	75%	X
Duration of intervention	24Feb-5Oct	24Feb-5Oct	
Social Distancing	✓	✓	
Coverage	50%	50%	
Adherence	50%	50%	X
Duration of intervention	25Feb-21April	25Feb-21April	
Handwashing	✓	✓	✓
Efficacy	5%	5%	5%
Duration of intervention	20Feb-31Dec	20Feb-31Dec	20Feb-31Dec
Working at home (Home C. infl. 10%)	✓		
Coverage	60%		
Efficacy	50%	X	X
Duration of intervention	26Feb-22April		
School Closure (Home C. infl. 20%)	✓		
Efficacy	85%	X	X
Duration of intervention	25Feb-8Sep		
Shielding the Elderly	✓	✓	
Coverage	80%	80%	
Efficacy	82%	82%	X
Duration of intervention	26Feb-6Jun	26Feb-6Jun	
Voluntary quarantine (Home C. infl. 20%, Other C. Dec. 60%)	✓	✓	
Coverage	50%	50%	
Days in isolation	14	14	X
Duration of intervention	24Feb-5Oct	24Feb-5Oct	
Travel Ban 50% (29Feb-25Apr)	✓	✓	X

Parameters for intervention scenarios included in the model

Baseline	**Scenario 1**	**Scenario 2**

55.2%	**67.4%** (12.2%)	**87.6%** (32.4%)
of the population infected during the range of simulation.	of the population infected during the range of simulation.	of the population infected during the range of simulation.
18,184	**19,415** (1,230)	**32,650** (14,465)
Covid-19 **attributable** deaths during the range of simulation.	Covid-19 **attributable** deaths during the range of simulation.	Covid-19 **attributable** deaths during the range of simulation.
18,208	**19,445** (1,236)	**32,705** (14,496)
Covid-19 **reported** deaths during the range of simulation.	Covid-19 **reported** deaths during the range of simulation.	Covid-19 **reported** deaths during the range of simulation.

◉ 👁 Display all days

You can either display only one data point per week i.e. Wednesday (Default) or display all days in the plots/tabole (Slower). le (Slower).
Either way, we display daily data.

Focus on:
○ Observed   ○ Predicted Reported   ● Predicted Reported + Unreported

Baseline Cases

Wednesday, Jun 10, 2020
Reported: 3 916
Reported + Unreported: 432 689
Observed: 2 011

Future Scenarios Cases

Wednesday, Apr 8, 2020
Reported: 10 183
Reported + Unreported: 1 252 466
Observed: 1 997

Future Scenarios Cases

Wednesday, Mar 25, 2020
Reported: 20 618
Reported + Unreported: 2 575 352
Observed: 2 206
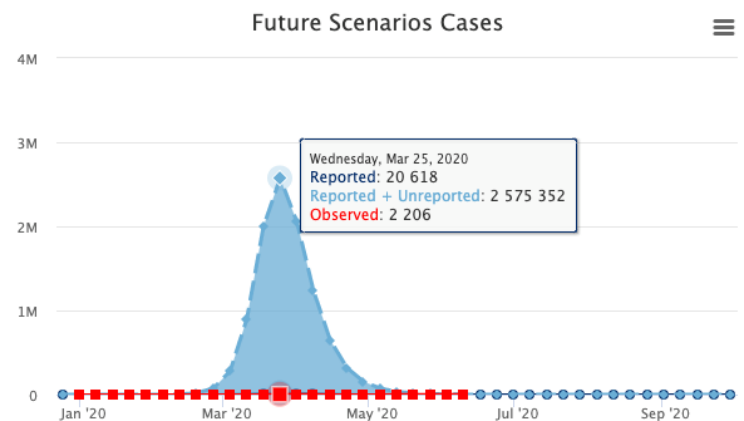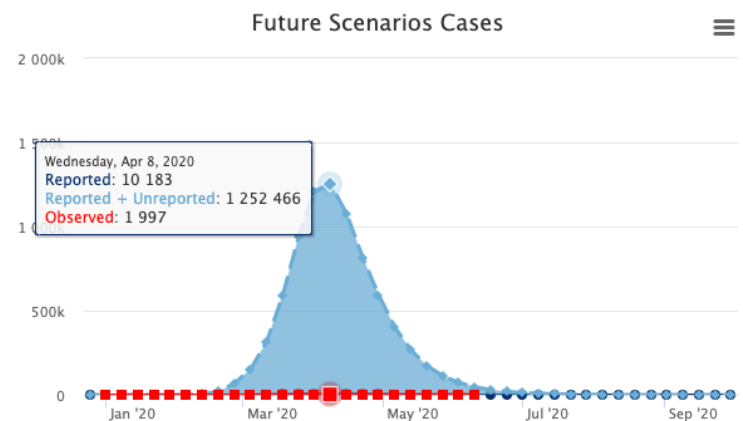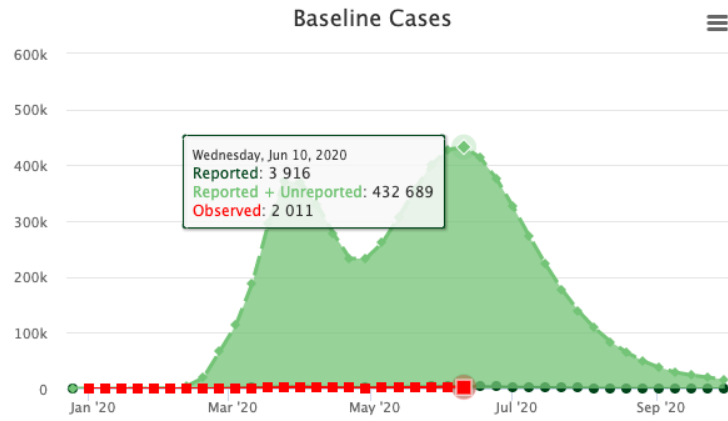
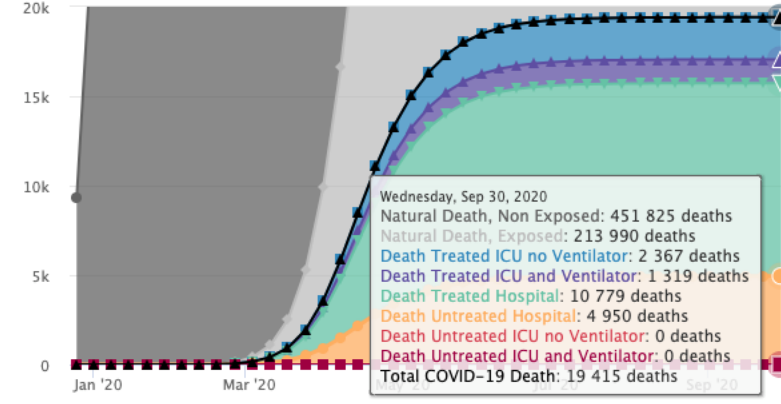**What if we had no "Lockdown", no "School closure" and no "Working at home"**

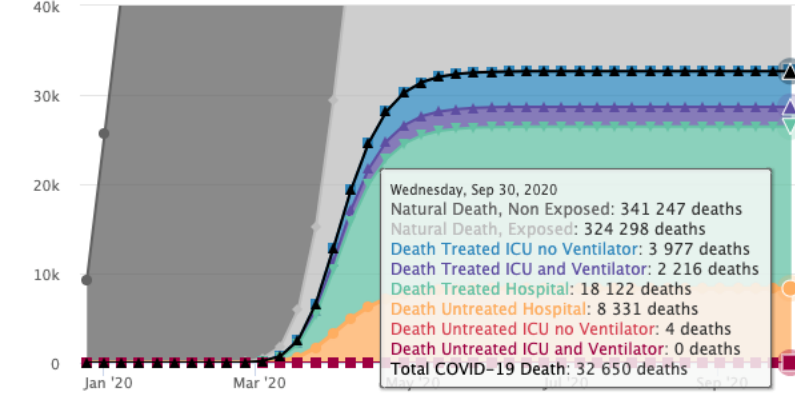**What if we had no intervention but "handwashing"**
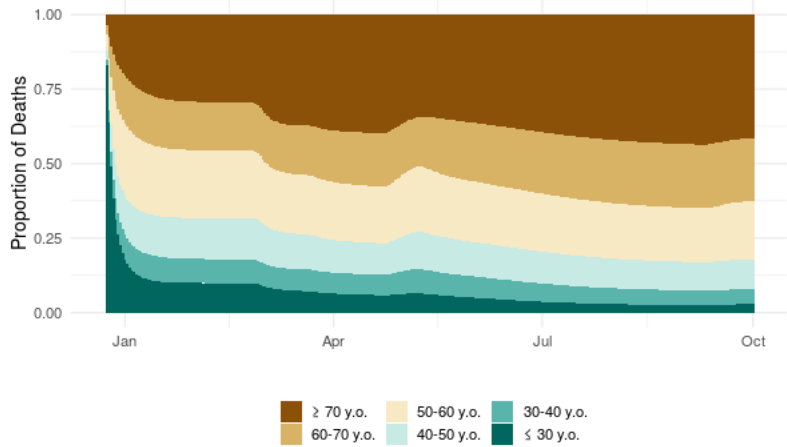
Baseline

Scenario 1

Scenario 2

Baseline Cumulative Deaths

Wednesday, Sep 30, 2020
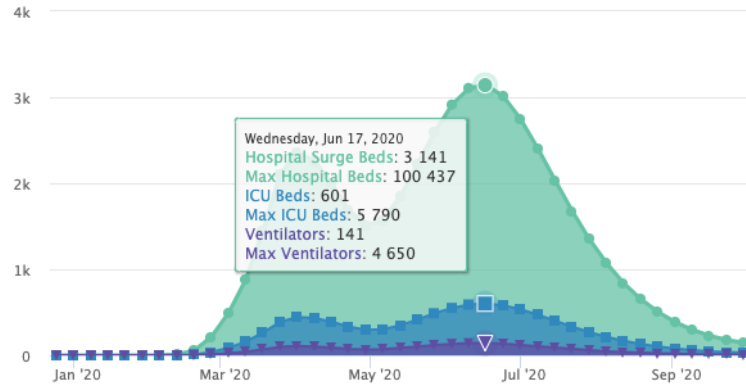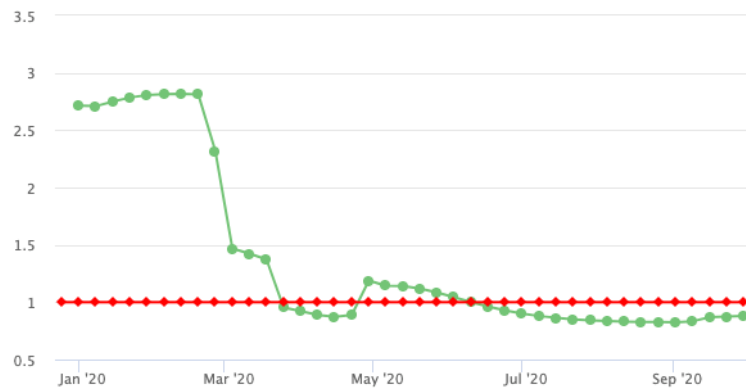Natural Death, Non Exposed: 482 283 deaths
Natural Death, Exposed: 183 600 deaths
Death Treated ICU no Ventilator: 2 216 deaths
Death Treated ICU and Ventilator: 1 236 deaths
Death Treated Hospital: 10 111 deaths
Death Untreated Hospital: 4 621 deaths
Death Untreated ICU no Ventilator: 0 deaths
Death Untreated ICU and Ventilator: 0 deaths
Total COVID-19 Death: 18 184 deaths

Future Scenarios Cumulative Deaths

Wednesday, Sep 30, 2020
Natural Death, Non Exposed: 451 825 deaths
Natural Death, Exposed: 213 990 deaths
Death Treated ICU no Ventilator: 2 367 deaths
Death Treated ICU and Ventilator: 1 319 deaths
Death Treated Hospital: 10 779 deaths
Death Untreated Hospital: 4 950 deaths
Death Untreated ICU no Ventilator: 0 deaths
Death Untreated ICU and Ventilator: 0 deaths
Total COVID-19 Death: 19 415 deaths

Future Scenarios Cumulative Deaths

Wednesday, Sep 30, 2020
Natural Death, Non Exposed: 341 247 deaths
Natural Death, Exposed: 324 298 deaths
Death Treated ICU no Ventilator: 3 977 deaths
Death Treated ICU and Ventilator: 2 216 deaths
Death Treated Hospital: 18 122 deaths
Death Untreated Hospital: 8 331 deaths
Death Untreated ICU no Ventilator: 4 deaths
Death Untreated ICU and Ventilator: 0 deaths
Total COVID-19 Death: 32 650 deaths

Proportion of Covid-19 Deaths per Age Category
Baseline

Proportion of Covid-19 Deaths per Age Category
Future Scenarios
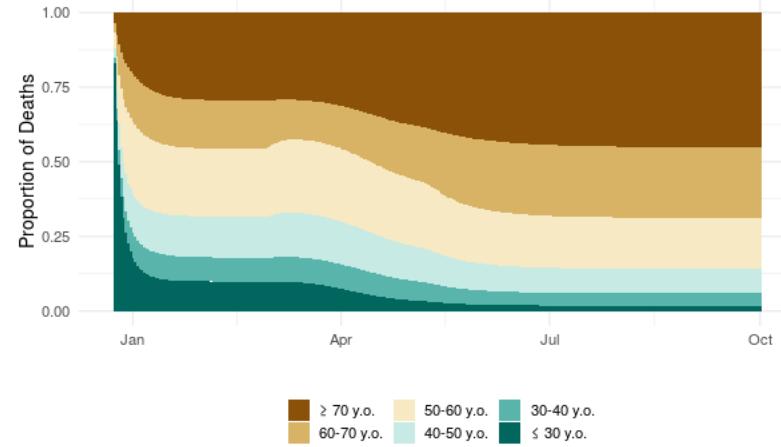
Proportion of Covid-19 Deaths per Age Category
Future Scenarios
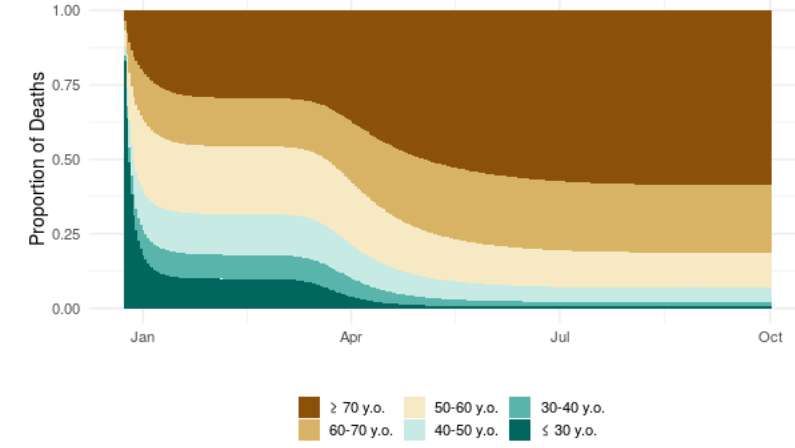
≥ 70 y.o.　50-60 y.o.　30-40 y.o.
60-70 y.o.　40-50 y.o.　≤ 30 y.o.

Baseline	Scenario 1	Scenario 2

● No Focus ○ Hospital Beds ○ ICU Beds ○ Ventilators

Baseline Hospital Occupancy

Wednesday, Jun 17, 2020
Hospital Surge Beds: 3 141
Max Hospital Beds: 100 437
ICU Beds: 601
Max ICU Beds: 5 790
Ventilators: 141
Max Ventilators: 4 650

Future Scenarios Hospital Occupancy

Wednesday, Apr 15, 2020
Hospital Surge Beds: 7 874
Max Hospital Beds: 100 437
ICU Beds: 1 503
Max ICU Beds: 5 790
Ventilators: 353
Max Ventilators: 4 650

Future Scenarios Hospital Occupancy

Wednesday, Apr 1, 2020
Hospital Surge Beds: 17 821
Max Hospital Beds: 100 437
ICU Beds: 3 338
Max ICU Beds: 5 790
Ventilators: 810
Max Ventilators: 4 650

Baseline Rt
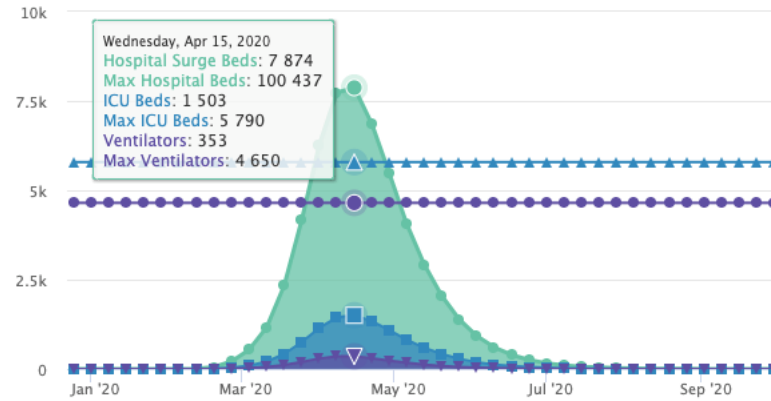
Future Scenarios Rt
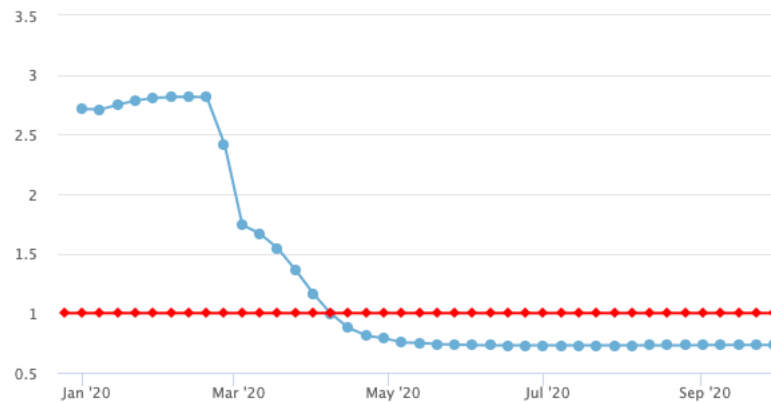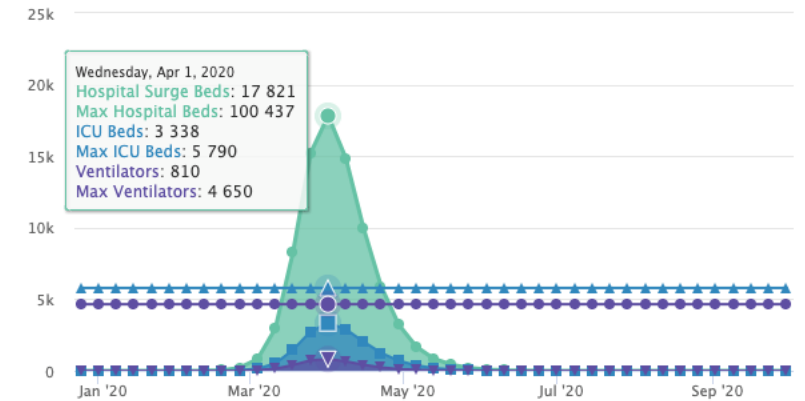
Future Scenarios Rt
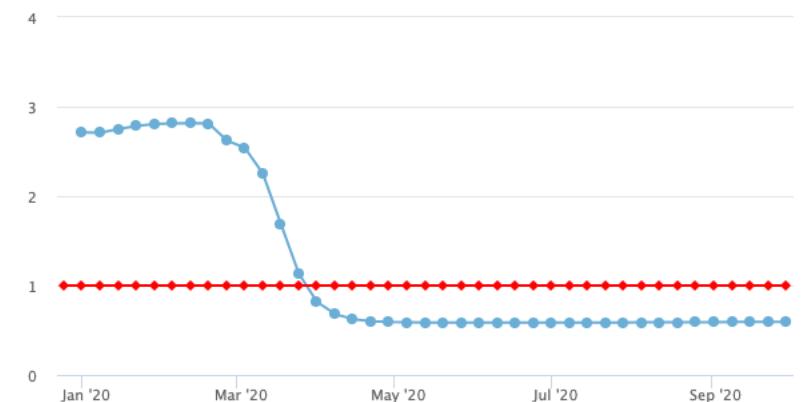
Main results

	Baseline	What if we had no "Lockdown", no "School closure" and no "Working at home" Scenario 1	What if we had no intervention but "handwashing" Scenario 2	Averted (Baseline vs. S2)
% Pop. Infected	55.20%	67.40%	87.60%	
COVID-19 Deaths	18,185 (63% in 60+ years)	19,415	32,650	14,465
IFR (%)	0.04%	0.03%	0.04%	
Total Infections	45,816,000	55,942,000	72,708,000	26,892,000

The infection fatality rate of COVID-19 inferred from seroprevalence data (Preprint – 8 June 2020)
John P.A. Ioannidis
https://doi.org/10.1101/2020.05.13.20101253

Infection fatality rates (IFR):
- Overall: 0.02% to 0.86% (**Median 0.25%**)
- Among people <70 years old: 0.01% to 0.23% (**Median 0.04%**)

The effect of large-scale anti-contagion policies on the COVID-19 pandemic

- Ongoing anti-contagion policies have already substantially reduced the number of COVID-19 infections observed in the world today. In Iran till 22 March, 2020:
  - **5 million** confirmed cases averted
  - **54 million** total infections averted
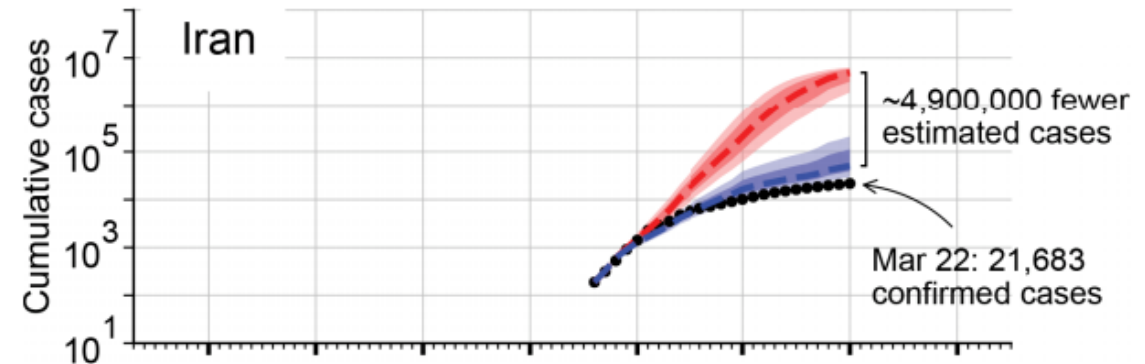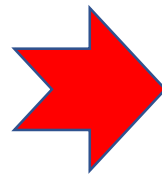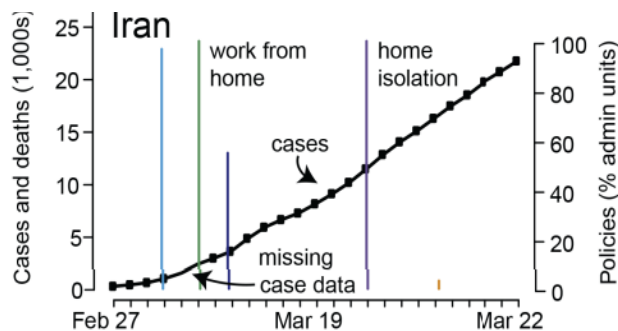
Baseline
(Simulation till first of June 2021)

21,244
Covid-19 **attributable** deaths during the range of simulation.

21,271
Covid-19 **reported** deaths during the range of simulation.

3.7 days
to double the number of infections at inception.

Saturday, Mar 28, 2020
Predicted Reported: 3 121
Predicted Reported + Unreported: 377 515
Observed: 3 076

Sunday, Jun 7, 2020
Predicted Reported: 3 718
Predicted Reported + Unreported: 433 681
Observed: 2 364

Tuesday, Mar 2, 2021
Predicted Reported: 309
Predicted Reported + Unreported: 34 753

Herd Immunity?

Baseline Rt

Baseline Cumulative Deaths
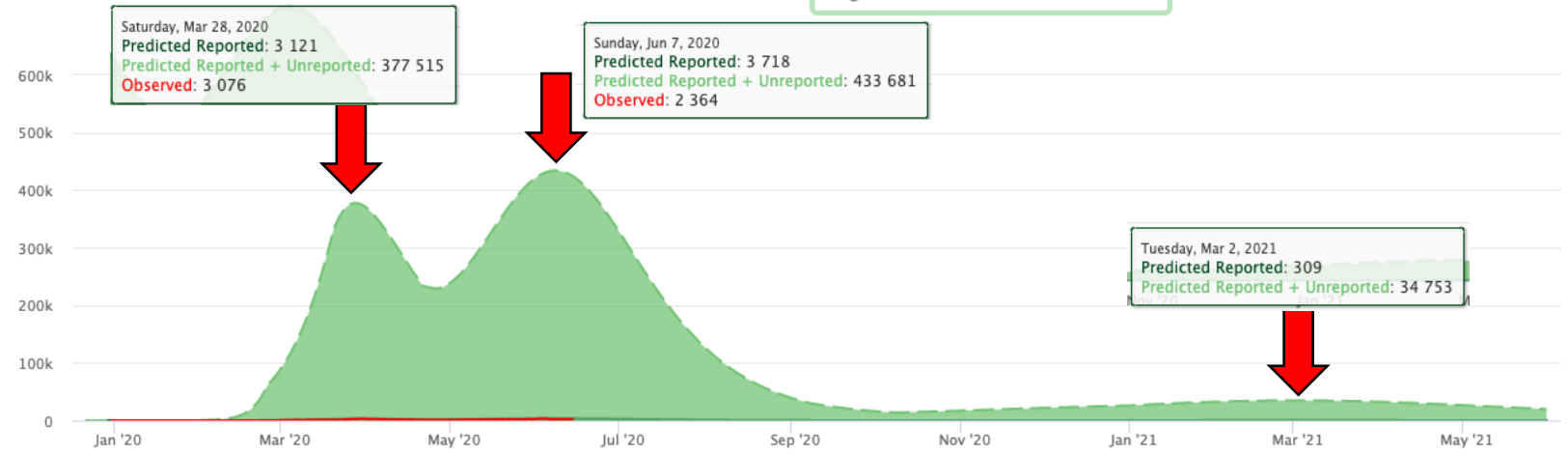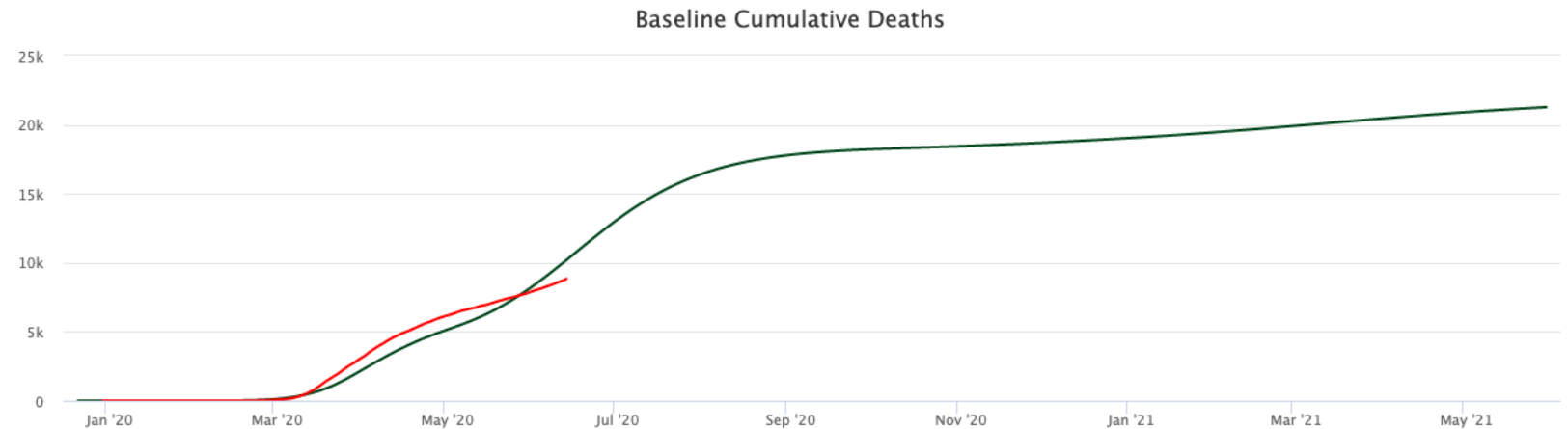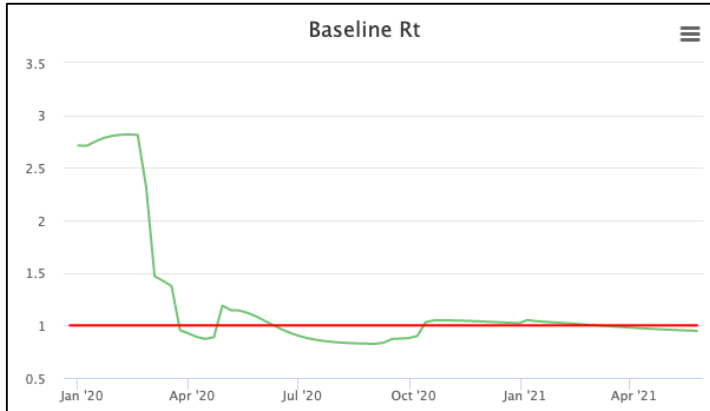
Uncertainties and assumptions

- COVID-19 is a novel disease – knowledge on transmission dynamics is still being discovered

- Models are therefore based on assumptions and unknown information about the disease.

- Model inputs and outputs will change as we learn more about the disease and the impact of interventions on the disease

- Uncertainty is even bigger if the epidemic is still at early stage in a country or population

- Options will change once better serology, treatments, vaccines become widely available

Conclusion

- Iran's non-pharmaceutical interventions strategy that started as early as Feb 24 might have prevented 28 million infections and about 15,000 deaths

- However the interventions were not long and rigid enough to prevent from the second and third wave of the epidemic.

- Slower and more gradual release of interventions is required to prevent future waves of the epidemic.

Thank you for listening ☺