



*Research article*

## **Model predictions and data fitting can effectively work in spreading COVID-19 pandemic**

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**Abstract:** Spreading COVID-19 pandemic has been considered as a global issue. Many international efforts including mathematical approaches have been recently discussed to control this disease more effectively. In this study, we have developed our previous SIUWR model and some transmission parameters are added. Accordingly, the basic reproduction number and elasticity coefficients are calculated at the equilibrium points. Then, some key critical model parameters are identified based on local sensitivities. In addition, the validation of the suggested model is checked by comparing some collected real data in Iraq and France from January 1<sup>st</sup>, 2021 to December 25<sup>th</sup>, 2021. Interestingly, there are good agreements between the model results and the real confirmed data using computational simulations in MATLAB. Results provide some biological interpretations and they can be used to control this pandemic more effectively. The model results will be used for both countries in minimizing the impact of this virus on their communities.

**Keywords:** mathematical modeling; COVID-19 pandemic; data fitting; elasticity and sensitivity analysis; computational simulations

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### **Appendices**

**Table 3.** The confirmed cases of the COVID-19 in France from January 1<sup>st</sup>, 2021 to December 3<sup>rd</sup>, 2021. The data are collected from the following source: <https://covid19.who.int/WHO-COVID-19-global-data.csv>

Date	Infected	Death	Date	Infected	Death
January 1, 2021	13186	250	February 1, 2021	22756	195
January 2, 2021	2711	133	February 2, 2021	20040	453
January 3, 2021	27817	156	February 3, 2021	20247	726
January 4, 2021	22099	116	February 4, 2021	21010	353
January 5, 2021	19026	376	February 5, 2021	11800	355
January 6, 2021	18634	867	February 6, 2021	1213	650
January 7, 2021	19211	282	February 7, 2021	25685	191
January 8, 2021	10728	276	February 8, 2021	19805	171
January 9, 2021	2167	589	February 9, 2021	17513	456
January 10, 2021	25931	168	February 10, 2021	17191	721
January 11, 2021	20189	151	February 11, 2021	17781	295
January 12, 2021	19408	309	February 12, 2021	10098	357
January 13, 2021	19807	742	February 13, 2021	2168	644
January 14, 2021	20698	229	February 14, 2021	23782	192
January 15, 2021	11335	280	February 15, 2021	19739	167
January 16, 2021	2682	633	February 16, 2021	19549	409
January 17, 2021	28922	192	February 17, 2021	20133	582
January 18, 2021	22710	141	February 18, 2021	21167	309
January 19, 2021	20813	401	February 19, 2021	12519	267

January 20, 2021	21609	656	February 20, 2021	2085	565
January 21, 2021	22604	310	February 21, 2021	28726	157
January 22, 2021	12515	346	February 22, 2021	22181	159
January 23, 2021	2072	648	February 23, 2021	20162	327
January 24, 2021	29448	229	February 24, 2021	20736	428
January 25, 2021	22205	172	February 25, 2021	20752	273
January 26, 2021	20900	445	February 26, 2021	12393	257
January 27, 2021	22313	612	February 27, 2021	2277	536
January 28, 2021	22627	349	February 28, 2021	27422	185
January 29, 2021	12464	343			
January 30, 2021	2957	819			
January 31, 2021	29782	242			
March 1, 2021	20412	114	April 1, 2021	38483	299
March 2, 2021	20453	375	April 2, 2021	24320	303
March 3, 2021	19786	410	April 3, 2021	3775	318
March 4, 2021	21912	322	April 4, 2021	8602	185
March 5, 2021	13157	278	April 5, 2021	53843	185
March 6, 2021	2364	431	April 6, 2021	39110	200
March 7, 2021	29327	170	April 7, 2021	35899	412
March 8, 2021	23466	127	April 8, 2021	37967	421
March 9, 2021	23706	358	April 9, 2021	23785	343
March 10, 2021	23945	356	April 10, 2021	3728	319
March 11, 2021	26255	331	April 11, 2021	46288	207
March 12, 2021	17026	265	April 12, 2021	34343	176

March 2021	13,	4135	223	April 13, 2021	30754	373
March 2021	14,	38276	168	April 14, 2021	31275	345
March 2021	15,	30555	132	April 15, 2021	32128	295
March 2021	16,	30439	333	April 16, 2021	20291	296
March 2021	17,	30375	392	April 17, 2021	4515	331
March 2021	18,	33123	236	April 18, 2021	39723	177
March 2021	19,	20670	268	April 19, 2021	30755	140
March 2021	20,	4986	276	April 20, 2021	29142	446
March 2021	21,	46270	175	April 21, 2021	26869	381
March 2021	22,	38088	138	April 22, 2021	28363	313
March 2021	23,	37136	343	April 23, 2021	17221	283
March 2021	24,	37079	269	April 24, 2021	3476	331
March 2021	25,	39932	245	April 25, 2021	32465	195
March 2021	26,	24890	223	April 26, 2021	24812	145
March 2021	27,	5122	897	April 27, 2021	21077	391
March 2021	28,	52323	183	April 28, 2021	20966	344
March 2021	29,	43554	131	April 29, 2021	22575	315
March 2021	30,	39629	360	April 30, 2021	3828	306
March 2021	31,	38379	361			

Date	Infected	Death	Date	Infected	Death
May 1, 2021	3376	290	June 1, 2021	938	126
May 2, 2021	27245	164	June 2, 2021	8498	117

May 3, 2021	20203	113	June 3, 2021	8582	95
May 4, 2021	17478	308	June 4, 2021	7978	69
May 5, 2021	15889	255	June 5, 2021	6953	88
May 6, 2021	17918	244	June 6, 2021	6038	43
May 7, 2021	3888	219	June 7, 2021	5070	25
May 8, 2021	1562	235	June 8, 2021	946	59
May 9, 2021	23884	176	June 9, 2021	4700	63
May 10, 2021	16618	115	June 10, 2021	5358	64
May 11, 2021	15762	290	June 11, 2021	4475	68
May 12, 2021	1571	231	June 12, 2021	3639	71
May 13, 2021	17164	182	June 13, 2021	3603	25
May 14, 2021	8576	131	June 14, 2021	2850	13
May 15, 2021	2262	173	June 15, 2021	407	60
May 16, 2021	18820	100	June 16, 2021	1867	72
May 17, 2021	15432	81	June 17, 2021	2865	44
May 18, 2021	13220	195	June 18, 2021	2775	55
May 19, 2021	11514	221	June 19, 2021	2132	63
May 20, 2021	11986	140	June 20, 2021	2322	20
May 21, 2021	4817	133	June 21, 2021	1815	14
May 22, 2021	13447	121	June 22, 2021	290	39
May 23, 2021	11821	75	June 23, 2021	978	45
May 24, 2021	9704	70	June 24, 2021	2287	33
May 25, 2021	1908	61	June 25, 2021	1796	44
May 26, 2021	1749	207	June 26, 2021	1851	33
May 27, 2021	12438	143	June 27, 2021	1874	11
May 28, 2021	13704	141	June 28, 2021	1459	16
May 29, 2021	11090	123	June 29, 2021	509	32
May 30, 2021	10007	66	June 30, 2021	1104	43
May 31, 2021	8541	44			

Date	Infected	Death	Date	Infected	Death
July 1, 2021	2336	25	August 1, 2021	20952	38
July 2, 2021	2572	28	August 2, 2021	19600	18
July 3, 2021	2581	22	August 3, 2021	1930	24
July 4, 2021	2695	12	August 4, 2021	25481	55
July 5, 2021	2549	9	August 5, 2021	27856	41
July 6, 2021	796	26	August 6, 2021	25481	42
July 7, 2021	2044	31	August 7, 2021	23355	64
July 8, 2021	3996	28	August 8, 2021	24978	16
July 9, 2021	4324	23	August 9, 2021	19692	26
July 10, 2021	4498	17	August 10, 2021	672	62
July 11, 2021	4102	14	August 11, 2021	24236	54
July 12, 2021	4231	4	August 12, 2021	30757	57
July 13, 2021	1120	24	August 13, 2021	26647	50
July 14, 2021	5367	40	August 14, 2021	25588	78
July 15, 2021	8748	6	August 15, 2021	21341	9
July 16, 2021	3583	16	August 16, 2021	21125	44
July 17, 2021	8433	14	August 17, 2021	5829	79
July 18, 2021	10949	16	August 18, 2021	17104	91
July 19, 2021	12523	5	August 19, 2021	27437	110
July 20, 2021	3959	16	August 20, 2021	23102	107
July 21, 2021	16723	21	August 21, 2021	18918	55
July 22, 2021	21386	22	August 22, 2021	22636	129
July 23, 2021	21769	10	August 23, 2021	17282	115

July 24, 2021	19052	33	August 24, 2021	4758	67
July 25, 2021	23373	18	August 25, 2021	22004	121
July 26, 2021	15233	6	August 26, 2021	22610	103
July 27, 2021	5154	42	August 27, 2021	18812	-6
July 28, 2021	24127	17	August 28, 2021	10563	30
July 29, 2021	27798	39	August 29, 2021	17381	74
July 30, 2021	21259	15	August 30, 2021	13589	53
July 31, 2021	22157	50	August 31, 2021	2132	57

Date	Infected	Death	Date	Infected	Death
September 1, 2021	17441	123	October 1, 2021	4858	54
September 2, 2021	17102	95	October 2, 2021	4124	21
September 3, 2021	15353	91	October 3, 2021	4948	30
September 4, 2021	8708	95	October 4, 2021	3744	9
September 5, 2021	13143	-41	October 5, 2021	1138	40
September 6, 2021	10360	49	October 6, 2021	3875	54
September 7, 2021	2310	112	October 7, 2021	4632	34
September 8, 2021	12851	67	October 8, 2021	4281	33
September 9, 2021	12348	117	October 9, 2021	4189	31
September 10, 2021	10649	89	October 10, 2021	4734	15
September 11, 2021	7575	0	October 11, 2021	3991	8
September 12, 2021	9408	44	October 12, 2021	635	28

September 13, 2021	7653	29	October 13, 2021	5291	32
September 14, 2021	415	82	October 14, 2021	5492	24
September 15, 2021	9944	80	October 15, 2021	4760	34
September 16, 2021	8686	75	October 16, 2021	5708	25
September 17, 2021	7690	69	October 17, 2021	4837	13
September 18, 2021	5898	32	October 18, 2021	3778	5
September 19, 2021	7414	42	October 19, 2021	757	38
September 20, 2021	5814	28	October 20, 2021	5689	36
September 21, 2021	180	9	October 21, 2021	5796	26
September 22, 2021	7465	144	October 22, 2021	5498	31
September 23, 2021	6400	55	October 23, 2021	6058	23
September 24, 2021	6110	59	October 24, 2021	6169	22
September 25, 2021	4527	20	October 25, 2021	4993	4
September 26, 2021	6012	29	October 26, 2021	1011	38
September 27, 2021	4683	14	October 27, 2021	6251	36
September 28, 2021	1161	73	October 28, 2021	6437	31
September 29, 2021	5859	49	October 29, 2021	6126	23
September 30, 2021	5479	43	October 30, 2021	6062	21
			October 31, 2021	7285	20



Date	Infected	Death	Date	Infected	Death
November 1, 2021	6329	12	December 1, 2021	46975	110
November 2, 2021	1834	6	December 2, 2021	49563	95
November 3, 2021	1859	84	December 3, 2021	48129	97
November 4, 2021	9592	33	December 4, 2021		
November 5, 2021	9283	47	December 5, 2021		
November 6, 2021	8451	10	December 6, 2021		
November 7, 2021	9537	25	December 7, 2021		
November 8, 2021	8489	8	December 8, 2021		
November 9, 2021	1958	54	December 9, 2021		
November 10, 2021	11500	42	December 10, 2021		
November 11, 2021	11822	31	December 11, 2021		
November 12, 2021	12504	17	December 12, 2021		
November 13, 2021	3600	44	December 13, 2021		
November 14, 2021	14645	16	December 14, 2021		
November 15, 2021	12475	17	December 15, 2021		
November 16, 2021	3162	75	December 16, 2021		
November 17, 2021	18413	44	December 17, 2021		
November 18, 2021	20201	56	December 18, 2021		
November 19, 2021	19840	49	December 19, 2021		
November 20, 2021	20847	49	December 20, 2021		
November 21, 2021	22568	22	December 21, 2021		

November 22, 2021	19749	15	December 22, 2021		
November 23, 2021	5201	96	December 23, 2021		
November 24, 2021	28255	82	December 24, 2021		
November 25, 2021	32451	76	December 25, 2021		
November 26, 2021	33320	72	December 26, 2021		
November 27, 2021	34251	58	December 27, 2021		
November 28, 2021	37137	32	December 28, 2021		
November 29, 2021	31642	23	December 29, 2021		
November 30, 2021	5981	118	December 30, 2021		
			December 31, 2021		

**Table 4.** The confirmed cases of the COVID-19 in Iraq from January 1, 2021 to December 3, 2021. The data are collected from the following source: <https://covid19.who.int/WHO-COVID-19-global-data.csv>

Date	Infected	Death	Date	Infected	Death
January 1, 2021	849	5	February 1, 2021	714	6
January 2, 2021	902	11	February 2, 2021	984	10
January 3, 2021	840	5	February 3, 2021	1135	11
January 4, 2021	741	5	February 4, 2021	1317	11
January 5, 2021	595	10	February 5, 2021	1150	12
January 6, 2021	757	12	February 6, 2021	1534	12
January 7, 2021	839	9	February 7, 2021	1660	8
January 8, 2021	790	4	February 8, 2021	1134	9
January 9, 2021	669	8	February 9, 2021	1713	6

January 10, 2021	907	4	February 10, 2021	1994	8
January 11, 2021	607	14	February 11, 2021	2282	6
January 12, 2021	801	11	February 12, 2021	2369	4
January 13, 2021	810	5	February 13, 2021	2530	13
January 14, 2021	867	4	February 14, 2021	2190	7
January 15, 2021	770	7	February 15, 2021	2224	15
January 16, 2021	805	10	February 16, 2021	2798	6
January 17, 2021	596	3	February 17, 2021	3332	7
January 18, 2021	645	9	February 18, 2021	3575	12
January 19, 2021	797	9	February 19, 2021	3896	16
January 20, 2021	823	9	February 20, 2021	4024	12
January 21, 2021	746	6	February 21, 2021	3273	13
January 22, 2021	809	9	February 22, 2021	3187	27
January 23, 2021	685	7	February 23, 2021	3864	23
January 24, 2021	778	4	February 24, 2021	4181	16
January 25, 2021	893	5	February 25, 2021	4306	13
January 26, 2021	813	7	February 26, 2021	4074	27
January 27, 2021	804	10	February 27, 2021	4336	14
January 28, 2021	879	8	February 28, 2021	3543	18
January 29, 2021	943	6			
January 30, 2021	945	12			
January 31, 2021	775	5			

March 1, 2021	3248	23	April 1, 2021	6664	37
March 2, 2021	3599	22	April 2, 2021	6015	37
March 3, 2021	4690	30	April 3, 2021	5882	30
March 4, 2021	5173	25	April 4, 2021	5379	40
March 5, 2021	5043	24	April 5, 2021	5368	33
March 6, 2021	5127	30	April 6, 2021	6423	39
March 7, 2021	4068	11	April 7, 2021	7300	33
March 8, 2021	3359	24	April 8, 2021	8331	37
March 9, 2021	4468	24	April 9, 2021	7817	34
March 10, 2021	4610	22	April 10, 2021	7937	35
March 11, 2021	4846	27	April 11, 2021	6779	37
March 12, 2021	5170	26	April 12, 2021	6791	35
March 13, 2021	4622	25	April 13, 2021	7953	44
March 14, 2021	4054	23	April 14, 2021	8179	39
March 15, 2021	3866	32	April 15, 2021	7972	40
March 16, 2021	4901	37	April 16, 2021	7810	49
March 17, 2021	5267	39	April 17, 2021	7575	30
March 18, 2021	5663	33	April 18, 2021	6552	33
March 19, 2021	5443	36	April 19, 2021	6188	33
March 20, 2021	5258	41	April 20, 2021	7775	45
March 21, 2021	4674	32	April 21, 2021	8208	34
March 22, 2021	4502	38	April 22, 2021	8696	38
March 23, 2021	4655	29	April 23, 2021	8450	30
March 24, 2021	4494	30	April 24, 2021	8017	46

March 25, 2021	6051	29	April 25, 2021	6967	43
March 26, 2021	6513	33	April 26, 2021	6034	40
March 27, 2021	6490	29	April 27, 2021	6536	46
March 28, 2021	5062	20	April 28, 2021	7152	45
March 29, 2021	5271	35	April 29, 2021	6858	44
March 30, 2021	5837	37	April 30, 2021	6926	41
March 31, 2021	5995	37			

Date	Infected	Death	Date	Infected	Death
May 1, 2021	6405	32	June 1, 2021	4270	24
May 2, 2021	5167	33	June 2, 2021	4170	30
May 3, 2021	4564	38	June 3, 2021	4583	31
May 4, 2021	5068	30	June 4, 2021	4262	26
May 5, 2021	6143	42	June 5, 2021	4157	26
May 6, 2021	5813	32	June 6, 2021	3154	30
May 7, 2021	6233	33	June 7, 2021	3314	20
May 8, 2021	5763	29	June 8, 2021	4129	28
May 9, 2021	4608	39	June 9, 2021	4119	23
May 10, 2021	4167	30	June 10, 2021	4616	25
May 11, 2021	4902	29	June 11, 2021	4684	34
May 12, 2021	5287	34	June 12, 2021	4320	20
May 13, 2021	4666	21	June 13, 2021	3831	22
May 14, 2021	4512	28	June 14, 2021	3952	15
May 15, 2021	2767	27	June 15, 2021	5040	31
May 16, 2021	2058	20	June 16, 2021	4618	26
May 17, 2021	2456	26	June 17, 2021	5139	19
May 18, 2021	3552	41	June 18, 2021	5189	30

May 19, 2021	4023	32	June 19, 2021	5068	23
May 20, 2021	4609	40	June 20, 2021	3608	26
May 21, 2021	4580	33	June 21, 2021	4160	25
May 22, 2021	4357	35	June 22, 2021	5235	25
May 23, 2021	3655	21	June 23, 2021	6003	25
May 24, 2021	3791	32	June 24, 2021	6297	33
May 25, 2021	4102	24	June 25, 2021	6093	31
May 26, 2021	4938	27	June 26, 2021	5325	34
May 27, 2021	4718	26	June 27, 2021	4814	28
May 28, 2021	4611	22	June 28, 2021	4468	30
May 29, 2021	4042	22	June 29, 2021	6346	30
May 30, 2021	3257	23	June 30, 2021	6558	35
May 31, 2021	3474	17			

Date	Infected	Death	Date	Infected	Death
July 1, 2021	7300	30	August 1, 2021	10215	62
July 2, 2021	7554	30	August 2, 2021	9394	77
July 3, 2021	6378	40	August 3, 2021	12734	68
July 4, 2021	5375	25	August 4, 2021	11644	63
July 5, 2021	6264	35	August 5, 2021	12713	73
July 6, 2021	8030	29	August 6, 2021	11871	62
July 7, 2021	8818	31	August 7, 2021	11435	87
July 8, 2021	8777	37	August 8, 2021	7973	59
July 9, 2021	9189	31	August 9, 2021	8346	57
July 10, 2021	8636	32	August 10, 2021	9619	67
July 11, 2021	6821	39	August 11, 2021	9970	66
July 12, 2021	7616	33	August 12, 2021	8635	66
July 13, 2021	9149	44	August 13, 2021	10243	64

July 14, 2021	9046	38	August 14, 2021	9967	75
July 15, 2021	9635	47	August 15, 2021	7610	65
July 16, 2021	9337	30	August 16, 2021	7011	66
July 17, 2021	8336	44	August 17, 2021	8830	68
July 18, 2021	8149	38	August 18, 2021	8778	75
July 19, 2021	8698	41	August 19, 2021	7992	71
July 20, 2021	9883	62	August 20, 2021	8012	72
July 21, 2021	8922	59	August 21, 2021	6121	67
July 22, 2021	8320	69	August 22, 2021	3958	85
July 23, 2021	8106	81	August 23, 2021	5634	74
July 24, 2021	8905	66	August 24, 2021	7151	78
July 25, 2021	7653	65	August 25, 2021	7670	75
July 26, 2021	9147	55	August 26, 2021	7787	73
July 27, 2021	12180	60	August 27, 2021	8084	70
July 28, 2021	12185	71	August 28, 2021	7202	79
July 29, 2021	13515	66	August 29, 2021	5369	73
July 30, 2021	13259	49	August 30, 2021	6083	67
July 31, 2021	12597	62	August 31, 2021	6778	65

Date	Infected	Death	Date	Infected	Death
September 1, 2021	6937	66	October 1, 2021	2434	39
September 2, 2021	7309	48	October 2, 2021	2688	42

September 2021	3,	6948	56	October 2021	3,	1236	42
September 2021	4,	5672	60	October 2021	4,	2451	21
September 2021	5,	4316	48	October 2021	5,	1956	27
September 2021	6,	4897	58	October 2021	6,	2470	28
September 2021	7,	5650	62	October 2021	7,	2519	20
September 2021	8,	5988	58	October 2021	8,	2044	33
September 2021	9,	5405	62	October 2021	9,	2215	36
September 2021	10,	5073	51	October 2021	10,	1227	28
September 2021	11,	4717	61	October 2021	11,	1652	26
September 2021	12,	3086	51	October 2021	12,	944	28
September 2021	13,	3554	51	October 2021	13,	1644	29
September 2021	14,	4204	54	October 2021	14,	1766	35
September 2021	15,	4400	46	October 2021	15,	2383	26
September 2021	16,	3895	35	October 2021	16,	2162	32
September 2021	17,	3923	52	October 2021	17,	1077	25
September 2021	18,	3559	56	October 2021	18,	1716	18
September 2021	19,	1959	36	October 2021	19,	1559	29
September 2021	20,	2515	47	October 2021	20,	1835	25
September 2021	21,	3192	47	October 2021	21,	1388	26
September 2021	22,	3081	42	October 2021	22,	1882	39
September 2021	23,	2906	38	October 2021	23,	1846	26
September 2021	24,	2953	44	October 2021	24,	1064	36



September 25, 2021	2964	46	October 25, 2021	1247	24
September 26, 2021	1312	33	October 26, 2021	1537	32
September 27, 2021	2139	38	October 27, 2021	1429	31
September 28, 2021	2447	32	October 28, 2021	1412	37
September 29, 2021	2401	45	October 29, 2021	1471	22
September 30, 2021	2254	34	October 30, 2021	1397	28
			October 31, 2021	682	27

Date	Infected	Death	Date	Infected	Death
November 1, 2021	1046	32	December 1, 2021	724	13
November 2, 2021	1153	26	December 2, 2021	889	24
November 3, 2021	1315	27	December 3, 2021	713	15
November 4, 2021	1198	25	December 4, 2021	741	8
November 5, 2021	1152	23	December 5, 2021	374	6
November 6, 2021	1156	26	December 6, 2021	457	12
November 7, 2021	717	22	December 7, 2021		
November 8, 2021	924	25	December 8, 2021		
November 9, 2021	1148	28	December 9, 2021		
November 10, 2021	1116	27	December 10, 2021		
November 11, 2021	915	16	December 11, 2021		
November 12, 2021	863	30	December 12, 2021		
November 13, 2021	892	26	December 13, 2021		

November 14, 2021	591	12	December 14, 2021		
November 15, 2021	859	20	December 15, 2021		
November 16, 2021	829	33	December 16, 2021		
November 17, 2021	807	26	December 17, 2021		
November 18, 2021	806	18	December 18, 2021		
November 19, 2021	789	27	December 19, 2021		
November 20, 2021	789	21	December 20, 2021		
November 21, 2021	568	14	December 21, 2021		
November 22, 2021	584	23	December 22, 2021		
November 23, 2021	829	21	December 23, 2021		
November 24, 2021	898	26	December 24, 2021		
November 25, 2021	776	13	December 25, 2021		
November 26, 2021	743	23	December 26, 2021		
November 27, 2021	856	17	December 27, 2021		
November 28, 2021	563	7	December 28, 2021		
November 29, 2021	538	21	December 29, 2021		
November 30, 2021	826	14	December 30, 2021		
			December 31, 2021		



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