Could masks curtail the post-lockdown resurgence of COVID-19 in the US?

Calistus N. Ngonghala[†,††,*], Enahoro Iboi[◇], and Abba B. Gumel[‡,‡‡]

[†] *Department of Mathematics, University of Florida, Gainesville, FL 32611, USA.*
[††] *Emerging Pathogens Institute, University of Florida, Gainesville, FL 32610, USA.*
[◇] *Department of Mathematics, Spelman College, Atlanta, Georgia, 30314, USA.*
[‡] *School of Mathematical and Statistical Sciences, Arizona State University, Tempe, Arizona, 85287, USA.*
[‡‡] *Department of Mathematics and Applied Mathematics, University of Pretoria, Pretoria 0002, South Africa.*

Appendices

A Tables of variable descriptions, parameter descriptions, and parameter values

Table A1: Description of the state variables of the model (2.1)

State variable	Description
S	Population of susceptible individuals
E	Population of exposed (newly-infected but not infectious) individuals
E_p	Population of pre-symptomatic (infectious) individuals
I_a	Population of asymptomatically-Infectious individuals
I_m	Population of infectious individuals with mild or moderate clinical symptoms of COVID-19
I_s	Population of infectious individuals with severe clinical symptoms of COVID-19
I_i	Population of infectious individuals in self-isolation
I_h	Population of hospitalized individuals
I_c	Population of individuals in ICU
R_u	Population of untested recovered individuals
R_t	Population of recovered individuals who received serology (antibody) test

[*]Corresponding author: Email: *calistusnn@ufl.edu*

Table A2: Description of parameters of the model (2.1)

Parameter	Description
$\beta_p(\beta_a)(\beta_m)(\beta_s)$	Effective contact rate for individuals in the $E_p(I_a)(I_m)(I_s)$ class
ε_m	Efficacy of face masks to prevent transmission and acquisition of infection $(0 < \varepsilon_m \leq 1)$
c_m	Compliance in face mask usage in the community $(0 < c_m \leq 1)$
θ	Efficacy of isolation (self-isolation), hospitalization and ICU admission to prevent infected individuals in isolation, from transmitting the disease $(0 \leq \theta \leq 1)$
τ_d	Detection rate of asymptomatically-infected individuals *via* random diagnostic/surveillance testing
τ_s	Detection rate of untested recovered individuals *via* serology (antibody) testing
$\tau_{dmax}(\tau_{smax})$	Maximum diagnostic (serology) detection rate
T_n	Average number of testing conducted *per* day
σ_e	Progression rate from E to E_p class
σ_p	Progression rate of pre-symptomatic exposed individuals to I_a, I_m or I_s class
r	Proportion of individuals in the E_p class who show no clinical symptoms of COVID-19 at the end of the incubation period (and move to the I_a class)
$1 - r$	Proportion of individuals in the E_p class who show clinical symptoms of COVID-19 at the end of the incubation period (and move to the I_m class, at a rate $g(1 - r)\sigma$, or to the I_s class, at a rate $(1 - g)(1 - r)\sigma$)
g	Proportion of individuals in the E_p class who develop mild symptoms of COVID-19 at the end of the incubation period
$1 - g$	Proportion of individuals in the E_p class who develop severe symptoms of COVID-19 at the end of the incubation period
f	Proportion of individuals in the I_s class who are hospitalized
$1 - f$	Proportion of individuals in the I_s class who are self-isolated
ρ_m	Self-isolation rate for individuals in the I_m class
$(1 - f)\rho_s$	Self-isolation rate for individuals in the I_s class
$f\rho_s$	Hospitalization rate for individuals in the I_s class
ξ_i	Hospitalization rate of self-isolated individuals
ψ_h	ICU admission rate for hospitalized individuals
$\gamma_a(\gamma_s)(\gamma_h)(\gamma_i)(\gamma_c)$	Recovery rate for individuals in the $I_a(I_s)(I_h)(I_i)(I_c)$ class
$\delta_s(\delta_h)(\delta_i)(\delta_c)$	Disease-induced death rate for individuals in the $I_s(I_h)(I_i)(I_c)$ class

Table A3: Baseline parameter values for the model (2.1) drawn from the literature.

Parameter	Value	Reference
ε_m	0.5	Estimated from [1]
σ_e	$1/2.5$	[2–6]
σ_p	$1/2.5$	[4–7]
r	0.324	Estimated from [8, 9]
g	0.719	Estimated from [8, 9]
ρ_s	1/3.5	[10]
ψ_h	$1/6$	[11]
γ_a	$1/5$	[11]
γ_s	$1/10$	[6, 12]
γ_h	$1/8$	[12]
γ_i	$1/7$	[13]
γ_c	$1/10$	[6, 12]
θ	1	Assumed

Table A4: Calibrated parameter values for the model (2.1) using cumulative mortality data for the state of Arizona. (a) Pre-lockdown period (i.e., from March 6 to March 31, 2020). (b) Lockdown period (i.e., from March 31 to May 15, 2020). The lower 95% confidence interval bound is denoted by CI (low), while the upper 95% confidence interval bound is denoted by CI (up).

(a) Estimated parameters for the pre-lockdown period.

Parameter	Value	95% CI (low)	95% CI (up)
β_p	1.4491	0.1988	1.8275
β_a	0.5746	0.1000	0.9678
β_m	0.6456	0.1000	3.1649
β_s	0.4233	0.1000	0.6055
c_m	0.0435	0.0357	0.0500
τ_{dmax}	0.2388	0.1537	0.4171
ρ_m	0.2857	0.0571	0.2972
ξ_i	0.2857	0.0857	0.2972
δ_h	0.0155	0.0050	0.0380
δ_c	0.0304	0.0300	0.0800
δ_s	0.0228	0.0225	0.0600
δ_i	0.0228	0.0225	0.0600
$\mathscr{R}_c$	2.0510	0.7623	2.5078

(b) Estimated parameters for the lockdown period.

Parameter	Value	95% CI (low)	95% CI (up)
β_p	1.3149	1.0225	1.4491
β_a	0.5746	0.4512	0.5746
β_m	0.4372	0.1000	0.6456
β_s	0.3893	0.2265	0.4233
c_m	0.1392	0.1100	0.1715
τ_{dmax}	0.4525	0.3257	0.5721
ρ_m	0.2552	0.0982	0.2857
ξ_i	0.2601	0.1287	0.2857
δ_h	0.0081	0.0073	0.0103
δ_c	0.0108	0.0097	0.0137
δ_s	0.0054	0.0073	0.0069
δ_i	0.0054	0.0049	0.0069
$\mathscr{R}_c$	0.9415	0.0049	0.9877

Table A5: Calibrated parameter values for the model (2.1) using cumulative mortality data for the state of Florida. (a) Pre-lockdown period (i.e., from March 1 to April 3, 2020). (b) Lockdown period (i.e., from April 3 to May 4, 2020). The lower 95% confidence interval bound is denoted by CI (low), while the upper 95% confidence interval bound is denoted by CI (up).

(a) Estimated parameters for the pre-lockdown period.

Parameter	**Value**	95% **CI (low)**	95% **CI (up)**
β_p	1.3523	0.8804	1.6706
β_a	0.9232	0.4013	1.926
β_m	0.6800	0.1000	0.8675
β_s	0.2062	0.0100	0.2479
c_m	0.0396	0.0374	0.05
τ_{dmax}	0.2309	0.1065	0.3011
ρ_m	0.2857	0.0571	0.2956
ξ_i	0.2561	0.0973	0.2857
δ_h	0.0051	0.0050	0.0320
δ_c	0.0308	0.0300	0.0702
δ_s	0.0231	0.0225	0.0527
δ_i	0.0231	0.0225	0.0527
$\mathscr{R}_c$	2.0997	1.9118	2.2214

(b) Estimated parameters for the lockdown period.

Parameter	**Value**	95% **CI (low)**	95% **CI (up)**
β_p	1.1505	0.6004	2.3827
β_a	0.9232	0.1160	0.9832
β_m	0.5064	0.1154	0.6800
β_s	0.1642	0.1021	0.2062
c_m	0.1647	0.0800	0.2056
τ_{dmax}	0.4681	0.3242	0.8105
ρ_m	0.1612	0.0857	0.1714
ξ_i	0.2568	0.1143	0.2571
δ_h	0.0067	0.0040	0.0150
δ_c	0.0075	0.0014	0.0135
δ_s	0.0056	0.0011	0.0101
δ_i	0.0056	0.0011	0.0101
$\mathscr{R}_c$	0.9772	0.6638	0.9859

Table A6: Calibrated parameter values for the model (2.1) using cumulative mortality data for the state of New York. (a) Pre-lockdown period (i.e., from March 1 to March 22, 2020). (b) Lockdown period ((i.e., from March 22 to May 28, 2020)). The lower 95% confidence interval bound is denoted by CI (low), while the upper 95% confidence interval bound is denoted by CI (up).

(a) Estimated parameters for the pre-lockdown period.

Parameter	**Value**	95% **CI (low)**	95% **CI (up)**
β_p	2.7450	1.3772	3.3895
β_a	0.8989	0.1000	2.0134
β_m	0.1254	0.1000	3.1228
β_s	0.4246	0.1000	0.8043
c_m	0.0190	0.0000	0.0500
τ_{dmax}	0.3010	0.3002	0.4940
ρ_m	0.2857	0.0571	0.2896
ξ_i	0.2822	0.0857	0.2857
δ_h	0.0371	0.0050	0.0400
δ_c	0.0434	0.0300	0.0800
δ_s	0.0326	0.0225	0.0600
δ_i	0.0326	0.0225	0.0600
$\mathscr{R}_c$	2.5321	1.5460	3.2335

(b) Estimated parameters for the lockdown period.

Parameter	**Value**	95% **CI (low)**	95% **CI (up)**
β_p	1.0363	0.4207	1.8901
β_a	0.8989	0.2228	0.9889
β_m	0.4046	0.1735	0.5978
β_s	0.5943	0.1000	0.7425
c_m	0.1500	0.1222	0.2162
τ_{dmax}	0.4485	0.3010	0.6142
ρ_m	0.2466	0.1716	0.2857
ξ_i	0.2426	0.1714	0.2571
δ_h	0.0097	0.0067	0.0221
δ_c	0.0129	0.0089	0.0221
δ_s	0.0065	0.0044	0.0111
δ_i	0.0065	0.0044	0.0111
$\mathscr{R}_c$	0.8480	0.5307	0.8955

Table A7: Calibrated parameter values for the model (2.1) using cumulative mortality data for the entire US. (a) Pre-lockdown period (i.e., from January 22 to April 7, 2020). (b) Lockdown period (i.e., from April 7 to May 28, 2020). The lower 95% confidence interval bound is denoted by CI (low), while the upper 95% confidence interval bound is denoted by CI (up).

(a) Estimated parameters for the pre-lockdown period.

Parameter	**Value**	95% **CI (low)**	95% **CI (up)**
β_p	0.7290	0.6677	0.7751
β_a	0.8969	0.7745	0.9764
β_m	0.8086	0.7530	0.9224
β_s	0.4010	0.1870	0.4642
c_m	0.0278	0.0276	0.0294
τ_{dmax}	0.1797	0.1722	0.1960
ρ_m	0.1801	0.1584	0.1853
ξ_i	0.1765	0.1316	0.2417
δ_h	0.0073	0.0052	0.0386
δ_c	0.0304	0.0300	0.0800
δ_s	0.0228	0.0225	0.0600
δ_i	0.0228	0.0225	0.0600
$\mathscr{R}_c$	2.3277	2.2854	2.3758

(b) Estimated parameters for the lockdown period.

Parameter	**Value**	95% **CI (low)**	95% **CI (up)**
β_p	0.4075	0.3327	0.5454
β_a	0.6036	0.1008	0.8614
β_m	0.4592	0.2531	0.7336
β_s	0.1344	0.1053	0.2635
c_m	0.1835	0.1312	0.2300
τ_{dmax}	0.2294	0.1799	0.3812
ρ_m	0.2571	0.1045	0.2684
ξ_i	0.0795	0.0571	0.1557
δ_h	0.0048	0.0043	0.0050
δ_c	0.0064	0.0058	0.0067
δ_s	0.0032	0.0029	0.0034
δ_i	0.0032	0.0029	0.0034
$\mathscr{R}_c$	0.8833	0.6363	0.8929

Table A8: Percentage of community transmission generated by asymptomatic $(\beta_p + \beta_a)/(\beta_p + \beta_a + \beta_m + \beta_s)$ and symptomatic infectious individuals $(\beta_m + \beta_s)/(\beta_p + \beta_a + \beta_m + \beta_s)$ during the pre-lockdown and lockdown periods in the states of Arizona, Florida, New York, and the entire US.

Period	**Transmission source**	**Arizona**	**Florida**	**New York**	**US**
Pre-lockdown	Pre-symptomatic and asymptomatic $(E_p + I_a)$	65%	72%	87%	57%
	Symptomatic $(I_m + I_s)$	35%	28%	13%	43%
Lockdown	Pre-symptomatic and asymptomatic $(E_p + I_a)$	70%	76%	66%	63%
	Symptomatic $(I_m + I_s)$	30%	24%	34%	37%

Table A9: Percentage of community transmission generated by pre-symptomatic $\beta_p/(\beta_p + \beta_a + \beta_m + \beta_s)$ and asymptomatic infectious individuals $\beta_a/(\beta_p + \beta_a + \beta_m + \beta_s)$ during the pre-lockdown and lockdown periods in the states of Arizona, Florida, New York, and the entire US.

Period	**Transmission source**	**Arizona**	**Florida**	**New York**	**US**
Pre-lockdown	Pre-symptomatic (E_p)	47%	43%	65%	26%
	Asymptomatic (I_a)	19%	29%	21%	32%
Lockdown	Pre-symptomatic (E_p)	48%	42%	35%	25%
	Asymptomatic (I_a)	21%	34%	31%	38%

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