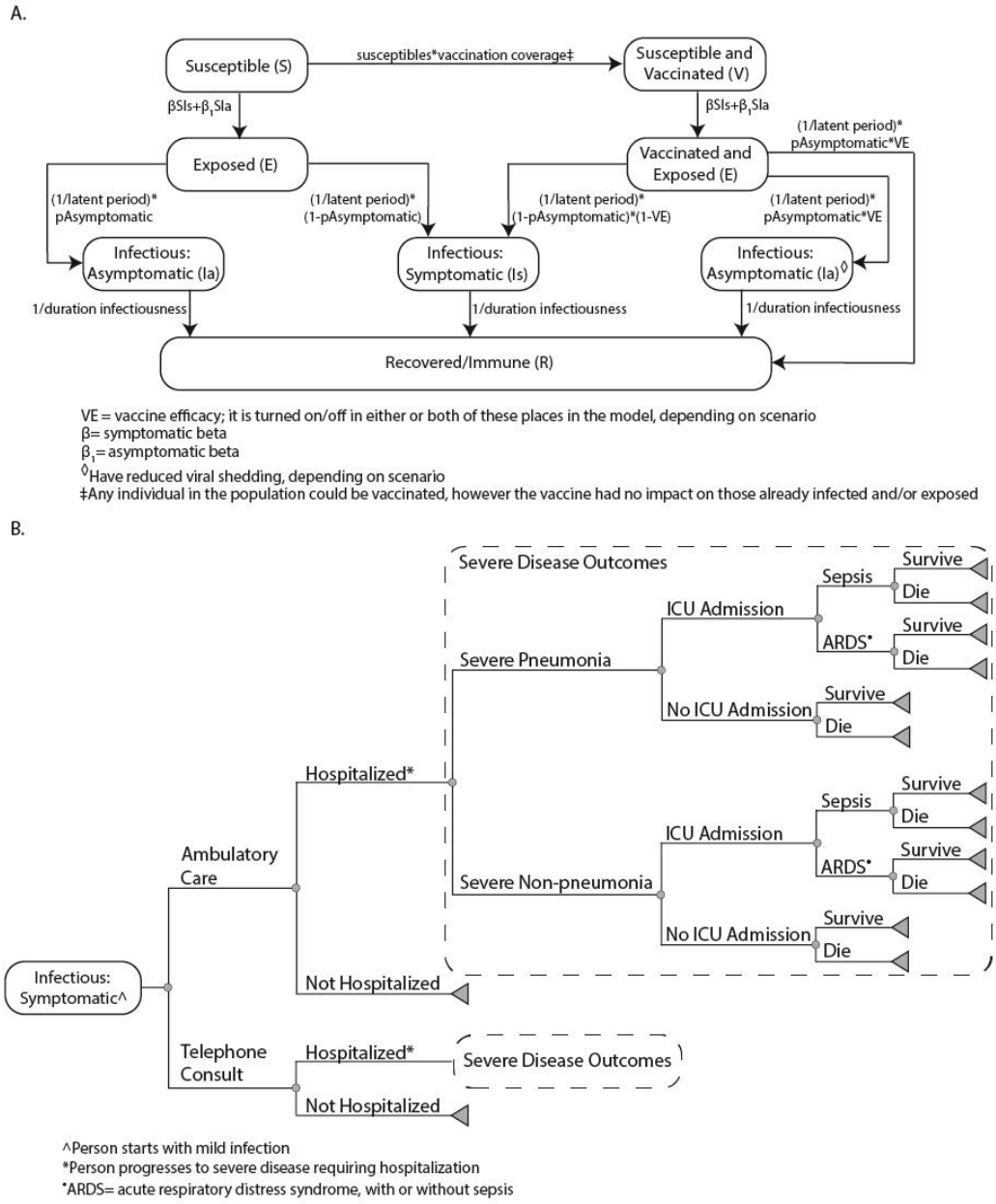
DATA SOURCES

Appendix Table 1 shows key model input parameters, values, distribution type, and sources. All costs, clinical probabilities, and durations were age-specific when available and come from scientific literature or nationally representative data sources. The probability of an infected individual being a given age was based on the age-distribution of cases in the U.S. and age-specific COVID-19 data are specific to the U.S. context as of March 16, 2020.[1] We report all costs in 2020 values, converting all past and future values to net present value using a 3% discount rate. We parameterized seeding SARS-CoV-2-infected persons into the population for a given R_0 such that simulated cases reflected case data reported as of March 24, 2020.[1]

MODEL PARAMETERIZATION

We parameterized the number of individuals starting in the I_a state and I_s state on day one (i.e., coronavirus seed) SARS-CoV2-infected persons into the population for a given R_0 such that simulated cases reflected case data reported as of March 24, 2020.[1] This date was the last date for which data was available at the time of model calibration. When the asymptomatic individuals were half as infectious as symptomatic individuals, for an R_0 of 2.5, this was equivalent to 400 symptomatic cases and 87 asymptomatic cases; for an R_0 of 3.5 this was 50 symptomatic cases and 11 asymptomatic cases. When the probability of asymptomatic infection was 35% and asymptomatic individuals were as infectious as symptomatic individuals (i.e., relative infectiousness of asymptomatic infection 100%),[2] for an R_0 of 2.5, this was equivalent to 250 symptomatic cases and 134 asymptomatic cases; for an R_0 of 3.5 this was 26 symptomatic cases and 14 asymptomatic cases. All of these parameterizations have a ratio of symptomatic to asymptomatic persons based on the probability of having symptoms.

Appendix Figure 1. Model structure A) transmission and B) clinical pathway of COVID-19 cases.



Appendix Table 1. Model Parameter Inputs, Values, and Sources

Parameter	Distribution type	Mean or median	SE or range	Source
SARS-CoV-2 transmission				
Latent period (days)	Triangular	5.2	4.1–7.0	[3]
Infectious period (days)	Uniform		3–14	[4–7]
Costs (2020 US$)				
Annual wages (all occupations)	Beta pert	40,993	21,950–104,403[a]	[8]
Ambulatory care visit	Uniform		110.43–148.33	[9]
Over the counter medications, daily				
0–12 years old[b]	Gamma	3.87	2.10	[10]
≥13 years old[c]	Gamma	0.46	0.17	[10]
Hospitalization for pneumonia[d]				
0–17 years old	Gamma	12,502.30	1,508.04	[11]
18–44 years old	Gamma	10,627.15	1,045.06	[11]
45–64 years old	Gamma	13,718.14	1,238.76	[11]
65–84 years old	Gamma	12,264.39	478.40	[11]
≥85 years old	Gamma	10,982.73	518.29	[11]
Hospitalization for severe non-pneumonia (all ages)[e]	Gamma	6,886.53	1,182.99	[11]
Hospitalization for sepsis[f]				
0–17 years old[g]	Gamma	22,694.30	1,861.33	[11]
18–44 years old	Gamma	43,778.39	5,382.40	[11]
45–64 years old	Gamma	38,734.24	2,725.10	[11]
65–84 years old	Gamma	30,308.29	1,367.91	[11]
≥85 years old	Gamma	22,694.30	1,861.33	[11]
Hospitalization for acute respiratory distress syndrome (ARDS)[h]				
0–17 years old	Gamma	42,350.58	4,198.97	[11]
18–44 years old	Gamma	26,210.96	1,558.61	[11]
45–64 years old	Gamma	19,863.98	453.92	[11]
65–84 years old	Gamma	18,718.55	335.69	[11]
≥85 years old	Gamma	16,559.75	754.12	[11]
Probabilities				
Asymptomatic infection	Beta	0.179	0.155 - 0.202	[12]
Relative infectiousness of asymptomatic infection	Point estimate	0.5		Assumption[2,13]
Missing work/school	Point estimate	1.0		Assumption
Ambulatory care				

0–4 years old	Beta	0.455	0.098	[14]
5–17 years old	Beta	0.318	0.061	[14]
18–64 years old	Beta	0.313	0.014	[14]
≥65 years old	Beta	0.62	0.027	[14]
Probability of hospitalization, given infection				
0–19 years old	Point estimate	0.016		[1]
20–44 years old	Point estimate	0.143		[1]
45–64 years old	Point estimate	0.208		[1]
65–84 years old	Point estimate	0.292		[1]
≥85 years old	Point estimate	0.313		[1]
Probability of intensive care unit (ICU) admission				
0–19 years old	Point estimate	0.0		[1]
20–44 years old	Point estimate	0.1399		[1]
45–64 years old	Point estimate	0.2422		[1]
65–84 years old	Point estimate	0.3048		[1]
≥85 years old	Point estimate	0.2013		[1]
Probability of mortality				
0–19 years old	Point estimate	0.0		[1]
20–44 years old	Point estimate	0.007		[1]
45–64 years old	Point estimate	0.0456		[1]
65–84 years old	Point estimate	0.1109		[1]
≥85 years old	Point estimate	0.3323		[1]
Pneumonia, given hospitalization	Beta	0.79	0.711–0.869[i]	[15]
ARDS, requiring ventilator use	Beta	0.73	0.1697	[16,17]
Age-group, given infection[j]				
0–19 years old	Point estimate	0.0502		[1]
20–44 years old	Point estimate	0.2879		[1]
45–64 years old	Point estimate	0.3503		[1]
65–84 years old	Point estimate	0.2528		[1]
≥85 years old	Point estimate	0.0588		[1]
Durations (days)				
Ambulatory care	Point estimate	0.5		Assumption
Duration of symptoms with mild illness	Triangular	7	3–17	[6,18,19]
Duration of symptoms prior to hospital admission	Triangular	7	3–9[j]	[16,20]
Hospitalization for pneumonia[d]				
0–17 years old	Gamma	4.7	0.4	[11]
18–44 years old	Gamma	4.3	0.4	[11]
45–64 years old	Gamma	5.1	0.2	[11]
65–84 years old	Gamma	5.5	0.2	[11]

≥85 years old	Gamma	5.0	0.2	[11]
Hospitalization for severe non-pneumonia (all ages)[e]	Gamma	3.1	0.5	[11]
Hospitalization for sepsis[f]				
0–17 years old[g]	Gamma	7.3	0.5	[11]
18–44 years old	Gamma	11.2	1.3	[11]
45–64 years old	Gamma	10.7	0.5	[11]
65–84 years old	Gamma	8.8	0.4	[11]
≥85 years old	Gamma	7.3	0.5	[11]
Hospitalization for acute respiratory distress syndrome (ARDS)[h]				
0–17 years old	Gamma	9.5	0.75	[11]
18–44 years old	Gamma	8.8	0.5	[11]
45–64 years old	Gamma	7.1	0.1	[11]
65–84 years old	Gamma	7.0	0.1	[11]
≥85 years old	Gamma	6.1	0.3	[11]

[a]Values are 95% CI.
[b]Assumes 5 to 10 mg/kg orally every 6 to 8 hours as needed OR 10 to 15 mg/kg orally every 4 to 6 hours as needed.
[c]Assumes 200 mg orally every 4 to 6 hours as needed.
[d]Uses ICD-10-CM code #J13 Pneumonia due to *Streptococcus pneumoniae.*
[e]Uses ICD-10-CM code #J11.89 Influenza due to unidentified influenza virus with other manifestations.
[f]Uses ICD-10-CM code #R65.21 Severe sepsis with septic shock.
[g]Data for age-group unavailable and uses lowest values of all age-groups as a proxy.
[h]Uses ICD-10-CM code #J96.22 Acute and chronic respiratory failure with hypercapnia for 18 years and older and ICD-10-CM code #J96.20 Acute and chronic respiratory failure, unspecified whether with hypoxia or hypercapnia for 0 to 17-year olds.
[i]Values account for the age-specific probability of infection.
[j]Values are 10%–90%.

Appendix
Vaccine Efficacy Needed for a COVID-19 Coronavirus Vaccine to Prevent or Stop an Epidemic as the Sole Intervention
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Appendix Table 2. Number of Clinical Outcomes, Resource Use, and Costs Due to COVID-19 During the Course of an Epidemic When Vaccination Occurs When 0% of the Population Has Been Exposed to SARS-CoV-2 With a Vaccine That Prevents Infection, Varying With Vaccine Efficacy

Scenario	Total SARS-CoV-2 cases (in millions)	Symptomatic cases (in millions)	Hospitalized cases (in millions)	Number of patients ventilated (in millions)	Deaths (in thousands)	Total beds days (in millions)	Ventilated days (in millions)	Direct medical costs (in billions)	Productivity losses (in billions)
	Median (95% CI)	Median (95% CI)	Median (95% CI)	Median (95% CI)	Median (95% CI)	Median (95% CI)	Median (95% CI)	Median (95% CI)	Median (95% CI)
R_0 of 2.5									
No vaccine	282.5 (280.7, 284.3)	232.1 (223.9, 240.0)	48.1 (46.4, 49.8)	8.5 (6.5, 9.7)	4,160.9 (4,014.2, 4,302.0)	267.2 (251.7, 282.6)	68.0 (51.8, 77.9)	883.5 (808.5, 980.8)	2,796.4 (1,661.8, 4,515.5)
60% vaccine efficacy, 75% coverage	43.0 (7.1, 53.8)	37.7 (6.2, 48.5)	7.8 (1.3, 10.0)	1.3 (0.2, 1.9)	675.9 (111.3, 869.0)	43.3 (7.2, 56.1)	10.5 (1.7, 15.1)	137.7 (22.5, 183.9)	386.6 (62.5, 771.4)
70% vaccine efficacy, 75% coverage	0.10 (0.04, 0.72)	0.09 (0.03, 0.65)	0.02 (0.01, 0.1)	0.003 (0.001, 0.02)	1.63 (0.58, 11.6)	0.10 (0.04, 0.75)	0.03 (0.01, 0.19)	0.33 (0.12, 2.34)	1.05 (0.32, 8.61)
80% vaccine efficacy, 60% coverage	27.1 (3.5, 45.8)	22.6 (2.9, 39.4)	4.7 (0.6, 8.2)	0.8 (0.1, 1.5)	404.3 (51.3, 705.5)	25.9 (3.3, 45.8)	6.5 (0.8, 11.9)	81.2 (10.5, 147.5)	239.0 (28.8, 604.0)
R_0 of 3.5									
No vaccine	312.9 (311.9, 314.0)	257.1 (248.7, 264.8)	53.3 (51.6, 54.9)	9.5 (7.2, 10.7)	4,608.3 (4,458.0, 4,747.6)	296.0 (281.4, 312.1)	76.2 (57.6, 85.7)	978.9 (896.4, 1,082.3)	3,141.3 (1,871.3, 5,059.2)
80% vaccine efficacy, 75% coverage	39.3 (5.6, 46.2)	33.3 (4.7, 40.5)	6.9 (1.0, 8.4)	1.1 (0.2, 1.6)	596.7 (84.5, 726.9)	38.2 (5.4, 46.9)	9.1 (1.4, 12.7)	119.7 (17.2, 154.3)	329.1 (54.3, 652.7)
80% vaccine efficacy, 60% coverage	110.9 (105.2, 119.3)	91.6 (86.9, 96.1)	19.0 (18.0, 19.9)	3.3 (2.6, 3.8)	1,642.8 (1,558.7, 1,723.1)	105.5 (98.2, 112.8)	26.7 (20.3, 31.0)	345.4 (311.2, 386.9)	1,076.7 (644.0, 1,795.9)

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