

Economic Benefits of COVID-19 Screening Tests with a Vaccine Rollout

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Abstract

This note estimates the costs and benefits of a nationwide COVID-19 screening testing program in the presence of an imminently arriving vaccine. Even for an optimistic vaccine rollout scenario, a well-designed federally-funded screening testing program, coupled with self-isolation of those who test positive, pays for itself in terms of increased fiscal revenues and is projected to save 10,000 or more lives. The sooner the testing program is put in place, the greater are its net economic benefits.

Key words: Epidemiological models, macroeconomics, antigen testing

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Since early in the COVID-19 pandemic, there have been calls for widespread, inexpensive and convenient COVID-19 screening tests as a way to identify infected individuals and control the spread of the virus.¹ In November 2020, Pfizer and BioNTech submitted an Emergency Use Authorization request to the US Food and Drug Administration for its vaccine, followed shortly by Moderna, and on December 8, 2020, the UK started a mass vaccination program. These promising vaccine developments raise the question of whether a national screening testing program is still cost effectiveness in light of an upcoming vaccine rollout.

This note reports the results of a macroeconomic cost-benefit analysis of a federally-funded national COVID-19 screening testing program in the presence of a vaccine distributed during 2021. This analysis updates Atkeson, Droste, Mina, and Stock (2020) (ADMS), which undertook a macroeconomic cost-benefit analysis of a national testing program with partial adherence, counterfactually introduced in the summer of 2020 in the absence of a vaccine. They estimated that a regular testing program with high specificity would pay for itself as measured by increased fiscal tax receipts and could save many tens of thousands of lives. ADMS used a 66-sector, five-age US national linked epidemiological-economic model that incorporates an economic behavioral response to the COVID-19 death rate. Here, we update ADMS to consider a testing program rolled out in early 2021 in conjunction with vaccine distribution during 2021.

We consider three vaccine paths (fast, medium, slow), two testing regimes (10-day and 5-day cadences), four testing regime start dates (Jan. 1, Jan. 15, Feb. 1, and Feb. 15, 2021), and two masking regimes (status quo and a 100-day mask push). In each combination of cases, we consider test sensitivities of 70%, 80%, and 90%.

Table 1 presents results for 10-day screening testing cadence with a fast vaccine path, in which vaccination begins in December 2020 and 50% of the US population has completed vaccination by the end of May 2020. The screening and diagnostic tests are assumed to cost \$5 (the cost of BinaxNOWTM antigen test) and \$50, respectively. The table shows results for both the status quo masking regime (panel A) and the 100-day masking push. All results are shown relative to a benchmark of no federal screening testing program.

¹ See for example Gottlieb et al. (2020), National Governors' Association (2020), The Conference Board (2020), Romer (2020), Rockefeller Institute (2020), Silcox et al (2020), and Kotlikoff and Mina (2020).

Table 1. Economic and mortality impacts of screening programs, fast vaccine rollout

Testing rollout	Additional testing costs (\$B)	Additional GPD (\$B)	Additional federal receipts (\$B)	Deaths averted (Thou)
<i>A. Status quo masking, 10-day cadence</i>				
Jan. 1	3.6	83.0	9.2	38
Jan. 15	3.1	58.4	6.5	27
Feb. 1	2.5	34.9	3.8	16
Feb. 15	2.0	20.7	2.3	10
<i>B. 100-day mask plan, 10-day cadence</i>				
Jan. 1	3.5	78.5	8.7	36
Jan. 15	3.0	54.5	6.0	25
Feb. 1	2.4	31.8	3.5	15
Feb. 15	2.0	18.5	2.0	9

Note: Figures are relative to a baseline scenario a uniform population daily screening rate of 1/328, about one million tests per day. Screening test sensitivity is 80% and specificity is 99.5%. Adherence to self-isolation among those testing positive is 50% for screening test alone. Simulation period runs through July 1, 2022.

For the cases considered in Table 1, the testing program averts between 10,000 and 38,000 deaths. The reduction in the prevalence of the virus leads to an increase in GDP of between \$19B and \$83B, which in turn increases federal revenues ranging from the cost of the testing to 2.5 times its cost. Measured by economic benefits (GDP), the benefits of the testing program exceed its costs by a factor of 9 to 23. Implementing the 100-day masking plan reduces testing program effectiveness by only 5% to 10%, measured by GDP and deaths averted. The impact of the testing program depends heavily on when it starts.

The results in Table 1 and in Tables 2-4 below for the other cases lead to the following conclusions:

1. Across all scenarios, the increase in GDP resulting from the testing program ranges from 8 to 29 times the incremental cost of the tests.
2. The timing of the introduction of the testing program has a large impact on the program's net benefits. For example, for the cases in Table 1, starting the testing program on January 1 instead of February 1 is estimated to save more than 20,000 lives.
3. In all scenarios, the screening test program pays for itself in part or in full. The breakeven screening test cost, at which the program just pays for itself because of increased federal revenues, is in the range \$4-\$14 per test for the fast vaccine path.

4. The results depend only weakly on the screening test sensitivity, a finding consistent with ADMS, Larremore et al (2020) and Paltiel, Zheng, and Walensky (2020).
5. The benefits of the testing program increase the longer the vaccine rollout is delayed. Thus, early implementation of a screening testing program acts as insurance against unexpected vaccination delays.

Model and assumptions

The ADMS model is a 66-sector national economic model linked through behavioral feedback to a 5-age national SIR model that includes susceptible, exposed, infected, recently recovered, fully recovered, and deceased compartments. All but the deceased compartments are differentiated by testing status (awaiting a screening test result, awaiting a diagnostic test result, or positive and self-isolating). Screening tests are given randomly to the non-symptomatic. Diagnostic tests are given to the symptomatic and are offered as a confirmatory test to those who test positive on the screening test. Because the screening test has imperfect specificity, the positive predictive value of a screening test can be low (typical values are 5%-25% for the parameter values considered here), so adherence to self-isolation is modeled as being partial in response to a positive screening test. The screening (antigen) test is assumed to be sensitive only to those infected, whereas the diagnostic (PCR) test is taken to be sensitive both to the infected and to the recently recovered. For additional discussion, see ADMS

Here, we extend the ADMS model to include vaccination. Vaccination is modeled as occurring randomly and independently of the infection status (susceptible, exposed, etc.), prior test results, and age. Vaccination is modeled as binary and completed so that a vaccinated individual is immune with probability equal to efficacy. It is not known whether a given individual becomes immune, and if she does not, she remains susceptible and active if she was susceptible prior to vaccination. Those vaccinated are removed from the screening and diagnostic testing programs.

Technical updates to the model include the addition of seasonality, re-estimation through Nov. 10, 2020, and updated estimates of the feedback rule. These updates are summarized in the Appendix.

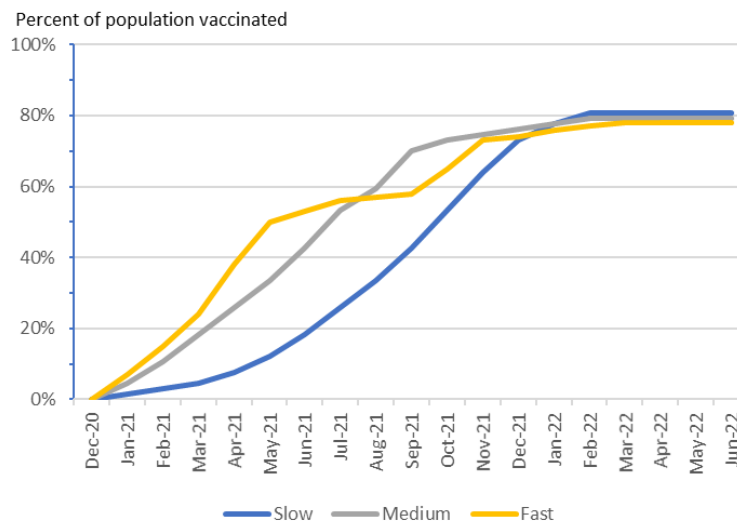
Testing, Vaccination, and Masking Scenarios

Testing. The baseline testing scenario is the current level of screening testing (approximately 1 million tests per day) and the current level of diagnostic testing. The federal screening testing programs make screening testing available to all non-vaccinated individuals at a specified rate (once every 5 or 10 days). Those who test positive on the screening test are offered a (free)

confirmatory PCR test; we assume that 90% of screening-positives take a confirmatory PCR test. All additional testing costs are paid by the federal government. The screening test is assumed to have specificity 99.5% and sensitivity 70%, 80%, or 90% and has marginal cost of \$5/test.² We assume 50% adherence for those testing positive on the screening test and not taking a confirmatory PCR test. The PCR test is assumed to have sensitivity 99.9%, specificity 99.7%, and marginal cost of \$50/test. The federal screening testing program is shut down when daily deaths fall below 100.

Vaccination. As of this writing, there is uncertainty about the number of distinct vaccines that will be available and the timetable for their availability and administration. Current polling data suggests that the take-up could be low, for example Gallup polling on Nov. 17, 2020 reported 58% of American adults would be willing to take the vaccine. Acceptance could increase as the vaccine is observed to be safe and effective, or it could fall if safety concerns arise. Vaccination could also be slowed if supply chain or administration disruptions occur.

Figure 1. Vaccination paths



We therefore consider three vaccination paths, shown in Figure 1 as the cumulative percentage of the US population that is vaccinated over time. Along the fast path, 50% of the population is vaccinated (two doses for two-dose vaccines) by the end of May, although take-up then slows because of limited demand until youth attending schools are vaccinated in the fall. Under the medium path, 53% are vaccinated by the end of July, with 75% vaccinated by the end of

² These costs and accuracy rates are for the Abbot Laboratories BinaxNOW™ antigen test. The BinaxNOW™ Emergency Use Authorization (US FDA (2020)) indicates a sensitivity of 97.1% and 98.5% specificity. The lower sensitivities used here are conservative and allow for failed tests or tests administered at home with administration errors. Research subsequent to the EUA suggests a lower sensitivity, 93.3%, and a higher specificity, 99.9% (Pilarowski et al [2020]). Our sensitivity of 99.5% and specificity of 80% are conservative relative to Pilarowski et al. (2020).

November. Under the slow path, 53% are vaccinated by the end of October. The vaccine is assumed to have 90% efficacy.

Masking. In December 2020, President-elect Biden announced that he would promote a call for national masking for the first 100 days of his administration. We calibrate the effect of this plan using updated estimates from Chernozhukov, Kasahara, and Schrimpf's (2020) analysis of the effect of mask mandates on deaths.³

Baseline. The baseline projections of deaths and GDP are shown in Figure 2 for status quo masking and the fast (upper) and slow (lower) vaccination path. There are 491,000 deaths in the baseline under the fast vaccination path and 538,000 under the slow path.⁴ Under all baseline paths there is a decrease in labor hours in early 2021. Under the slow vaccination path, there is a decline in GDP (double-dip) in the first quarter of 2021.

Cost-Benefit Estimates

We compute three measures of benefits of tests: incremental federal government revenues, incremental GDP in 2020 dollars, and total benefits which are incremental GDP plus the monetized value of deaths avoided, all cumulative through Dec. 31, 2022. Monetary values are in 2020 dollars. Revenues flowing from an increase in GDP are computed following the Congressional Budget Office (Russek and Kowalewski (2015, Table 3) and CBO (2019)). Deaths are monetized using the value of statistical life is from the US EPA (2020), converted to 2020 dollars, which is \$9.3 million per life. For additional details see ADMS.

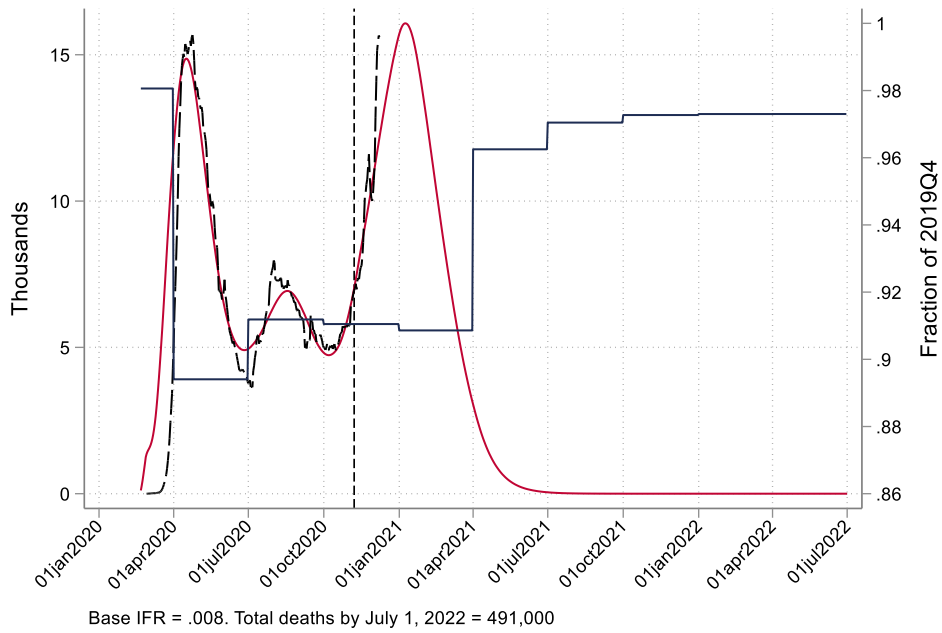
The results are summarized in Tables 2, 3, and 4 for the fast, medium, and slow vaccine timetables, respectively. Part (a) of each table provides additional testing costs, federal receipts, deaths averted, along with the screening testing cost at which the testing program would pay for itself in terms of additional revenue or, alternatively, in terms of additional GDP. Part (b) of each table provides additional detail on incremental days in quarantine, days employed, testing numbers, and net benefits. As discussed below, the results depend only weakly on sensitivity, so the tables present results only for screening test sensitivity of 80%.

³ Specifically, the mask order is estimated to reduce transmission by 6% (Chernozhukov et al. [2020, updated], personal communication).

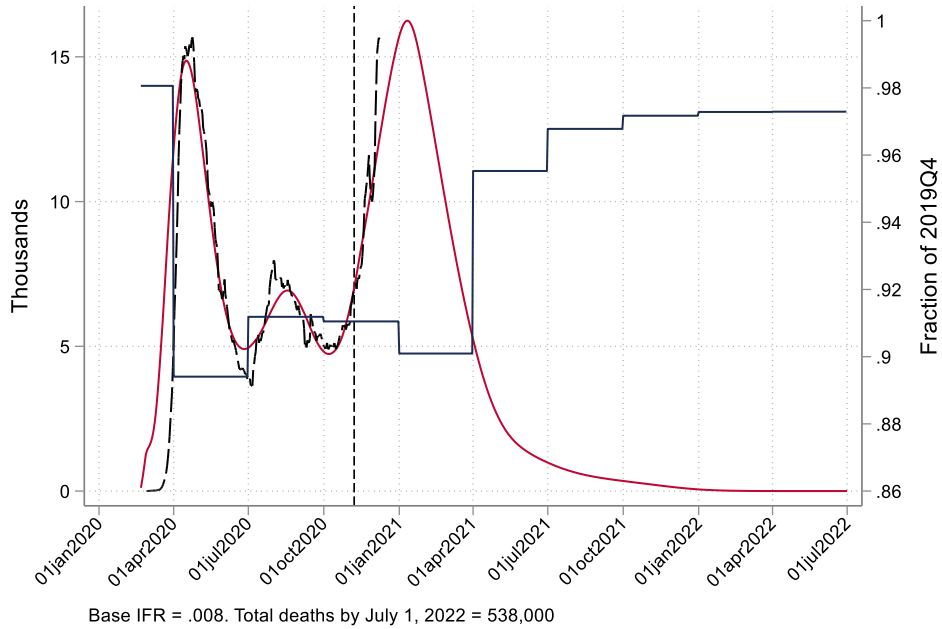
⁴ For comparison, the IHME model projection as of December 9, 2020, which incorporates vaccination, is for 539,000 deaths by April 1, 2021.

Figure 2. Two baseline time paths for deaths and quarterly GDP

(a) Fast vaccination path, status quo masks



(b) Slow vaccination path, status quo masks



The results in Table 2-4, and unreported results for different screening test sensitivities, suggest the following broad observations, in addition to those listed above. For example, increasing the screening program from a 10- to a 5-day cadence reduces deaths and increases economic activity. The returns from more frequent testing, however, are diminishing.

The results in Tables 2, 3, and 4, which are for a screening test with 80% sensitivity, depend only weakly on this sensitivity. For example, under the 100-day masking plan with 10-day cadence, a screening testing program with 70%, 80%, and 90% sensitivity started on January 1 averts 34,000, 36,000, and 39,000 deaths, respectively, and increases GDP by \$71.7B, \$78.5B, and \$84.9B. Given these small increments, it follows that a screening test with high sensitivity is not much more valuable than a screening test with low sensitivity, measured by its fiscal breakeven cost per test. For this same scenario, for example, the fiscal breakeven cost for tests with 70%, 80%, and 90% sensitivity is \$11, \$12, and \$14 per test.

Comparing Tables 2 and 4 shows that the benefits of the screening testing program are substantially larger if the vaccine timetable is delayed. For example, a 10-day testing program starting January 1 averts 56,000 deaths, and increases GDP by \$122B, under the slow vaccine timetable and 100-day masking, compared to averting 36,000 and increasing GDP by \$79B under the fast vaccine timetable. Such comparisons lead to the conclusion that the screening testing program serves as insurance against vaccination delays.

Table 2a. Economic and mortality impacts of screening programs (Fast vaccination path)

Test roll-out	Test cadence (days)	Additional testing costs (\$B)	Additional GDP (\$B)	Additional federal receipts (\$B)	Deaths averted (Thou)	Fiscal break-even cost (\$/test)	GDP break-even cost (\$/test)
<i>A. Status quo masking</i>							
Jan. 1	10	3.60	83.0	9.2	38	13.06	120.00
Jan. 15	10	3.05	58.4	6.5	27	10.81	99.72
Feb. 1	10	2.47	34.9	3.8	16	7.92	73.63
Feb. 15	10	2.02	20.7	2.3	10	5.70	53.61
Jan. 1	5	6.47	130.5	14.4	60	11.38	104.66
Jan. 15	5	5.57	92.5	10.2	43	9.34	86.27
Feb. 1	5	4.47	56.0	6.2	26	7.00	65.23
Feb. 15	5	3.69	34.1	3.8	16	5.11	48.10
<i>B. 100-day mask plan</i>							
Jan. 1	10	3.51	78.5	8.7	36	12.66	116.37
Jan. 15	10	3.00	54.5	6.0	25	10.26	94.78
Feb. 1	10	2.42	31.8	3.5	15	7.38	68.74
Feb. 15	10	1.97	18.5	2.0	9	5.20	49.11
Jan. 1	5	6.47	123.2	13.6	57	10.72	98.76
Jan. 15	5	5.39	86.6	9.6	40	9.03	83.48
Feb. 1	5	4.35	51.4	5.7	24	6.58	61.44
Feb. 15	5	3.58	30.6	3.4	15	4.72	44.60

Note: Figures are relative to a baseline scenario a uniform population daily screening rate of 1/328, about one million tests per day. Screening test sensitivity is 80% and specificity is 99.5%. Adherence to self-isolation among those testing positive is 50% for screening test alone. Simulation period is Nov. 7, 2020 - July 1, 2022.

Table 2b. Economic and mortality impacts of screening programs (Fast vaccination path)

Test roll-out	Test cadence (days)	Quarantine days (M)	Employment days (M)	Additional diagnostic tests (M)	Additional screening tests (M)	Net fiscal benefits (\$B)	Net economic benefits (\$B)	Total net benefits (\$B)
<i>A. Status quo masking</i>								
Jan. 1	10	4.37	263.8	2.90	690	5.6	79.4	434.1
Jan. 15	10	7.06	188.6	2.61	585	3.4	55.4	305.1
Feb. 1	10	6.85	114.9	2.24	472	1.4	32.4	182.4
Feb. 15	10	4.80	69.7	1.92	385	0.3	18.7	109.6
Jan. 1	5	9.02	415.8	4.94	1245	7.9	124.1	680.4
Jan. 15	5	15.98	298.3	4.49	1069	4.6	86.9	483.9
Feb. 1	5	17.11	184.2	3.80	856	1.7	51.6	294.7
Feb. 15	5	14.73	114.0	3.26	706	0.1	30.4	181.7
<i>B. 100-day mask plan</i>								
Jan. 1	10	5.16	250.0	2.85	674	5.2	75.0	412.4
Jan. 15	10	7.73	176.3	2.58	574	3.0	51.5	285.9
Feb. 1	10	7.09	105.2	2.21	461	1.1	29.4	167.2
Feb. 15	10	4.74	62.4	1.88	374	0.1	16.5	98.2
Jan. 1	5	11.67	392.5	5.00	1245	7.1	116.7	643.6
Jan. 15	5	16.80	279.6	4.38	1034	4.2	81.2	454.7
Feb. 1	5	17.52	169.3	3.73	834	1.3	47.1	271.5
Feb. 15	5	14.59	102.8	3.17	684	-0.2	27.1	164.2

See the notes to Table 2a.

Table 3a. Economic and mortality impacts of screening programs (Medium vaccination path)

Test roll-out	Test cadence (days)	Additional testing costs (\$B)	Additional GDP (\$B)	Additional federal receipts (\$B)	Deaths averted (Thou)	Fiscal break-even cost (\$/test)	GDP break-even cost (\$/test)
<i>A. Status quo masking</i>							
Jan. 1	10	3.92	94.7	10.5	44	13.68	125.45
Jan. 15	10	3.41	69.2	7.6	32	11.48	105.71
Feb. 1	10	2.82	43.9	4.8	20	8.76	81.12
Feb. 15	10	2.36	28.0	3.1	13	6.62	61.91
Jan. 1	5	7.00	146.9	16.2	67	11.84	108.76
Jan. 15	5	6.04	107.5	11.9	50	10.02	92.39
Feb. 1	5	5.00	68.7	7.6	32	7.70	71.45
Feb. 15	5	4.21	44.6	4.9	21	5.89	55.11
<i>B. 100-day mask plan</i>							
Jan. 1	10	3.83	89.3	9.9	41	13.20	121.15
Jan. 15	10	3.32	64.3	7.1	30	10.96	100.98
Feb. 1	10	2.73	39.9	4.4	19	8.22	76.28
Feb. 15	10	2.27	24.9	2.8	12	6.12	57.37
Jan. 1	5	6.81	138.9	15.3	64	11.50	105.74
Jan. 15	5	5.85	100.2	11.1	47	9.64	88.96
Feb. 1	5	4.81	62.9	6.9	30	7.32	68.04
Feb. 15	5	4.02	39.9	4.4	19	5.50	51.64

See the notes to Table 2a.

Table 3b. Economic and mortality impacts of screening programs (Medium vaccination path)

Test roll-out	Test cadence (days)	Quarantine days (M)	Employment days (M)	Additional diagnostic tests (M)	Additional screening tests (M)	Net fiscal benefits (\$B)	Net economic benefits (\$B)	Total net benefits (\$B)
<i>A. Status quo masking</i>								
Jan. 1	10	0.28	301.2	3.08	753	6.5	90.7	493.9
Jan. 15	10	3.91	223.2	2.82	653	4.2	65.8	360.3
Feb. 1	10	4.80	144.3	2.47	539	2.0	41.0	228.9
Feb. 15	10	3.62	93.6	2.16	450	0.7	25.6	147.7
Jan. 1	5	3.09	468.4	5.24	1349	9.2	139.9	763.9
Jan. 15	5	10.96	346.7	4.75	1161	5.8	101.5	560.8
Feb. 1	5	14.26	225.3	4.14	959	2.6	63.7	360.1
Feb. 15	5	13.23	148.6	3.61	806	0.7	40.4	236.8
<i>B. 100-day mask plan</i>								
Jan. 1	10	1.46	284.3	3.03	736	6.0	85.4	467.5
Jan. 15	10	4.79	207.9	2.77	635	3.8	61.0	336.2
Feb. 1	10	5.20	131.6	2.41	522	1.7	37.2	209.2
Feb. 15	10	3.66	83.7	2.09	433	0.5	22.7	132.3
Jan. 1	5	5.01	443.1	5.13	1311	8.5	132.1	724.7
Jan. 15	5	12.38	323.6	4.64	1124	5.2	94.4	524.8
Feb. 1	5	14.75	206.9	4.02	922	2.1	58.1	331.4
Feb. 15	5	13.16	133.4	3.48	770	0.4	35.9	213.1

See the notes to Table 2a.

Table 4a. Economic and mortality impacts of screening programs (Slow vaccination path)

Test roll-out	Test cadence (days)	Additional testing costs (\$B)	Additional GDP (\$B)	Additional federal receipts (\$B)	Deaths averted (Thou)	Fiscal break-even cost (\$/test)	GDP break-even cost (\$/test)
<i>A. Status quo masking</i>							
Jan. 1	10	5.04	130.1	14.4	59	14.65	133.98
Jan. 15	10	4.48	105.7	11.7	48	13.37	122.44
Feb. 1	10	3.85	79.1	8.7	36	11.61	106.65
Feb. 15	10	3.42	60.6	6.7	28	10.01	92.17
Jan. 1	5	8.31	190.9	21.1	87	12.99	118.95
Jan. 15	5	7.36	154.2	17.1	71	11.85	108.65
Feb. 1	5	6.32	114.6	12.7	53	10.22	93.99
Feb. 15	5	5.53	87.0	9.6	41	8.85	81.61
<i>B. 100-day mask plan</i>							
Jan. 1	10	4.82	121.7	13.5	56	14.32	131.02
Jan. 15	10	4.26	97.7	10.8	45	12.98	118.96
Feb. 1	10	3.67	72.1	8.0	33	11.10	102.02
Feb. 15	10	3.24	54.5	6.0	26	9.50	87.65
Jan. 1	5	8.01	179.3	19.8	82	12.65	115.85
Jan. 15	5	7.06	143.0	15.8	66	11.44	105.03
Feb. 1	5	6.03	104.6	11.6	49	9.78	90.05
Feb. 15	5	5.31	78.6	8.7	37	8.31	76.84

See the notes to Table 2a.

Table 4b. Economic and mortality impacts of screening programs (Slow vaccination path)

Test roll-out	Test cadence (days)	Quarantine days (M)	Employment days (M)	Additional diagnostic tests (M)	Additional screening tests (M)	Net fiscal benefits (\$B)	Net economic benefits (\$B)	Total net benefits (\$B)
<i>A. Status quo masking</i>								
Jan. 1	10	-14.20	415.8	3.75	970	9.4	125.1	674.6
Jan. 15	10	-11.25	342.1	3.45	862	7.2	101.3	548.7
Feb. 1	10	-9.61	259.6	3.07	740	4.9	75.2	412.4
Feb. 15	10	-9.18	201.1	2.81	656	3.3	57.2	319.5
Jan. 1	5	-16.31	611.0	5.95	1603	12.8	182.6	986.5
Jan. 15	5	-9.37	498.8	5.45	1417	9.7	146.9	800.8
Feb. 1	5	-4.67	375.6	4.86	1216	6.4	108.2	598.8
Feb. 15	5	-3.29	288.2	4.37	1063	4.1	81.4	459.5
<i>B. 100-day mask plan</i>								
Jan. 1	10	-12.59	389.5	3.62	927	8.6	116.9	633.9
Jan. 15	10	-9.83	316.8	3.31	820	6.5	93.4	509.4
Feb. 1	10	-8.53	237.3	2.96	705	4.3	68.4	378.0
Feb. 15	10	-8.50	181.7	2.69	621	2.8	51.3	289.7
Jan. 1	5	-13.42	574.4	5.79	1545	11.8	171.2	930.7
Jan. 15	5	-6.81	463.4	5.28	1359	8.8	136.0	746.5
Feb. 1	5	-2.92	343.8	4.68	1159	5.5	98.6	549.7
Feb. 15	5	-2.00	261.4	4.23	1021	3.4	73.3	418.4

See the notes to Table 2a.

Appendix: Technical Updates and Parameter Values

This appendix summarizes three technical updates of the model, relative to ADMS.

First, the model was updated to include seasonality in the transmissibility of the virus. The literature on COVID seasonality is limited because COVID has not existed for a full seasonal cycle. IHME (2020) calibrated COVID seasonality using pneumonia seasonality. We rely instead on regression estimates of COVID seasonality in Tzampoglou and Loukidis (2020), who use country-level data from March through May 2020. Their estimates imply fluctuations in deaths of 21% to 32% as a result of temperature variation across the full range of cross-country temperatures. We adopt the approximate midpoint of this range and use a 25% full seasonal fluctuation in transmissibility, which we approximate as a seasonal cosine peaking on January 1, a pattern consistent with Merow and Urban (2020).

Second, we reestimated the model using daily U.S. deaths data (7-day moving average) from March 15, 2020 through Nov. 10, 2020. The simulation period runs from Nov. 7, 2020 through July 1, 2022. The ADMS model uses a nonparametric flexible functional form to fit unobserved self-protective behavior such as masking and social distancing, specifically on a Type-II cosine expansion with three terms. The ADMS parameter estimation sample was March 15 – June 12, 2020. For the longer sample used here, we added two more terms to the Type-II cosine expansion. Also, the ADMS model calibrated protections for the elderly, however the longer sample afforded sufficient data to estimate a separate factor multiplying the cosine expansion to apply to the oldest age group, 75+. In all the model used here has 8 estimated parameters: the number of infections on February 21, 2020, the initial transmissibility rate per adult contact (equivalently, the initial R_0), the five parameters of the cosine expansion, and the elderly protection factor.

Third, the behavioral feedback rule was updated. ADMS considered two behavioral response rules from deaths to economic activity: the calibrated rule used in Baqaee, Farhi, Mina, and Stock (2020) and a simpler rule estimated by Arnon, Ricco, and Smetters (2020). Both those feedback rules are based on data from Spring 2020. A plausible concern is that the response of economic activity to the prevalence of the virus diminished as individuals adapt and experience lockdown fatigue. Here, we therefore adopt a behavioral rule in which economic activity depends on the current death rate (as in Arnon, Ricco, and Smetters (2020)), where the feedback parameter is estimated so that an exogenous disappearance of the virus would bring labor hours, as a fraction of potential, to a specified level.⁵

⁵ Specifically we assume a post-pandemic level of labor hours at 96.4% of potential, which we compute from the Hall-Kudlyak (2020) estimate of the unemployed without jobs plus the change in the labor force participation rate from February through November 2020.

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