

Supplementary Material

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COVID-19 Natural History Estimations

Estimated Time of COVID-19 Infection to Diagnosis

We used a range 5 to 10 days to estimate time from COVID-19 infection to diagnosis of the case by community laboratory testing. In doing so, we estimated both the time from infection to symptom onset, as well as time from symptom onset to laboratory diagnosis. We estimated the time from COVID-19 infection to symptom onset to be a median of 5 days with interquartile range of 4 to 7 based on aggregate analysis of multiple peer-reviewed publications of confirmed COVID-19 cases in China.¹⁻⁷ We then estimated the time from COVID-19 symptom onset to laboratory diagnosis to be a median of 2 days with interquartile range of 1 to 3, factoring in data reported from China^{1,3} and limitations in U.S. testing.⁸ We also considered that the time from symptom onset to laboratory diagnosis would likely decrease over the duration of the pandemic, based on data describing COVID-19 in China^{4,5} and data describing reductions in this time during the severe acute respiratory syndrome epidemic in Hong Kong.³ Combining the estimations of COVID-19 infection to symptoms and symptoms to diagnosis yield an interquartile range of 5 to 10 days.

Estimated Time of COVID-19 Diagnosis to Death

We used an *a priori* definition of range 6 to 15 days to estimate time from COVID-19 diagnosis to death. This definition was informed by data reported by the Centers for Disease Control and Prevention describing patients who died with COVID-19 in the United States from February 12, 2020 to May 18, 2020.⁹ Review of literature reporting time from illness onset to death in China was grossly similar although generally greater time periods.^{3,8,10}

Model Phasing

Phases were aligned with calendar weeks being modeled. These phases were determined subjectively based on total numbers of COVID-19 cases over different periods of the pandemic. Four were used in the presented modeling: (1) March 22, 2020 – June 13, 2020, (2) June 14, 2020 – September 12, 2020, (3) September 13, 2020 – December 12, 2020, and (4) December 12, 2020 – February 12, 2021. These phases agree with chronological patterns in the type of breakpoint (increase vs. decrease in case velocity) over the study period (**Figures S2 and S3**) but are an unverifiable assumption in our models.

Table S1. Dates of Non-Pharmaceutical Intervention Adoptions and Discontinuations by U.S. State

<i>State</i>	<i>Policy</i>	<i>Gathering Ban Level</i>	<i>Date</i>
Alabama	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	mild	03/19/2020
	indoor public gathering ban	severe	03/28/2020
	stay at home order (on)		04/04/2020
	stay at home order (off)		04/30/2020
	indoor public gathering ban	no gathering ban	05/11/2020
	indoor restaurant dining ban (off)		05/11/2020
	public mask mandate (on)		07/16/2020
Alaska	indoor restaurant dining ban (on)		03/18/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/28/2020
	stay at home order (off)		04/24/2020
	indoor restaurant dining ban (off)		05/19/2020
	indoor public gathering ban	no gathering ban	05/22/2020
Arizona	indoor public gathering ban	severe	03/16/2020
	indoor restaurant dining ban (on)		03/31/2020
	stay at home order (on)		03/31/2020
	indoor restaurant dining ban (off)		05/11/2020
	indoor public gathering ban	no gathering ban	05/12/2020
	stay at home order (off)		05/15/2020
	indoor public gathering ban	mild	06/29/2020
Arkansas	indoor restaurant dining ban (on)		03/19/2020
	indoor public gathering ban	severe	03/27/2020
	indoor public gathering ban	mild	05/04/2020
	indoor restaurant dining ban (off)		05/11/2020
	public mask mandate (on)		07/20/2020
	indoor public gathering ban	severe	01/02/2021
California	indoor public gathering ban	mild	03/11/2020
	indoor public gathering ban	severe	03/19/2020
	indoor restaurant dining ban (on)		03/19/2020
	stay at home order (on)		03/19/2020
	indoor restaurant dining ban (off)		05/19/2020
	public mask mandate (on)		06/18/2020
	indoor restaurant dining ban (on)		07/13/2020

	indoor restaurant dining ban (off)		08/28/2020
	stay at home order (off)		01/25/2021
Colorado	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/19/2020
	stay at home order (on)		03/26/2020
	stay at home order (off)		04/26/2020
	indoor restaurant dining ban (off)		05/27/2020
	public mask mandate (on)		07/16/2020
Connecticut	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/16/2020
	stay at home order (on)		03/23/2020
	indoor public gathering ban	severe	03/26/2020
	public mask mandate (on)		04/20/2020
	stay at home order (off)		05/20/2020
	indoor public gathering ban	mild	06/17/2020
	indoor restaurant dining ban (off)		06/17/2020
Delaware	indoor public gathering ban	mild	03/16/2020
	indoor restaurant dining ban (on)		03/16/2020
	stay at home order (on)		03/24/2020
	indoor public gathering ban	severe	04/02/2020
	public mask mandate (on)		04/28/2020
	stay at home order (off)		05/31/2020
	indoor restaurant dining ban (off)		06/01/2020
	indoor public gathering ban	mild	06/15/2020
	indoor public gathering ban	severe	12/14/2020
Florida	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/20/2020
	indoor public gathering ban	severe	04/03/2020
	stay at home order (on)		04/03/2020
	stay at home order (off)		05/04/2020
	indoor restaurant dining ban (off)		05/18/2020
	indoor public gathering ban	mild	06/05/2020
	indoor public gathering ban	no gathering ban	09/25/2020
Georgia	indoor public gathering ban	mild	03/19/2020
	indoor public gathering ban	severe	03/23/2020
	indoor restaurant dining ban (on)		04/03/2020

	stay at home order (on)		04/03/2020
	indoor restaurant dining ban (off)		04/27/2020
	stay at home order (off)		04/30/2020
	indoor public gathering ban	mild	06/01/2020
Hawaii	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/25/2020
	stay at home order (on)		03/25/2020
	public mask mandate (on)		04/25/2020
	stay at home order (off)		05/31/2020
	indoor restaurant dining ban (off)		06/05/2020
	indoor restaurant dining ban (on)		08/27/2020
	stay at home order (on)		08/27/2020
	indoor restaurant dining ban (off)		09/24/2020
	stay at home order (off)		09/24/2020
Idaho	indoor public gathering ban	mild	03/16/2020
	indoor public gathering ban	severe	03/19/2020
	indoor restaurant dining ban (on)		03/25/2020
	stay at home order (on)		03/25/2020
	stay at home order (off)		04/30/2020
	indoor restaurant dining ban (off)		05/16/2020
Illinois	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/21/2020
	stay at home order (on)		03/21/2020
	public mask mandate (on)		05/01/2020
	stay at home order (off)		05/29/2020
	indoor public gathering ban	mild	06/26/2020
	indoor restaurant dining ban (off)		06/26/2020
	indoor restaurant dining ban (on)		10/22/2020
	indoor public gathering ban	severe	11/20/2020
	indoor public gathering ban	mild	01/15/2021
	indoor restaurant dining ban (off)		01/19/2021
Indiana	indoor public gathering ban	mild	03/12/2020
	indoor public gathering ban	severe	03/16/2020
	indoor restaurant dining ban (on)		03/16/2020
	stay at home order (on)		03/24/2020
	stay at home order (off)		05/01/2020

	indoor public gathering ban	mild	05/04/2020
	indoor restaurant dining ban (off)		05/11/2020
	public mask mandate (on)		07/27/2020
	indoor public gathering ban	no gathering ban	09/26/2020
Iowa	indoor public gathering ban	severe	03/17/2020
	indoor restaurant dining ban (on)		03/17/2020
	indoor restaurant dining ban (off)		05/15/2020
	indoor public gathering ban	mild	06/01/2020
	public mask mandate (on)		11/17/2020
Kansas	indoor public gathering ban	mild	03/16/2020
	indoor public gathering ban	severe	03/25/2020
	indoor restaurant dining ban (on)		03/30/2020
	stay at home order (on)		03/30/2020
	stay at home order (off)		05/03/2020
	indoor restaurant dining ban (off)		05/04/2020
	indoor public gathering ban	mild	05/22/2020
	public mask mandate (on)		07/03/2020
Kentucky	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	mild	03/19/2020
	indoor public gathering ban	severe	03/25/2020
	stay at home order (on)		03/26/2020
	indoor restaurant dining ban (off)		05/22/2020
	indoor public gathering ban	mild	06/29/2020
	stay at home order (off)		06/29/2020
	public mask mandate (on)		07/09/2020
	indoor public gathering ban	severe	07/20/2020
Louisiana	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/22/2020
	stay at home order (on)		03/23/2020
	indoor public gathering ban	mild	05/15/2020
	indoor restaurant dining ban (off)		05/15/2020
	stay at home order (off)		05/15/2020
	public mask mandate (on)		07/13/2020
Maine	indoor public gathering ban	mild	03/12/2020
	indoor public gathering ban	severe	03/18/2020
	indoor restaurant dining ban (on)		03/18/2020

	stay at home order (on)		04/02/2020
	public mask mandate (on)		05/01/2020
	indoor restaurant dining ban (off)		05/18/2020
	indoor public gathering ban	mild	05/31/2020
	stay at home order (off)		05/31/2020
Maryland	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/19/2020
	stay at home order (on)		03/30/2020
	public mask mandate (on)		04/18/2020
	stay at home order (off)		05/15/2020
	indoor restaurant dining ban (off)		06/12/2020
	indoor public gathering ban	no gathering ban	09/01/2020
	indoor public gathering ban	severe	12/17/2020
Massachusetts	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/24/2020
	public mask mandate (on)		05/06/2020
	stay at home order (off)		05/18/2020
	indoor restaurant dining ban (off)		06/22/2020
	indoor public gathering ban	mild	07/06/2020
	indoor public gathering ban	severe	11/06/2020
Michigan	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/24/2020
	indoor restaurant dining ban (off)		05/22/2020
	stay at home order (off)		06/01/2020
	indoor public gathering ban	mild	06/10/2020
	public mask mandate (on)		07/10/2020
	public mask mandate (off)		10/02/2020
	public mask mandate (on)		10/05/2020
	indoor restaurant dining ban (on)		12/09/2020
	indoor public gathering ban	severe	12/21/2020
Minnesota	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/17/2020

	indoor public gathering ban	severe	03/26/2020
	stay at home order (on)		03/27/2020
	stay at home order (off)		05/17/2020
	indoor public gathering ban	mild	05/18/2020
	indoor restaurant dining ban (off)		06/05/2020
	public mask mandate (on)		07/25/2020
	indoor restaurant dining ban (on)		11/21/2020
	indoor restaurant dining ban (off)		01/11/2021
	indoor public gathering ban	severe	01/13/2021
Mississippi	indoor public gathering ban	severe	03/25/2020
	indoor restaurant dining ban (on)		04/03/2020
	stay at home order (on)		04/03/2020
	stay at home order (off)		04/27/2020
	indoor restaurant dining ban (off)		05/07/2020
	indoor public gathering ban	mild	06/01/2020
	indoor public gathering ban	severe	07/13/2020
	public mask mandate (on)		08/05/2020
	public mask mandate (off)		09/30/2020
	public mask mandate (on)		10/19/2020
Missouri	indoor public gathering ban	mild	03/15/2020
	indoor public gathering ban	severe	03/23/2020
	indoor restaurant dining ban (on)		04/06/2020
	stay at home order (on)		04/06/2020
	stay at home order (off)		05/03/2020
	indoor public gathering ban	no gathering ban	05/04/2020
	indoor restaurant dining ban (off)		05/04/2020
Montana	indoor public gathering ban	mild	03/16/2020
	indoor restaurant dining ban (on)		03/20/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/28/2020
	stay at home order (off)		04/26/2020
	indoor restaurant dining ban (off)		05/04/2020
	indoor public gathering ban	mild	06/01/2020
	public mask mandate (on)		11/17/2020
	indoor public gathering ban	no gathering ban	01/15/2021
Nebraska	indoor public gathering ban	mild	03/13/2020
	indoor public gathering ban	severe	03/16/2020

	indoor restaurant dining ban (on)		03/19/2020
	indoor restaurant dining ban (off)		05/04/2020
	indoor public gathering ban	mild	06/01/2020
Nevada	indoor restaurant dining ban (on)		03/20/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/31/2020
	indoor restaurant dining ban (off)		05/09/2020
	stay at home order (off)		05/15/2020
	indoor public gathering ban	mild	05/29/2020
	public mask mandate (on)		06/26/2020
New Hampshire	indoor public gathering ban	mild	03/16/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/27/2020
	indoor public gathering ban	no gathering ban	06/15/2020
	indoor restaurant dining ban (off)		06/15/2020
	stay at home order (off)		06/15/2020
	public mask mandate (on)		11/20/2020
New Jersey	indoor public gathering ban	mild	03/16/2020
	indoor public gathering ban	severe	03/21/2020
	indoor restaurant dining ban (on)		03/21/2020
	stay at home order (on)		03/21/2020
	stay at home order (off)		06/09/2020
	indoor public gathering ban	mild	06/22/2020
	public mask mandate (on)		07/08/2020
	indoor restaurant dining ban (off)		09/04/2020
	indoor public gathering ban	severe	12/07/2020
New Mexico	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/19/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/24/2020
	public mask mandate (on)		05/16/2020
	indoor restaurant dining ban (off)		06/01/2020
	stay at home order (off)		06/30/2020
	indoor restaurant dining ban (on)		07/13/2020
	indoor restaurant dining ban (off)		08/29/2020
	stay at home order (on)		11/13/2020

	indoor restaurant dining ban (on)		11/16/2020
	stay at home order (off)		11/30/2020
	indoor restaurant dining ban (off)		12/02/2020
New York	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/22/2020
	stay at home order (on)		03/22/2020
	public mask mandate (on)		04/17/2020
	stay at home order (off)		05/28/2020
	indoor restaurant dining ban (off)		06/12/2020
	indoor public gathering ban	mild	06/15/2020
	indoor public gathering ban	severe	11/11/2020
North Carolina	indoor public gathering ban	mild	03/14/2020
	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/30/2020
	stay at home order (on)		03/30/2020
	indoor restaurant dining ban (off)		05/22/2020
	stay at home order (off)		05/22/2020
	public mask mandate (on)		06/26/2020
North Dakota	indoor restaurant dining ban (on)		03/20/2020
	indoor restaurant dining ban (off)		05/01/2020
	public mask mandate (on)		11/14/2020
	public mask mandate (off)		01/18/2021
Ohio	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/15/2020
	indoor public gathering ban	severe	03/22/2020
	stay at home order (on)		03/23/2020
	stay at home order (off)		05/19/2020
	indoor restaurant dining ban (off)		05/21/2020
	public mask mandate (on)		07/23/2020
Oklahoma	indoor public gathering ban	severe	03/24/2020
	indoor restaurant dining ban (on)		03/25/2020
	indoor restaurant dining ban (off)		05/01/2020
	indoor public gathering ban	mild	05/15/2020
	indoor public gathering ban	mild	12/10/2020
Oregon	indoor public gathering ban	mild	03/12/2020
	indoor restaurant dining ban (on)		03/17/2020

	indoor public gathering ban	severe	03/23/2020
	stay at home order (on)		03/23/2020
	indoor public gathering ban	mild	05/15/2020
	indoor restaurant dining ban (off)		05/15/2020
	stay at home order (off)		06/19/2020
	public mask mandate (on)		07/01/2020
	indoor public gathering ban	severe	07/15/2020
	indoor restaurant dining ban (on)		11/18/2020
	indoor restaurant dining ban (off)		12/02/2020
	indoor public gathering ban	mild	12/18/2020
Pennsylvania	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/17/2020
	stay at home order (on)		04/01/2020
	indoor public gathering ban	mild	05/08/2020
	indoor restaurant dining ban (off)		05/29/2020
	stay at home order (off)		06/04/2020
	public mask mandate (on)		07/01/2020
	indoor public gathering ban	no gathering ban	09/22/2020
	indoor public gathering ban	mild	10/01/2020
	indoor restaurant dining ban (on)		12/12/2020
	indoor restaurant dining ban (off)		01/04/2021
Rhode Island	indoor public gathering ban	mild	03/11/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/28/2020
	stay at home order (on)		03/28/2020
	public mask mandate (on)		05/08/2020
	stay at home order (off)		05/08/2020
	indoor public gathering ban	mild	06/01/2020
	indoor restaurant dining ban (off)		06/01/2020
South Carolina	indoor public gathering ban	mild	03/15/2020
	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/23/2020
	stay at home order (on)		04/07/2020
	stay at home order (off)		05/04/2020
	indoor restaurant dining ban (off)		05/11/2020
	indoor public gathering ban	mild	06/11/2020
South Dakota	indoor public gathering ban	severe	03/23/2020

	indoor public gathering ban	no gathering ban	04/28/2020
Tennessee	indoor public gathering ban	mild	03/13/2020
	indoor public gathering ban	severe	03/22/2020
	indoor restaurant dining ban (on)		03/23/2020
	stay at home order (on)		03/31/2020
	indoor restaurant dining ban (off)		04/27/2020
	stay at home order (off)		04/30/2020
	indoor public gathering ban	mild	05/22/2020
	indoor public gathering ban	no gathering ban	09/29/2020
	indoor public gathering ban	severe	12/20/2020
Texas	indoor restaurant dining ban (on)		03/20/2020
	indoor public gathering ban	severe	03/21/2020
	stay at home order (on)		04/02/2020
	stay at home order (off)		04/30/2020
	indoor restaurant dining ban (off)		05/01/2020
	indoor public gathering ban	mild	05/05/2020
	public mask mandate (on)		07/03/2020
Utah	indoor public gathering ban	mild	03/16/2020
	indoor restaurant dining ban (on)		03/18/2020
	indoor public gathering ban	severe	03/21/2020
	indoor restaurant dining ban (off)		05/01/2020
	indoor public gathering ban	mild	05/16/2020
	public mask mandate (on)		11/08/2020
	indoor public gathering ban	no gathering ban	11/24/2020
Vermont	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/21/2020
	stay at home order (on)		03/25/2020
	stay at home order (off)		05/15/2020
	indoor public gathering ban	mild	06/01/2020
	indoor restaurant dining ban (off)		06/05/2020
	public mask mandate (on)		08/01/2020
	indoor public gathering ban	severe	11/14/2020
Virginia	indoor public gathering ban	mild	03/15/2020
	indoor restaurant dining ban (on)		03/24/2020
	indoor public gathering ban	severe	03/25/2020
	stay at home order (on)		03/30/2020

	stay at home order (off)		05/28/2020
	public mask mandate (on)		05/29/2020
	indoor public gathering ban	mild	06/05/2020
	indoor restaurant dining ban (off)		06/05/2020
	indoor public gathering ban	severe	12/14/2020
Washington	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/16/2020
	indoor public gathering ban	severe	03/23/2020
	stay at home order (on)		03/23/2020
	indoor restaurant dining ban (off)		05/11/2020
	stay at home order (off)		05/31/2020
	indoor public gathering ban	mild	06/19/2020
	public mask mandate (on)		06/26/2020
	indoor public gathering ban	severe	07/20/2020
	indoor public gathering ban	mild	10/13/2020
	indoor restaurant dining ban (on)		11/18/2020
	indoor restaurant dining ban (off)		01/28/2021
West Virginia	indoor restaurant dining ban (on)		03/17/2020
	indoor public gathering ban	severe	03/24/2020
	stay at home order (on)		03/24/2020
	stay at home order (off)		05/03/2020
	indoor restaurant dining ban (off)		05/21/2020
	indoor public gathering ban	mild	05/24/2020
	public mask mandate (on)		07/07/2020
Wisconsin	indoor public gathering ban	mild	03/16/2020
	indoor public gathering ban	severe	03/17/2020
	indoor restaurant dining ban (on)		03/17/2020
	stay at home order (on)		03/25/2020
	indoor public gathering ban	no gathering ban	05/13/2020
	indoor restaurant dining ban (off)		05/13/2020
	stay at home order (off)		05/13/2020
	public mask mandate (on)		08/01/2020
	indoor public gathering ban	severe	10/08/2020
	indoor public gathering ban	no gathering ban	11/10/2020
Wyoming	indoor public gathering ban	mild	03/13/2020
	indoor restaurant dining ban (on)		03/19/2020
	indoor public gathering ban	severe	03/20/2020

indoor public gathering ban	mild	05/15/2020
indoor restaurant dining ban (off)		05/15/2020
public mask mandate (on)		12/09/2020
indoor public gathering ban	severe	01/02/2021

Table S2. Total Cases & Deaths & Per Capita (100,000) by U.S. State

<i>State</i>	<i>Total Cases</i>	<i>Total Deaths</i>	<i>Cases Per Capita (100,000)</i>	<i>Deaths Per Capita (100,000)</i>
<i>Alabama</i>	499,819	10,148	10,226	208
<i>Alaska</i>	56,886	305	7,714	41
<i>Arizona</i>	826,454	16,328	11,524	228
<i>Arkansas</i>	324,818	5,319	10,778	176
<i>California</i>	3,501,394	54,124	8,852	137
<i>Colorado</i>	436,602	5,989	7,666	105
<i>Connecticut</i>	285,330	7,704	7,986	216
<i>Delaware</i>	88,354	1,473	9,135	152
<i>Florida</i>	1,909,209	32,266	8,964	151
<i>Georgia</i>	1,023,487	17,906	9,729	170
<i>Hawaii</i>	28,699	445	2,020	31
<i>Idaho</i>	172,931	1,879	9,858	107
<i>Illinois</i>	1,198,335	23,014	9,405	181
<i>Indiana</i>	667,262	12,737	9,971	190
<i>Iowa</i>	282,384	5,558	8,947	176
<i>Kansas</i>	295,861	4,812	10,162	165
<i>Kentucky</i>	410,709	4,819	9,191	108
<i>Louisiana</i>	433,785	9,748	9,309	209
<i>Maine</i>	45,794	706	3,422	53
<i>Maryland</i>	387,319	7,955	6,410	132
<i>Massachusetts</i>	591,356	16,417	8,568	238
<i>Michigan</i>	656,072	16,658	6,563	167
<i>Minnesota</i>	490,011	6,550	8,733	117
<i>Mississippi</i>	297,581	6,808	9,964	228
<i>Missouri</i>	480,643	8,161	7,845	133
<i>Montana</i>	100,914	1,381	9,500	130
<i>Nebraska</i>	203,026	2,113	10,523	110
<i>Nevada</i>	296,190	5,037	9,761	166
<i>New Hampshire</i>	76,861	1,184	5,666	87
<i>New Jersey</i>	812,609	23,574	9,122	265
<i>New Mexico</i>	186,922	3,808	8,920	182
<i>New York</i>	1,681,169	39,029	8,603	200
<i>North Carolina</i>	872,176	11,502	8,400	111
<i>North Dakota</i>	100,391	1,478	13,208	194
<i>Ohio</i>	978,471	17,656	8,371	151
<i>Oklahoma</i>	428,997	4,534	10,880	115
<i>Oregon</i>	157,079	2,296	3,748	55
<i>Pennsylvania</i>	948,643	24,349	7,407	190
<i>Rhode Island</i>	128,781	2,547	12,180	241
<i>South Carolina</i>	525,865	8,754	10,343	172
<i>South Dakota</i>	113,589	1,900	12,875	215
<i>Tennessee</i>	782,206	11,543	11,554	171
<i>Texas</i>	2,686,818	44,451	9,361	155
<i>Utah</i>	378,850	1,976	11,985	63
<i>Vermont</i>	16,083	208	2,568	33
<i>Virginia</i>	585,700	9,596	6,876	113
<i>Washington</i>	344,532	5,041	4,572	67
<i>West Virginia</i>	133,445	2,325	7,390	129
<i>Wisconsin</i>	621,654	7,106	10,693	122
<i>Wyoming</i>	54,764	682	9,479	118

Figure S1. Example Graphs of Alabama COVID-19 Case Data Manipulations for the Identification of Breakpoints.

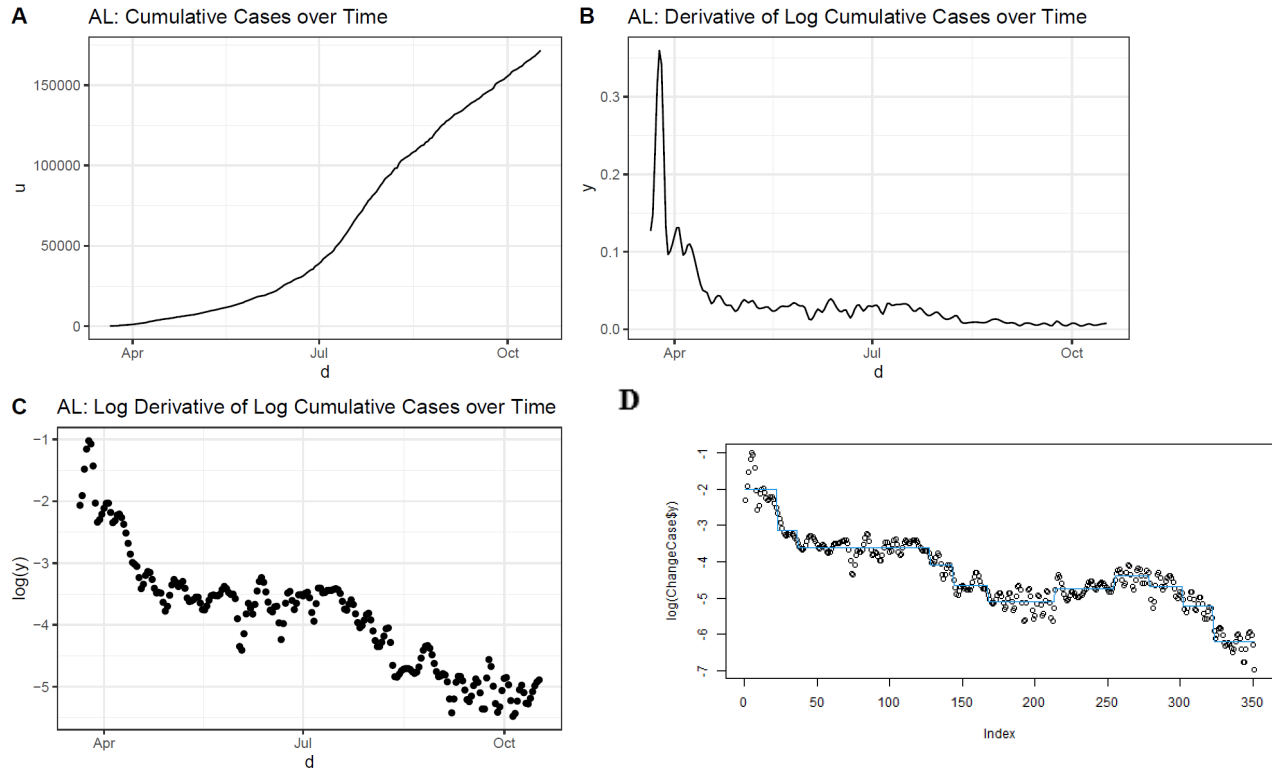


Figure S1(a) shows cumulative cases over time. Figure S1(b) shows the 1st derivative of the log of cumulative cases over time, or case velocity. Figure S1(c) shows the log of case velocity, which was mapped to an entire real line for modeling as a linear function in Figure S1(d). Based on this breakpoint approach, Alabama experienced eight decreases and two increases in case velocity.

Figure S2. Count of State-Level Case Velocity Breakpoints by Week in the United States

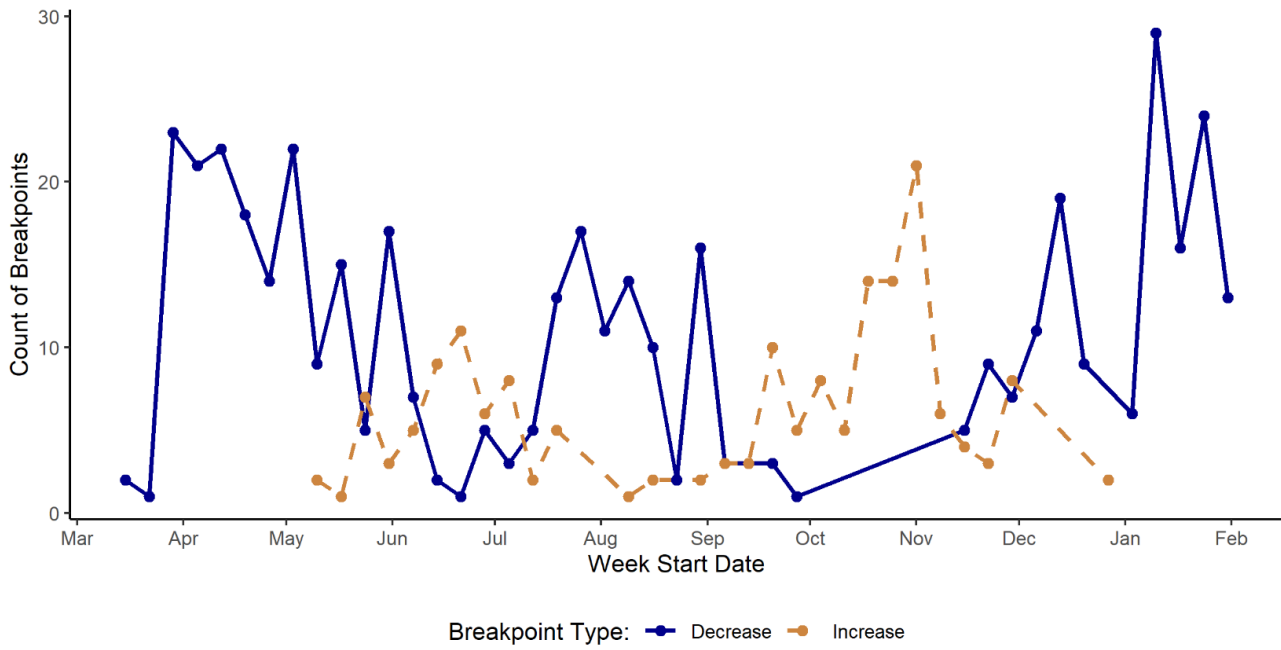


Figure S3. Count of State-Level Death Velocity Breakpoints by Week in the United States

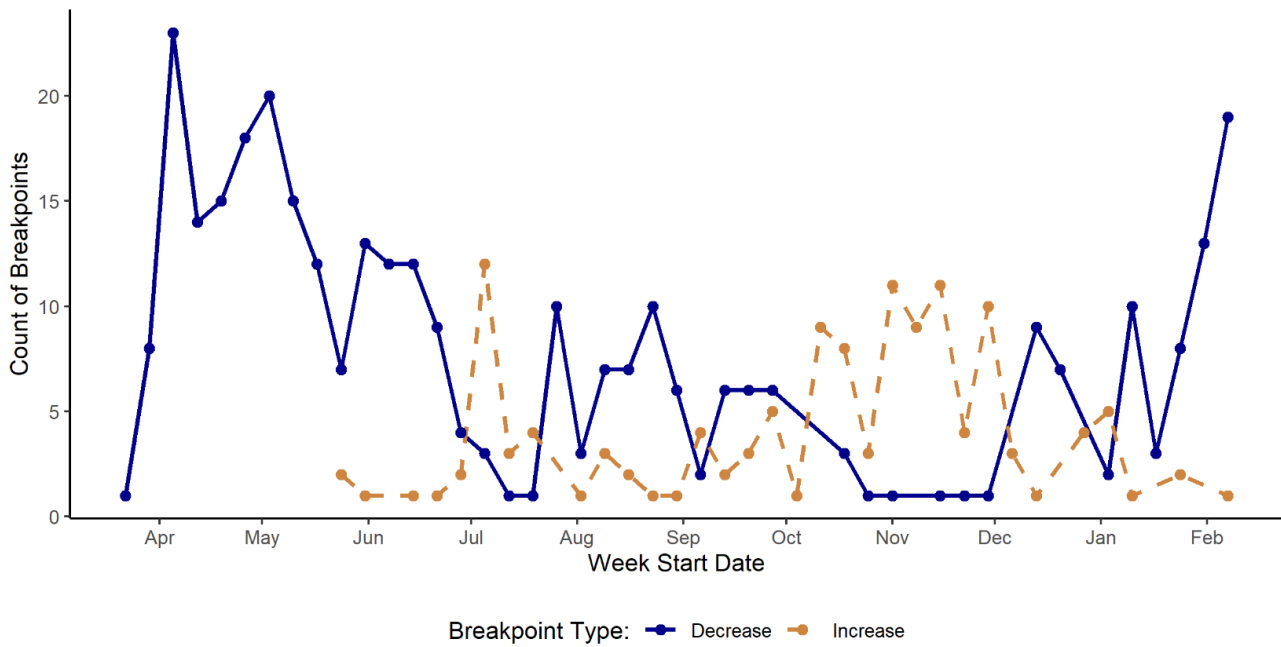
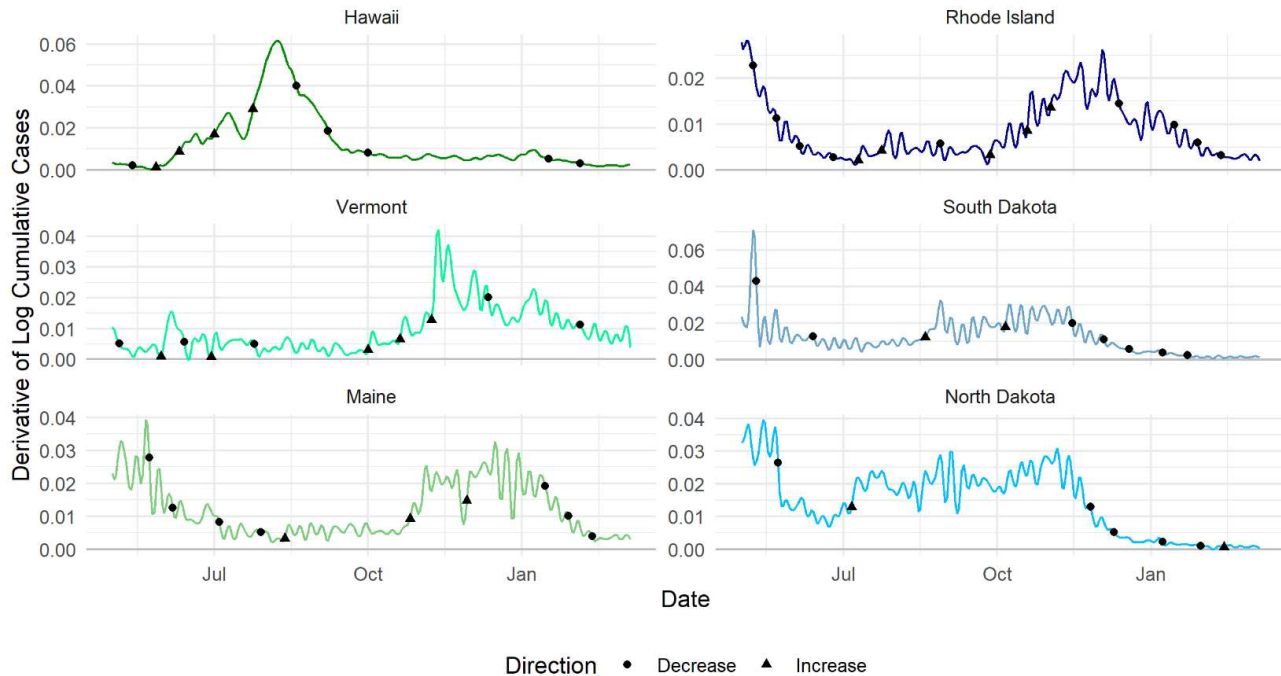
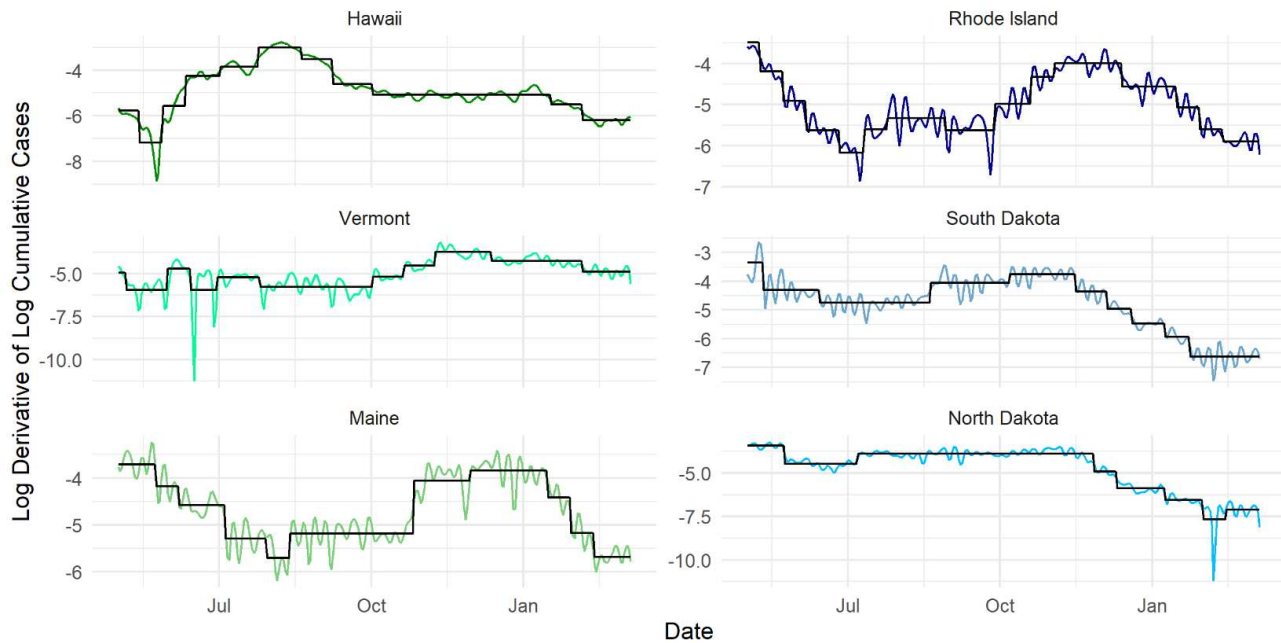


Figure S4. Derivative of the logarithm of cumulative cases and the breakpoints identified for the top 3 lowest and highest U.S. states by COVID-19 cases per capita



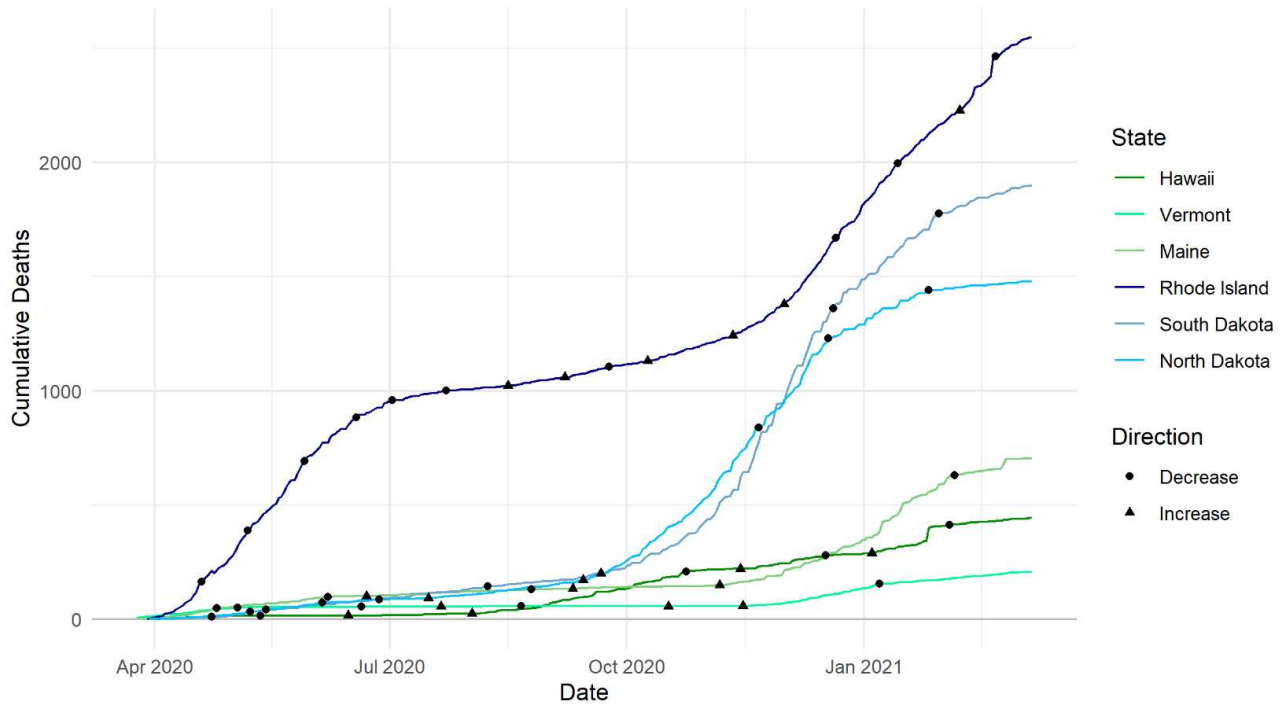
Derivative of the logarithm of cumulative cases most closely represents case velocities graphed. $Y=0$ for graphs were set as May 1st, 2020 rather than date of first cumulative case due to high initial velocities, pictorially obscuring clinically informative later breakpoints. Hawaii, Vermont, and Maine ranked as the three best performing states by cumulative number of COVID-19 cases per capita as of March 7, 2021. Rhode Island, South Dakota, and North Dakota ranked as the three worst performing states over the same time period. Breakpoints, dates at which the linear segments of COVID-19 case velocities showed substantial change in their rate, are plotted over the liner plot of cases for each respective state.

Figure S5. Logarithm of the derivative of the logarithm of cumulative cases and the breakpoints identified for the top 3 lowest and highest U.S. states by COVID-19 cases per capita



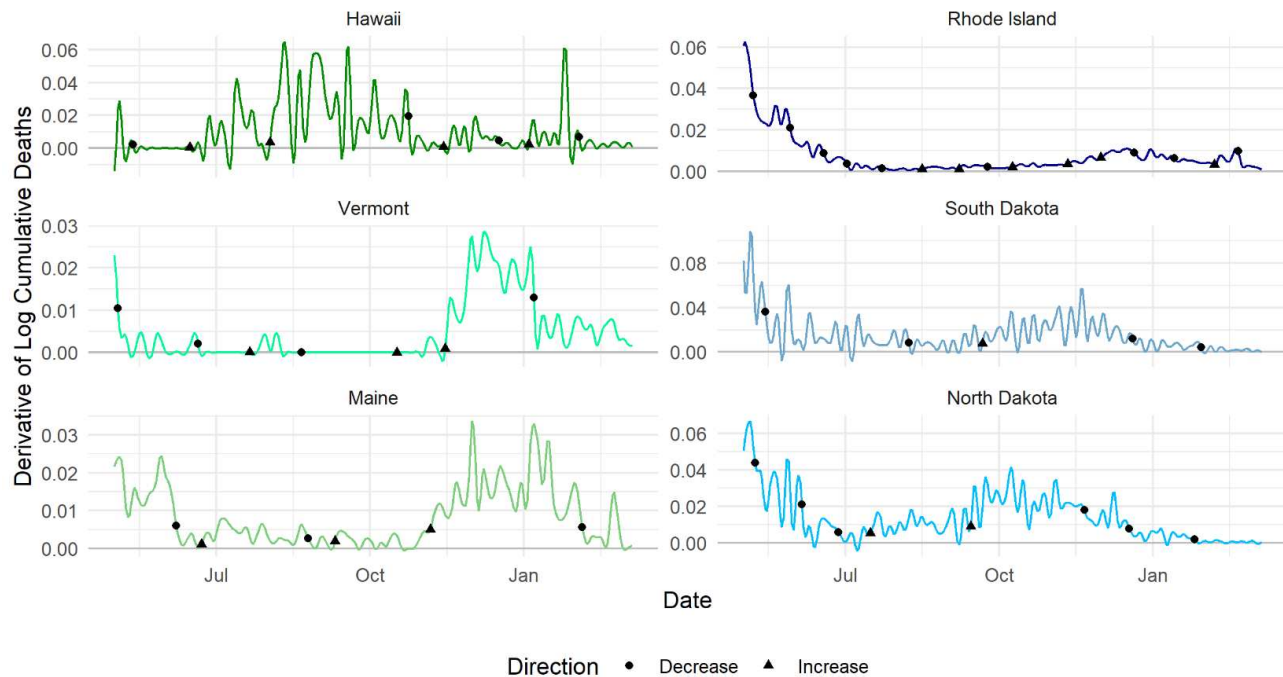
Logarithm of the derivative of the logarithm of cumulative cases most closely represents curation of data implemented to models. $Y=0$ for graphs were set as May 1st, 2020 rather than date of first cumulative case due to high initial velocities, pictorially obscuring clinically informative later breakpoints. Hawaii, Vermont, and Maine ranked as the three best performing states by cumulative number of COVID-19 cases per capita as of March 7, 2021. Rhode Island, South Dakota, and North Dakota ranked as the three worst performing states over the same time period. Breakpoints, dates at which the linear segments of COVID-19 case velocities showed substantial change in their rate, is fitted over the liner plot of cases for each respective state.

Figure S6. Cumulative COVID-19 deaths and the breakpoints identified for the top 3 lowest and highest U.S. states by COVID-19 cases per capita



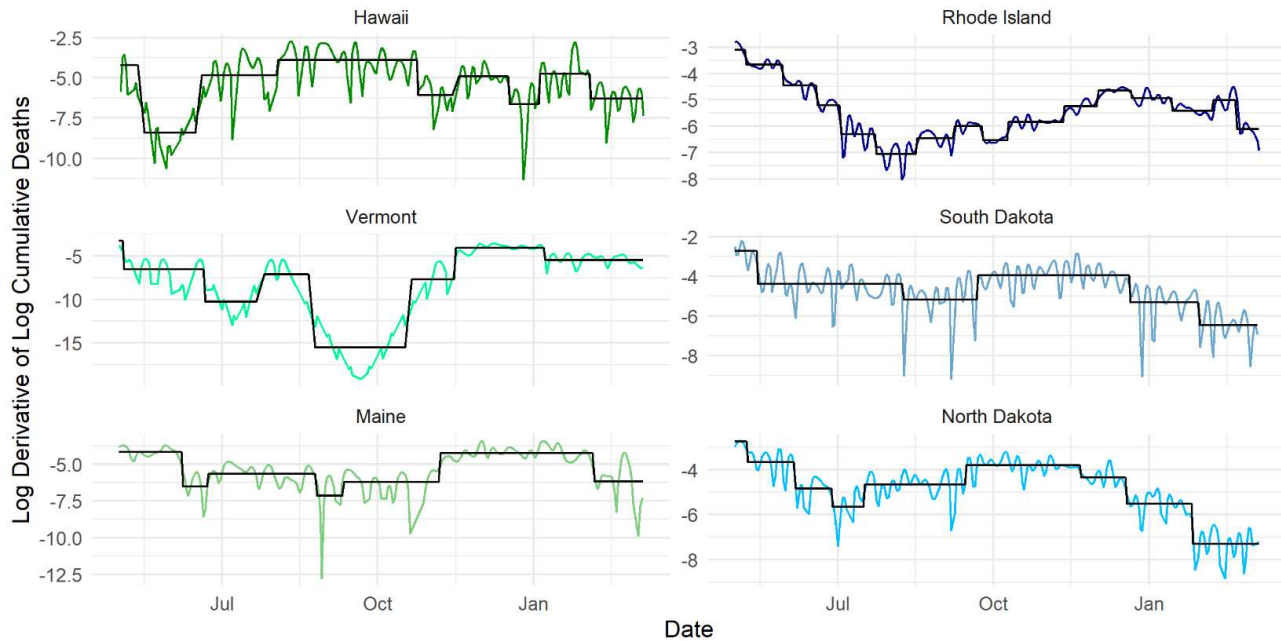
Hawaii, Vermont, and Maine ranked as the three best performing states by cumulative number of COVID-19 cases per capita as of March 7, 2021. Rhode Island, South Dakota, and North Dakota ranked as the three worst performing states over the same time period. Breakpoints, dates at which the linear segments of COVID-19 death velocities showed substantial change in their rate, are plotted over the liner plot of deaths for each respective state.

Figure S7. Derivative of the logarithm of cumulative deaths and the breakpoints identified for the top 3 lowest and highest U.S. states by COVID-19 cases per capita



Derivative of the logarithm of cumulative deaths most closely represents case velocities graphed. $X=0$ for graphs were set as May 1st, 2020 rather than date of first cumulative death due to high initial velocities, pictorially obscuring clinically informative later breakpoints. Hawaii, Vermont, and Maine ranked as the three best performing states by cumulative number of COVID-19 cases per capita as of March 7, 2021. Rhode Island, South Dakota, and North Dakota ranked as the three worst performing states over the same time period. Breakpoints, dates at which the linear segments of COVID-19 death velocities showed substantial change in their rate, are plotted over the liner plot of deaths for each respective state.

Figure S8. Logarithm of the derivative of the logarithm of cumulative deaths and the breakpoints identified for the top 3 lowest and highest U.S. states by COVID-19 cases per capita



Logarithm of the derivative of the logarithm of cumulative deaths most closely represents curation of data implemented to models. $X=0$ for graphs were set as May 1st, 2020 rather than date of first cumulative death due to high initial velocities, pictorially obscuring clinically informative later breakpoints. Hawaii, Vermont, and Maine ranked as the three best performing states by cumulative number of COVID-19 cases per capita as of March 7, 2021. Rhode Island, South Dakota, and North Dakota ranked as the three worst performing states over the same time period. Breakpoints, dates at which the linear segments of COVID-19 death velocities showed substantial change in their rate, are plotted over the liner plot of deaths for each respective state.

Supplementary Appendix

Sensitivity Analysis: Lag Time

eTable 1. Association of non-pharmaceutical interventions and the odds of decreasing COVID-19 case and death burden: one model per intervention, examining different potential lag times

	Cases				Deaths			
	LT	OR	95% CI	p-value	LT	OR	95% CI	p-value
Stay at Home Order On	0-21	2.02	1.63, 2.52	< .0001	7-35	2.00	1.53, 2.62	< .0001
	-7-14	1.87	1.30, 2.68	.0007	0-28	1.48	1.14, 1.92	.0030
	7-28	2.51	1.77, 3.55	< .0001	14-42	2.16	1.70, 2.73	< .0001
Stay at Home Order Off	0-21	0.87	0.53, 1.42	.5741	7-35	1.21	0.89, 1.63	.2194
	-7-14	1.35	0.92, 1.98	.1294	0-28	1.16	0.86, 1.57	.3204
	7-28	0.58	0.33, 1.00	.0501	14-42	1.11	0.77, 1.58	.5815
Indoor Restaurant Dining Ban On	0-21	1.62	1.25, 2.10	.0003	7-35	1.50	1.15, 1.95	.0024
	-7-14	0.78	0.52, 1.19	.2543	0-28	1.05	0.73, 1.52	.7824
	7-28	2.60	1.92, 3.51	< .0001	14-42	2.12	1.67, 2.68	< .0001
Indoor Restaurant Dining Ban Off	0-21	0.94	0.60, 1.45	.7652	7-35	1.04	0.78, 1.41	.7641
	-7-14	1.44	0.97, 2.13	.0715	0-28	1.07	0.78, 1.45	.6895
	7-28	0.39	0.26, 0.60	< .0001	14-42	0.83	0.58, 1.20	.3267
Public Mask Mandate On	0-21	2.18	1.47, 3.23	.0001	7-35	1.39	0.94, 2.05	.1015
	-7-14	1.75	1.16, 2.64	.0079	0-28	1.06	0.67, 1.66	.8094
	7-28	2.71	1.83, 4.00	< .0001	14-42	1.84	1.29, 2.62	.0008
Mild Indoor Public Gathering Ban On	0-21	0.51	0.39, 0.68	< .0001	7-35	0.86	0.62, 1.18	.3405
	-7-14	0.49	0.33, 0.72	.0003	0-28	0.87	0.68, 1.10	.2446
	7-28	0.77	0.57, 1.04	.0859	14-42	1.07	0.80, 1.42	.6610
Severe Indoor Public Gathering Ban On	0-21	1.68	1.31, 2.16	< .0001	7-35	1.45	1.12, 1.88	.0044
	-7-14	1.06	0.73, 1.54	.7645	0-28	1.01	0.77, 1.31	.9686
	7-28	2.42	1.82, 3.22	< .0001	14-42	1.67	1.30, 2.16	< .0001
Indoor Public Gathering Ban Off	0-21	0.64	0.29, 1.40	.2683	7-35	1.19	0.65, 2.19	.5728
	-7-14	0.80	0.44, 1.45	.4584	0-28	1.10	0.61, 2.00	.7440
	7-28	0.61	0.26, 1.45	.2658	14-42	1.27	0.63, 2.55	.5104

LT = lag time expressed as a range of days. OR = odds ratio. CI = confidence interval. A lag time of 0-21 for cases and 7-35 for deaths was our base assumption model based on literature review, reported in **Table 2**. A lag time of 7-35 indicates that, for a given week, the policy window considered lies between 7 and 35 days before the first day of the week. A lag time of -7-14 indicates that, for a given week, the policy window considered lies between the last day of the week and 14 days before the first day of the week. An odds ratio greater than one is associated with an increased probability that COVID-19 case or death velocities decreased. We evaluated each NPI in an individual model. We classified indoor public gathering bans with a maximum of 10 or fewer as severe, and indoor public gathering bans with maximums greater than 10 as mild. Indoor restaurant dining ban was defined as adopted when indoor dining was banned and discontinued when indoor dining was reinstated, regardless of capacity specification or outdoor dining policies.

Stay at home order remained highly significantly associated with decreased case and death velocities regardless of lag time chosen. The association between enactment of a public mask mandate and decrease in case velocity was strongest for the most distal lag time, and this was the only statistically significant lag time when examining association with death velocity. Indoor restaurant dining ban was significantly associated with decreased case and death velocities when using the original lag time and the more distal lag time, but not the more proximal lag time. Severe indoor public gathering ban was significantly associated with decreased case and death velocities when using the original lag time and the more distal lag time, but not the more proximal lag time.

eTable 2. Association of non-pharmaceutical interventions and the odds of decreasing COVID-19 case and death burden: one model including all interventions, examining different potential lag times

	Cases				Deaths			
	LT	AOR	95% CI	p-value	LT	AOR	95% CI	p-value
Stay at Home Order On	0-21	1.47	1.04, 2.07	.0284	7-35	1.89	1.25, 2.87	.0027
	-7-14	2.28	1.44, 3.62	.0004	0-28	1.68	1.17, 2.42	.0052
	7-28	1.25	0.76, 2.04	.3778	14-42	1.58	1.11, 2.24	.0116
Stay at Home Order Off	0-21	0.93	0.56, 1.55	.7911	7-35	1.28	0.89, 1.85	.1850
	-7-14	1.26	0.82, 1.93	.2854	0-28	1.18	0.84, 1.64	.3405
	7-28	0.83	0.48, 1.43	.5014	14-42	1.28	0.86, 1.91	.2236
Indoor Restaurant Dining Ban On	0-21	1.47	0.96, 2.26	.0731	7-35	1.15	0.76, 1.74	.5024
	-7-14	0.77	0.47, 1.28	.3180	0-28	0.96	0.58, 1.59	.8809
	7-28	2.05	1.22, 3.45	.0066	14-42	1.74	1.15, 2.63	.0088
Indoor Restaurant Dining Ban Off	0-21	1.25	0.77, 2.03	.3654	7-35	1.13	0.81, 1.59	.4781
	-7-14	1.70	1.11, 2.61	.0147	0-28	1.09	0.77, 1.52	.6358
	7-28	0.51	0.32, 0.81	.0045	14-42	0.92	0.60, 1.43	.7142
Public Mask Mandate On	0-21	2.27	1.51, 3.41	< .0001	7-35	1.45	0.97, 2.17	.0670
	-7-14	1.84	1.22, 2.78	.0036	0-28	1.07	0.68, 1.69	.7564
	7-28	2.68	1.78, 4.04	< .0001	14-42	1.95	1.35, 2.82	.0004
Mild Indoor Public Gathering Ban On	0-21	0.46	0.34, 0.61	< .0001	7-35	0.78	0.56, 1.09	.1480
	-7-14	0.47	0.32, 0.71	.0003	0-28	0.85	0.65, 1.12	.2430
	7-28	0.65	0.46, 0.92	.0143	14-42	0.90	0.65, 1.23	.4964
Severe Indoor Public Gathering Ban On	0-21	1.38	0.97, 1.95	.0738	7-35	1.08	0.72, 1.64	.6924
	-7-14	0.99	0.62, 1.57	.9604	0-28	0.87	0.60, 1.24	.4303
	7-28	1.73	1.20, 2.51	.0036	14-42	1.07	0.74, 1.56	.7148
Indoor Public Gathering Ban Off	0-21	0.64	0.30, 1.39	.2608	7-35	1.16	0.62, 2.17	.6426
	-7-14	0.67	0.38, 1.21	.1840	0-28	1.05	0.58, 1.92	.8687
	7-28	0.81	0.33, 1.96	.6364	14-42	1.38	0.68, 2.81	.3770

LT = lag time expressed as a range of days. AOR = adjusted odds ratio. CI = confidence interval. A lag time of 0-21 for cases and 7-35 for deaths was our base assumption model based on literature review, reported in **Table 3**. A lag time of 7-35 indicates that, for a given week, the policy window considered lies between 7 and 35 days before the first day of the week. A lag time of -7-14 indicates that, for a given week, the policy window considered lies between the last day of the week and 14 days before the first day of the week. An adjusted odds ratio greater than 1 is associated with increased probability that COVID-19 case or death velocities decreased. We included all four NPIs as covariates in this model. We classified indoor public gathering bans with a maximum of 10 or fewer as severe, and indoor public gathering bans with maximums greater than 10 as mild. Indoor restaurant dining ban was defined as adopted when indoor dining was banned and discontinued when indoor dining was reinstated, regardless of capacity specification or outdoor dining policies.

Stay at home order was most strongly associated with decreased case and death velocities for the two more proximal lag times vs. the distal lag times. Although adoption of indoor restaurant dining bans were not significant in the adjusted models when using the original lag time, they were significantly associated with decreased case and death velocity when using the more distal lag time. For this same distal lag time, discontinuation of indoor dining bans was significantly associated with an increase in case velocity. In adjusted models, public mask mandates were significantly associated with decreased case velocity across all three lag times and decreased death velocity for the most distal lag time. Mild indoor public gathering bans were associated with increased case velocity across all three lag times. Severe indoor public gathering bans were associated with decreased case velocity for only the most distal lag time.

Collinearity Diagnostics

Case Model

- For generalized linear models, collinearity of predictors is a concern in such that it could potentially lead to an ill-conditioned weighted information matrix (but does not necessarily), which can cause inflation of standard errors associated with model parameters thereby impacted inferences.
- We assess the potential impact of collinearity by examining the correlation matrix for the estimated parameters and looking for large correlations.
- We also use PROC REG to generate collinearity diagnostics (Condition Indices) for the set of predictors
- For the case model, both steps indicated that collinearity was not likely to be a problem. High correlation existed only between the two intercepts, and the parameters corresponding to the week number/splines. These high correlations (> 0.60 in absolute magnitude) are to be expected and are not cause for concern.

Correlation Matrix among Estimated Parameters

Estimated Correlation Matrix

	Intercept1	Intercept2	Prm1	Prm3	Prm5	Prm7	Prm9	Prm11	Prm13	Prm15	Prm17	Prm18	Prm19	Prm20
Intercept1	1.0000	0.9841	-0.2036	-0.3037	-0.0305	-0.2454	-0.4497	-0.1436	-0.0420	-0.5839	-0.2916	0.3348	-0.2136	0.0436
Intercept2		1.0000	-0.2022	-0.2967	-0.0375	-0.2461	-0.4612	-0.1195	-0.0466	-0.5669	-0.2978	0.3251	-0.1947	0.0700
HOME_ON			1.0000	0.0263	-0.3039	0.0324	0.0201	0.0890	-0.3349	-0.0038	-0.0780	0.0261	0.0195	0.0031
HOME_OFF				1.0000	-0.0109	-0.2899	-0.0219	-0.0187	0.0328	-0.0665	0.1305	-0.1798	0.1480	-0.0393
RESTAURANT_ON					1.0000	0.0290	0.0275	-0.2128	-0.2812	0.0030	-0.2398	0.1961	-0.0456	-0.0486
RESTAURANT_OFF						1.0000	0.1079	-0.1275	-0.0200	-0.1158	0.2119	-0.2449	0.1567	-0.0111
MASK_ON							1.0000	-0.0046	0.0064	0.0067	0.1216	-0.1228	0.0469	-0.0376
MILD_ON								1.0000	-0.0447	0.0262	-0.1066	0.0290	0.0487	0.0225
SEVERE_ON									1.0000	0.0168	-0.1354	0.0993	-0.0004	0.0140
NONE_ON										1.0000	-0.0223	0.0296	-0.0241	0.0148
WKNUM											1.0000	-0.9257	0.4248	-0.0908
WKNUM_SPLINE1												1.0000	-0.6966	0.2084
WKNUM_SPLINE2													1.0000	-0.6306
WKNUM_SPLINE3														1.0000

Collinearity Diagnostics (CASE MODEL)

- Condition Indices produced by PROC REG using an identical set of predictors were all below 40, suggesting collinearity is not likely to be a concern. The highest condition index equals 39.1 with high variance proportions for week number and week number spline 1, which indicates there may be some collinearity among these predictors which is to be expected and not cause for concern. The second highest index equals only 11.9 and is certainly not concerning.

Number	Eigenvalue	Condition Index
1	4.20052	1
2	2.34328	1.33887
3	1.61264	1.61392
4	1.03589	2.0137
5	0.92576	2.13011
6	0.74208	2.37918
7	0.5925	2.66261
8	0.55769	2.74444
9	0.40956	3.20251
10	0.38422	3.30645
11	0.16361	5.06697
12	0.0295	11.93375
13	0.00274	39.14931

Death Model

For the death model, both steps described previously for case model were followed and they indicated that collinearity was not likely to be of concern. High correlation existed only between the two intercepts, and the parameters corresponding to the week number/splines. These high correlations (> 0.60 in absolute magnitude) are to be expected and are not cause for concern.

Correlation Matrix among Estimated Parameters

Estimated Correlation Matrix

	Intercept1	Intercept2	Prm1	Prm3	Prm5	Prm7	Prm9	Prm11	Prm13	Prm15	Prm17	Prm18	Prm19	Prm20
Intercept1	1.0000	0.9750	-0.1917	-0.3106	0.0062	-0.2886	-0.4852	-0.0928	-0.0124	-0.5566	-0.4456	0.4765	-0.2811	0.0623
Intercept2		1.0000	-0.1904	-0.3055	0.0015	-0.2815	-0.4831	-0.0830	-0.0144	-0.5392	-0.4329	0.4442	-0.2716	0.1382
HOME_ON			1.0000	0.0534	-0.3460	0.0585	0.0204	0.0422	-0.3611	-0.0012	0.0063	-0.0550	0.0707	-0.0201
HOME_OFF				1.0000	-0.0175	-0.2799	-0.0086	-0.0292	0.0296	-0.0689	0.1933	-0.2406	0.1811	-0.0476
RESTAURANT_ON					1.0000	0.0156	0.0457	-0.1860	-0.2873	-0.0021	-0.2607	0.2099	-0.0365	-0.0526
RESTAURANT_OFF						1.0000	0.1237	-0.1685	-0.0078	-0.1284	0.2867	-0.3153	0.1880	-0.0068
MASK_ON							1.0000	0.0067	-0.0151	0.0225	0.1259	-0.1189	0.0274	-0.0195
MILD_ON								1.0000	-0.0489	0.0603	-0.1233	0.0615	0.0107	0.0251
SEVERE_ON									1.0000	0.0146	-0.1423	0.1038	-0.0043	0.0357
NONE_ON										1.0000	0.0038	-0.0069	0.0203	-0.0216
WKNUM											1.0000	-0.9326	0.4314	-0.0818
WKNUM_SPLINE1												1.0000	-0.6854	0.1752
WKNUM_SPLINE2													1.0000	-0.6194
WKNUM_SPLINE3														1.0000

Collinearity Diagnostics (DEATH MODEL)

- Condition Indices produced by PROC REG using an identical set of predictors were all below 50, suggesting collinearity is not likely to be a concern. The highest condition index equals 46.7 with high variance proportions for week number and week number spline 1, which indicates there may be some collinearity among these predictors which is to be expected and not cause for concern. The second highest index equals only 13.2 and is certainly not concerning.

Number	Eigenvalue	Condition Index
1	4.33054	1
2	2.4818	1.32095
3	1.67492	1.60796
4	1.02688	2.05358
5	0.92298	2.16608
6	0.66258	2.55654
7	0.53998	2.83193
8	0.49791	2.94913
9	0.36727	3.43381
10	0.33096	3.61727
11	0.13725	5.61713
12	0.02492	13.18171
13	0.00198	46.72029

Supplemental References

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