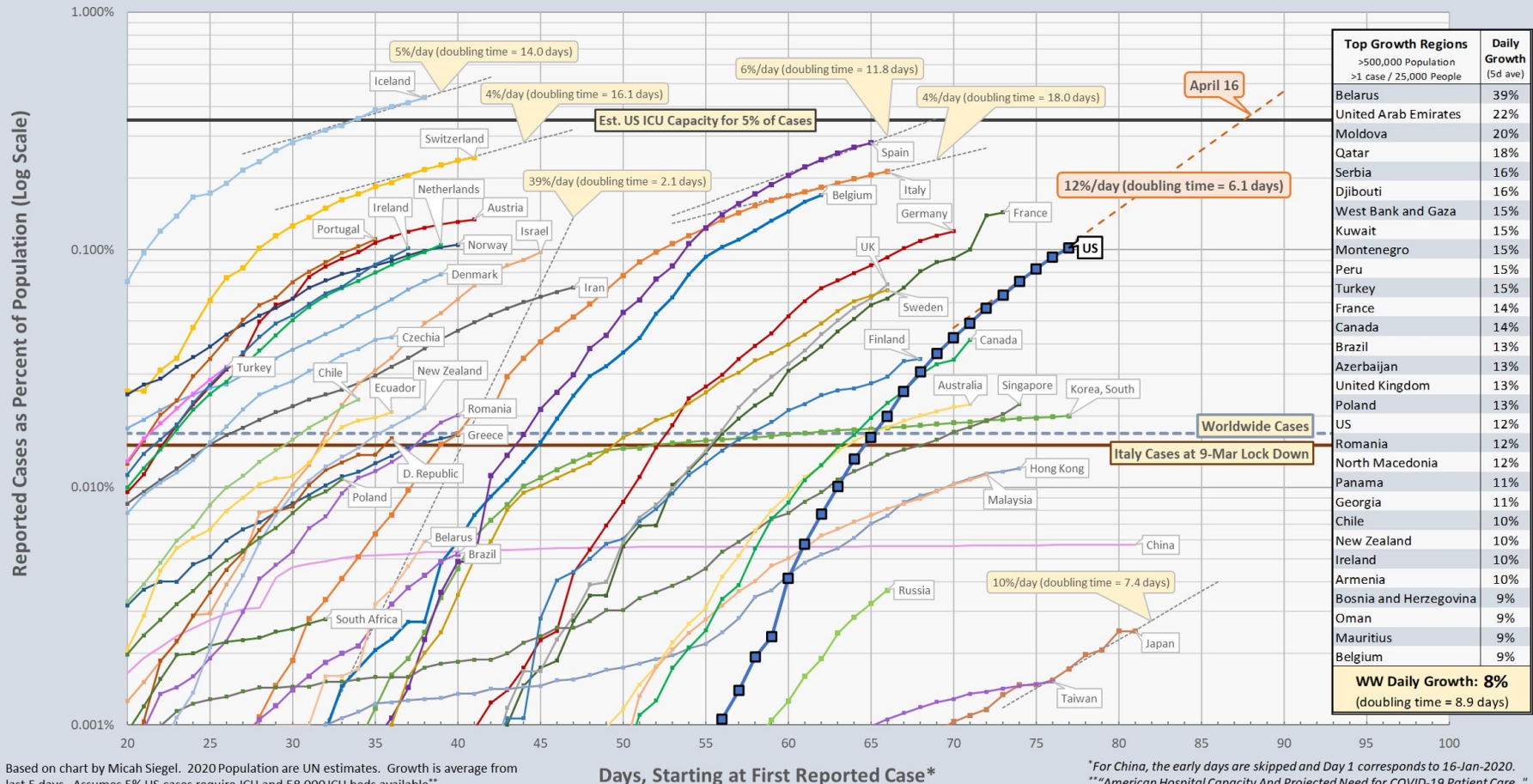# COVID-19 MODELING
April 6, 2020

Overview

- **Goal**: Develop multiple forecasting perspectives
  - Oliver Wyman – Helen Leis
  - Columbia University – Professor Jeffrey Shaman, Ph.D.
  - Northeastern University – Professor Alessandro Vespignani, Ph.D.

- **Forecasting is imprecise:**
  - <u>Focus on the near term:</u> Forecasting is much less predictable the further out you model
  - <u>Focus on ranges rather than specifics:</u> Forecasts are represented as a range of possible outcomes (i.e., likely, best & worst)
  - <u>Consistent refinement:</u> Continually updating with new data and new assumptions
  - <u>Appropriate Perspective:</u> Ultimately forecasts are developed for planning purposes and are not representative of definitive outcomes

- **Ultimate Purpose of Forecasting: Medical Surge Planning**
  - Tracking the available staffed hospital beds
  - Tracking the available ICU beds
  - Tracking the available ventilators
  - Tracking the supply of PPE

Comparison of Growth by Country

COVID-19 Coronavirus Cases per Capita over Time by Country, updated 5-April-2020

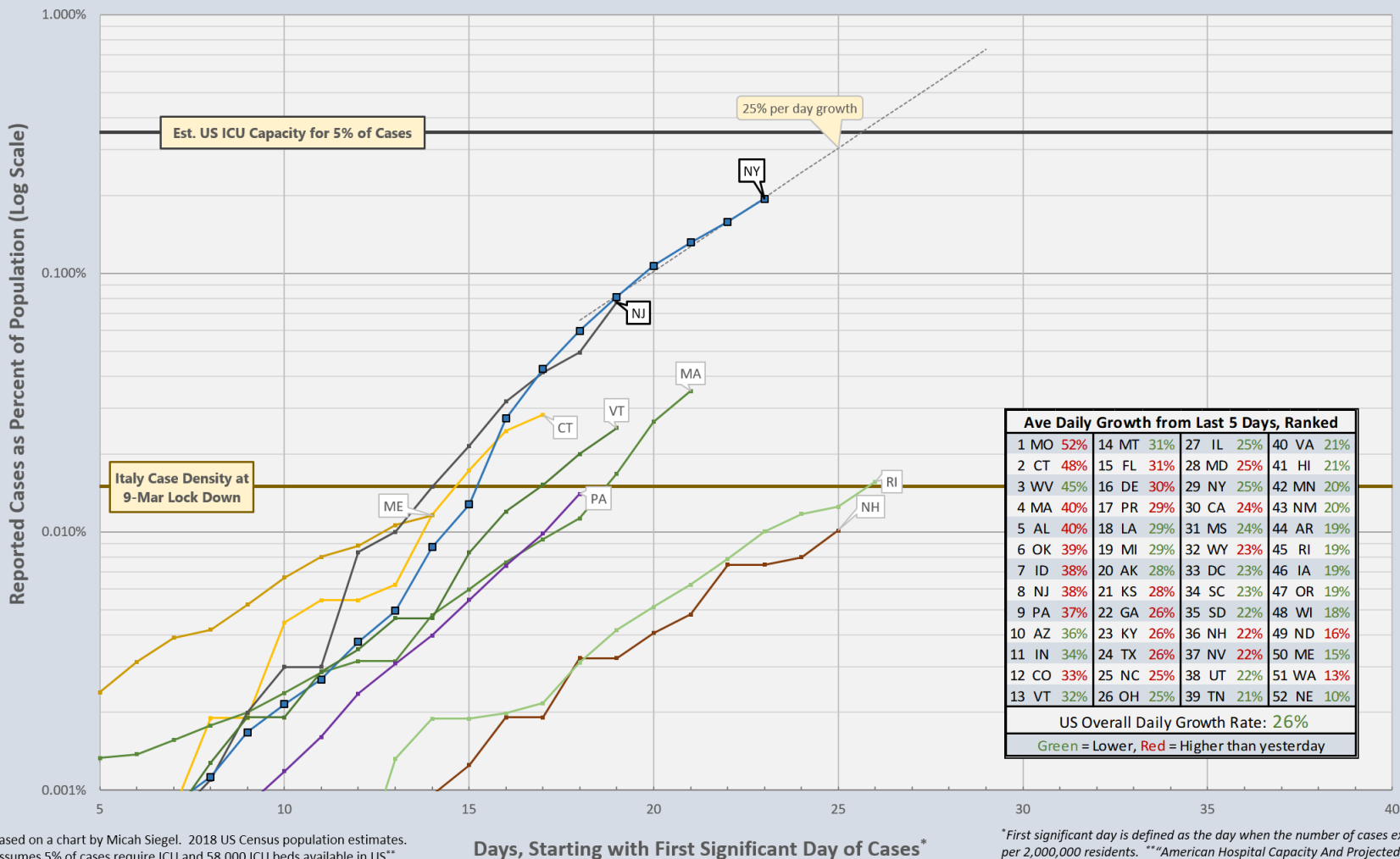| Top Growth Regions >500,000 Population >1 case / 25,000 People	Daily Growth (5d ave)
Belarus	39%
United Arab Emirates	22%
Moldova	20%
Qatar	18%
Serbia	16%
Djibouti	16%
West Bank and Gaza	15%
Kuwait	15%
Montenegro	15%
Peru	15%
Turkey	15%
France	14%
Canada	14%
Brazil	13%
Azerbaijan	13%
United Kingdom	13%
Poland	13%
US	12%
Romania	12%
North Macedonia	12%
Panama	11%
Georgia	11%
Chile	10%
New Zealand	10%
Ireland	10%
Armenia	10%
Bosnia and Herzegovina	9%
Oman	9%
Mauritius	9%
Belgium	9%
WW Daily Growth: 8% (doubling time = 8.9 days)	

Based on chart by Micah Siegel. 2020 Population are UN estimates. Growth is average from last 5 days. Assumes 5% US cases require ICU and 58,000 ICU beds available**.
Source Data: JHU CSSE (https://github.com/CSSEGISandData/COVID-19)

*For China, the early days are skipped and Day 1 corresponds to 16-Jan-2020.
**"American Hospital Capacity And Projected Need for COVID-19 Patient Care, " Health Affairs Blog, March 17, 2020.DOI: 10.1377/hblog20200317.457910

3

VT's Growth Rate Compared to Northeast States

COVID-19 Coronavirus US Case Density over Time by State, updated 26-Mar-2020

Reported Cases as Percent of Population (Log Scale)

Est. US ICU Capacity for 5% of Cases

25% per day growth

Italy Case Density at 9-Mar Lock Down

NY, NJ, MA, VT, CT, ME, PA, RI, NH

Ave Daily Growth from Last 5 Days, Ranked							
1 MO	52%	14 MT	31%	27 IL	25%	40 VA	21%
2 CT	48%	15 FL	31%	28 MD	25%	41 HI	21%
3 WV	45%	16 DE	30%	29 NY	25%	42 MN	20%
4 MA	40%	17 PR	29%	30 CA	24%	43 NM	20%
5 AL	40%	18 LA	29%	31 MS	24%	44 AR	19%
6 OK	39%	19 MI	29%	32 WY	23%	45 RI	19%
7 ID	38%	20 AK	28%	33 DC	23%	46 IA	19%
8 NJ	38%	21 KS	28%	34 SC	23%	47 OR	19%
9 PA	37%	22 GA	26%	35 SD	22%	48 WI	18%
10 AZ	36%	23 KY	26%	36 NH	22%	49 ND	16%
11 IN	34%	24 TX	26%	37 NV	22%	50 ME	15%
12 CO	33%	25 NC	25%	38 UT	22%	51 WA	13%
13 VT	32%	26 OH	25%	39 TN	21%	52 NE	10%
US Overall Daily Growth Rate: 26%							
Green = Lower, Red = Higher than yesterday							

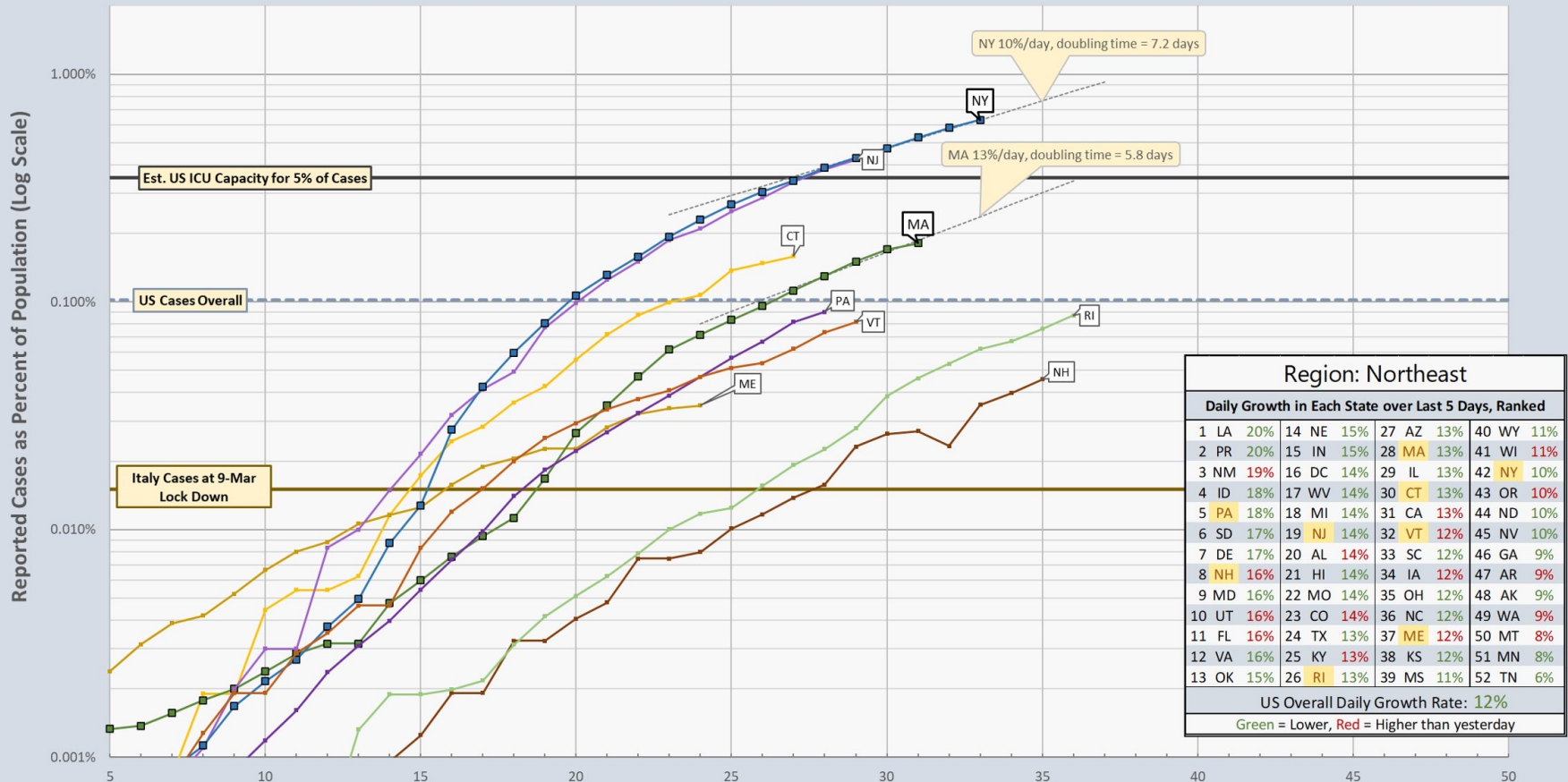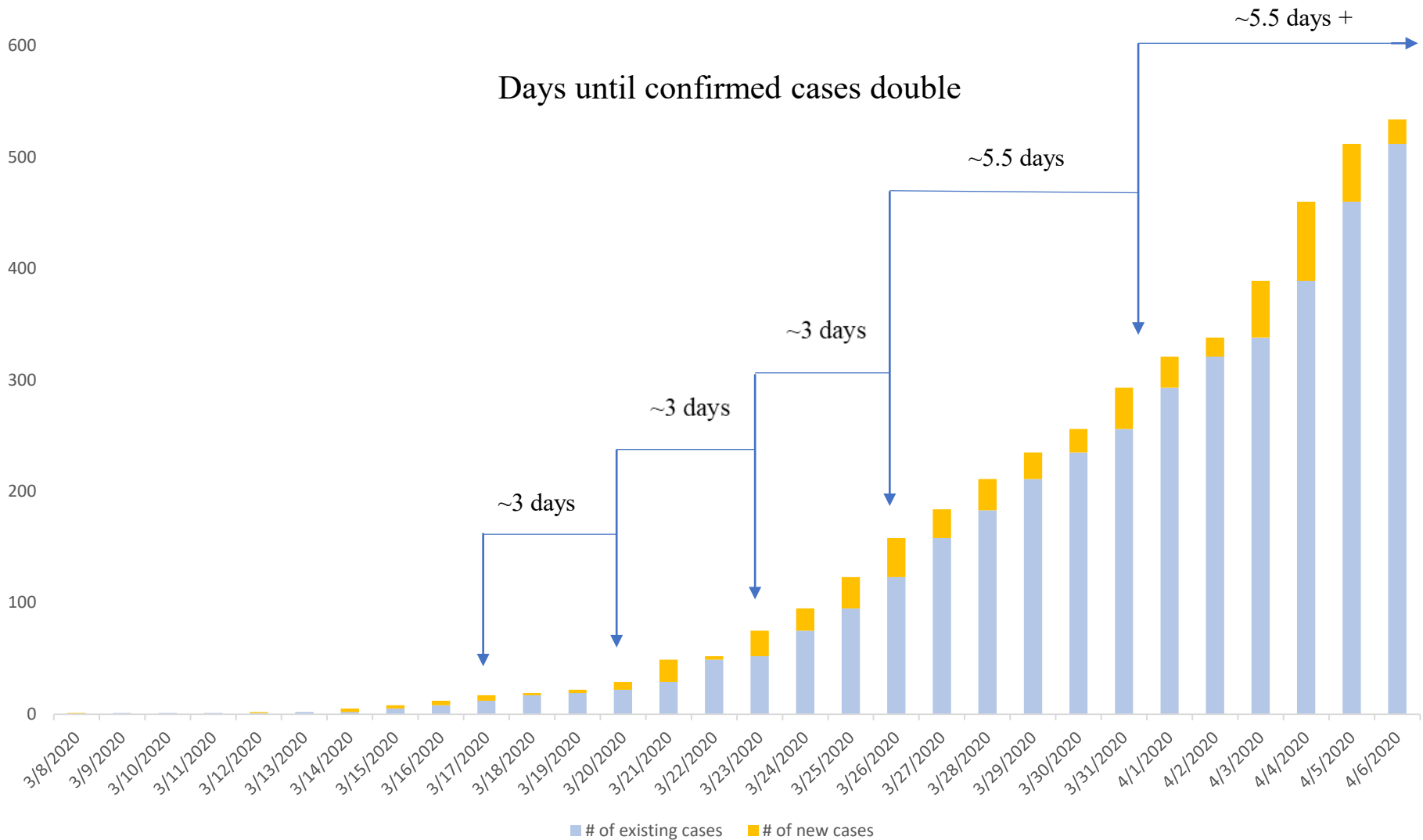**Days, Starting with First Significant Day of Cases***

Based on a chart by Micah Siegel. 2018 US Census population estimates.
Assumes 5% of cases require ICU and 58,000 ICU beds available in US**.
Source Data: JHU CSSE (https://github.com/CSSEGISandData/COVID-19)

*First significant day is defined as the day when the number of cases exceeds 1 case per 2,000,000 residents. **"American Hospital Capacity And Projected Need for COVID-19 Patient Care, " Health Affairs Blog, March 17, 2020.DOI: 10.1377/hblog20200317.457910

4

VT's Growth Rate Compared to Northeast States

COVID-19 Coronavirus US Cases per Capita over Time by State, updated 5-April-2020

NY 10%/day, doubling time = 7.2 days

MA 13%/day, doubling time = 5.8 days

Est. US ICU Capacity for 5% of Cases

US Cases Overall

Italy Cases at 9-Mar Lock Down

Reported Cases as Percent of Population (Log Scale)

Days, Starting with First Significant Day of Cases*

Region: Northeast

Daily Growth in Each State over Last 5 Days, Ranked

#	State	%	#	State	%	#	State	%	#	State	%
1	LA	20%	14	NE	15%	27	AZ	13%	40	WY	11%
2	PR	20%	15	IN	15%	28	MA	13%	41	WI	11%
3	NM	19%	16	DC	14%	29	IL	13%	42	NY	10%
4	ID	18%	17	WV	14%	30	CT	13%	43	OR	10%
5	PA	18%	18	MI	14%	31	CA	13%	44	ND	10%
6	SD	17%	19	NJ	14%	32	VT	12%	45	NV	10%
7	DE	17%	20	AL	14%	33	SC	12%	46	GA	9%
8	NH	16%	21	HI	14%	34	IA	12%	47	AR	9%
9	MD	16%	22	MO	14%	35	OH	12%	48	AK	9%
10	UT	16%	23	CO	14%	36	NC	12%	49	WA	9%
11	FL	16%	24	TX	13%	37	ME	12%	50	MT	8%
12	VA	16%	25	KY	13%	38	KS	12%	51	MN	8%
13	OK	15%	26	RI	13%	39	MS	11%	52	TN	6%

US Overall Daily Growth Rate: 12%

Green = Lower, Red = Higher than yesterday

Based on a chart by Micah Siegel. 2018 US Census population estimates.
Assumes 5% of cases require ICU and 58,000 ICU beds available in US**.
Source Data: JHU CSSE (https://github.com/CSSEGISandData/COVID-19)

*First significant day is defined as the day when the number of cases exceeds 1 case per 2,000,000 residents. **"American Hospital Capacity And Projected Need for COVID-19 Patient Care," Health Affairs Blog, March 17, 2020.DOI: 10.1377/hblog20200317.457910

# Vermont's Daily COVID-19 Confirmed Case Growth

Source: Vermont Department of Health

Days until confirmed cases double

~5.5 days +

~5.5 days

~3 days

~3 days

~3 days

■ # of existing cases   ■ # of new cases

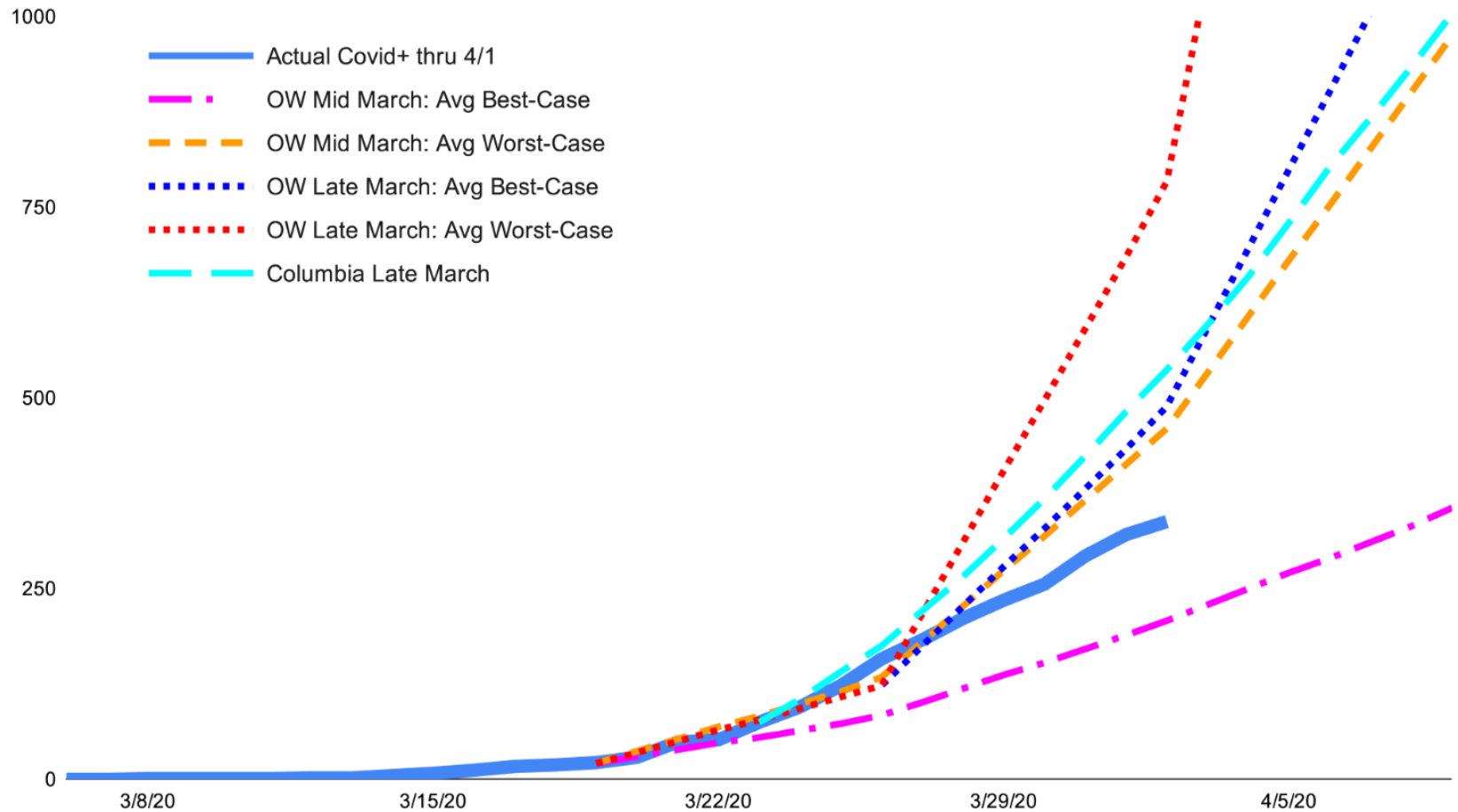# Vermont's Daily Growth Rate Compared to Total Cases

Source: Vermont Department of Health

Note: This chart notes the stability of Vermont's case growth rate as we approached and surpassed 100 confirmed cases.
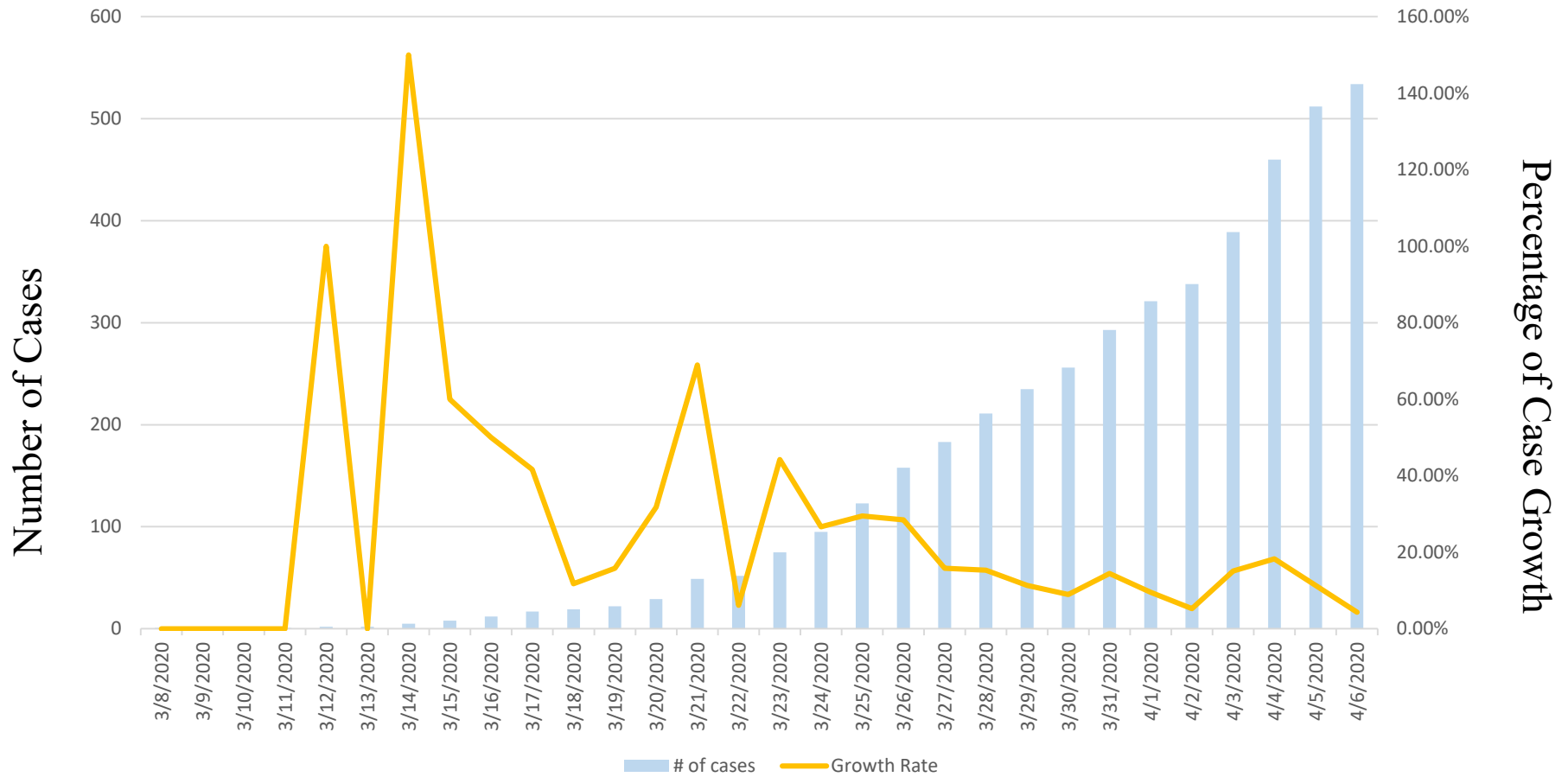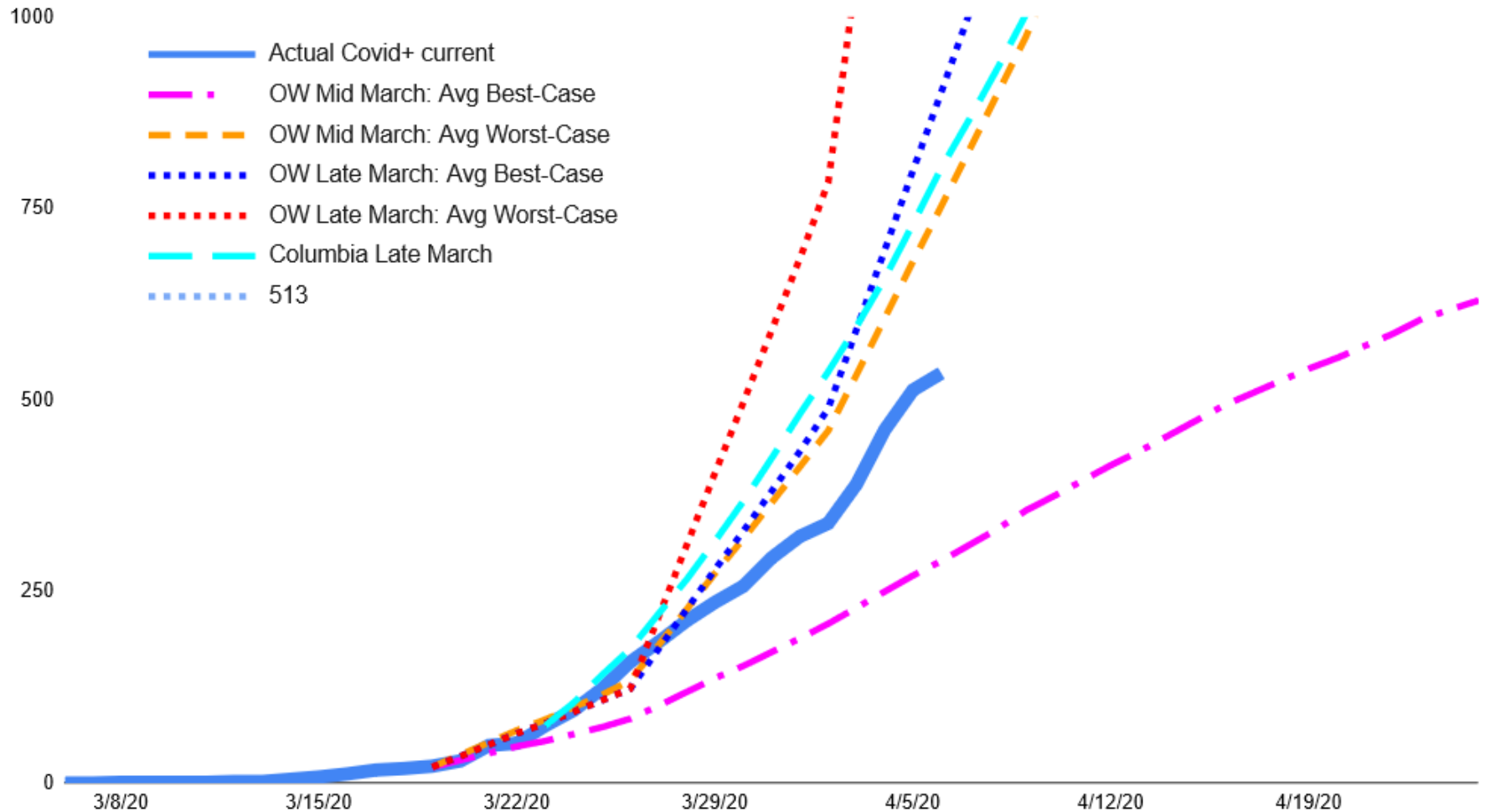
Close Look at Forecasting vs. Actual Case Count

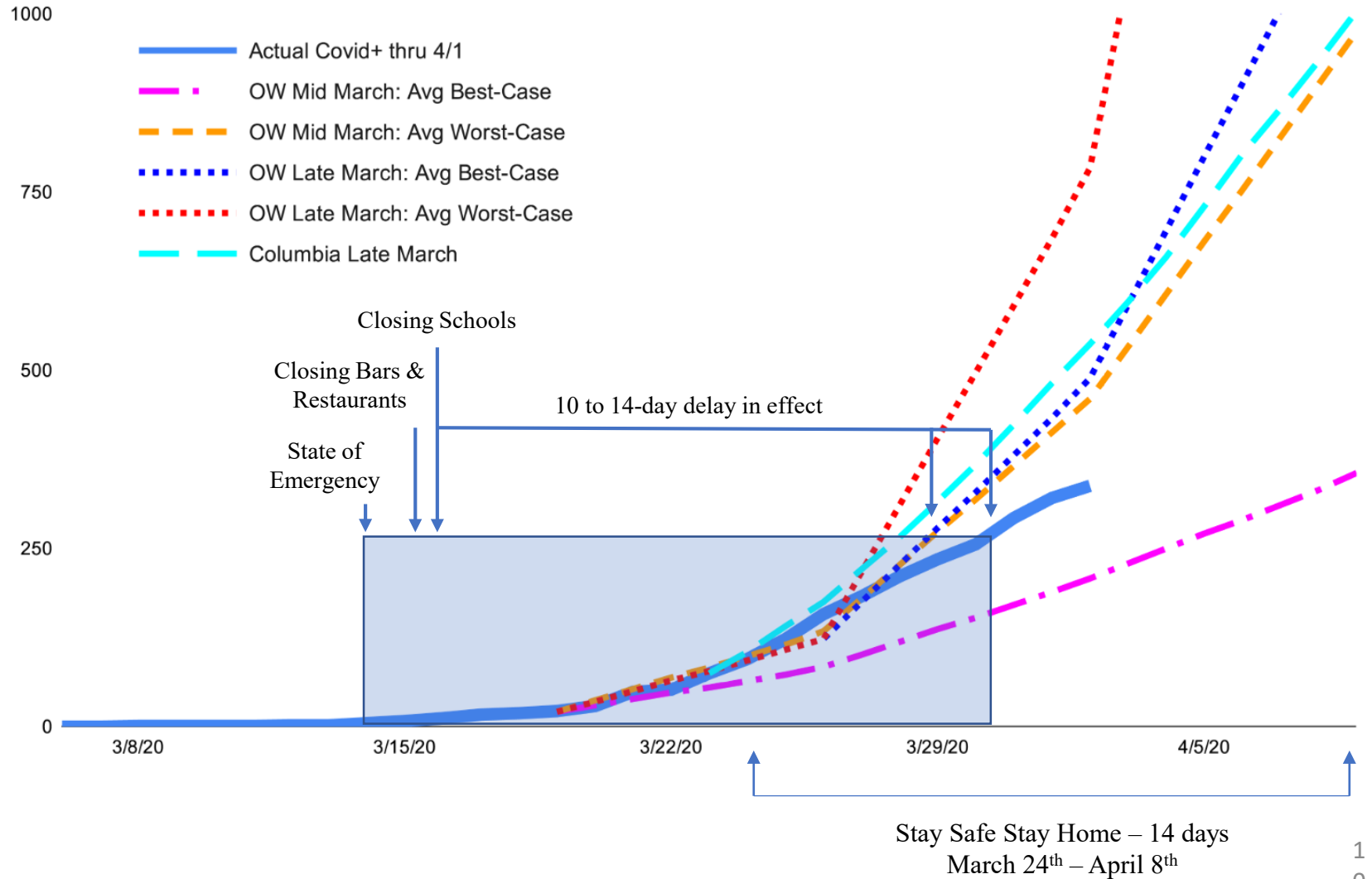Actual Cases vs. Projections (March 8th to April 9th // 0-1,000 Cases)

Close Look at Forecasting vs. Actual Case Count

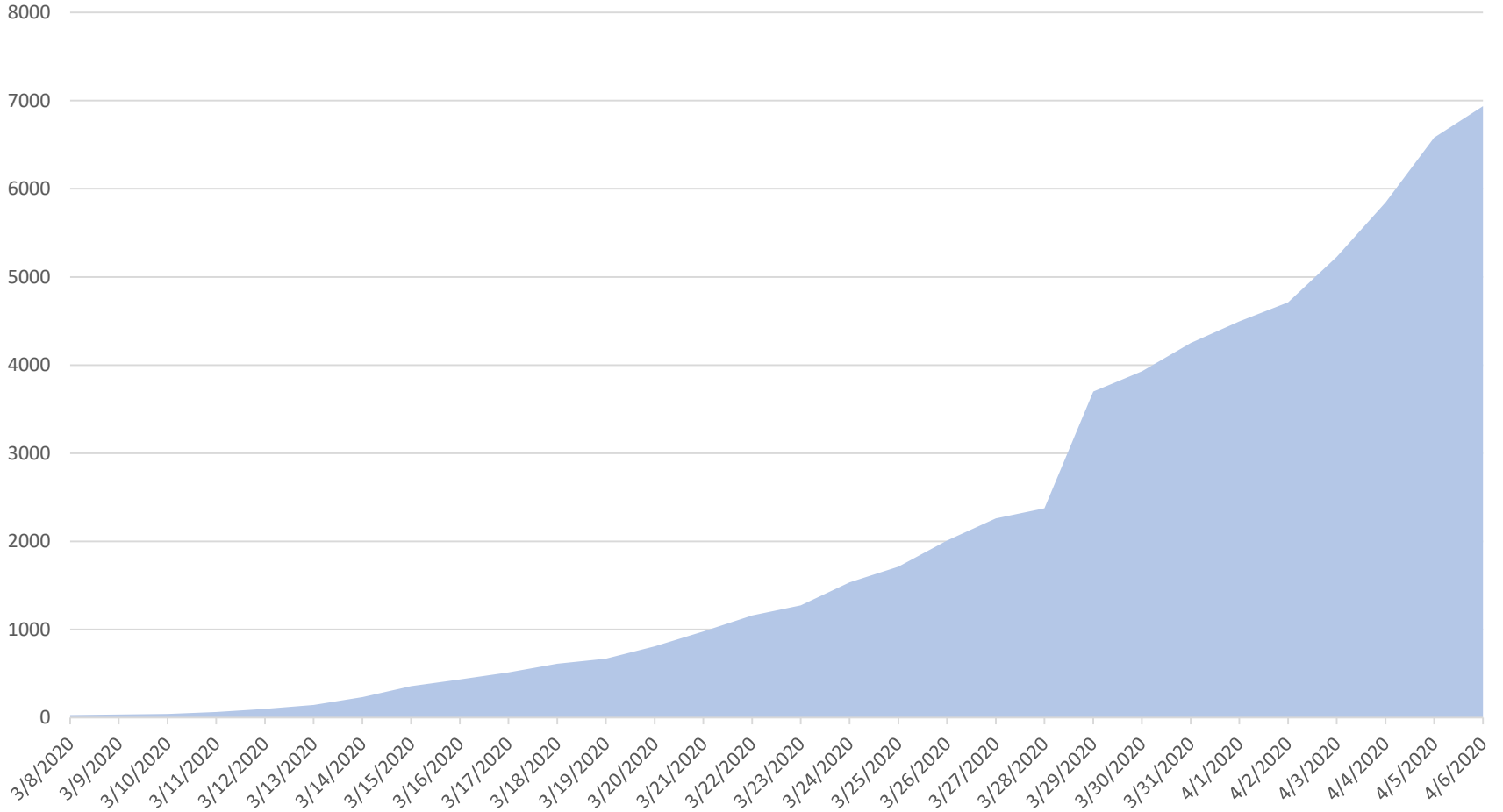Actual Cases vs. Projections (March 8th to April 9th // 0-1,000 Cases)

Legend:
- Actual Covid+ current
- OW Mid March: Avg Best-Case
- OW Mid March: Avg Worst-Case
- OW Late March: Avg Best-Case
- OW Late March: Avg Worst-Case
- Columbia Late March
- 513

Days Until the Impact of Social Distancing is Seen

Actual Cases vs. Projections (March 8th to April 9th // 0-1,000 Cases)

Legend:
- Actual Covid+ thru 4/1
- OW Mid March: Avg Best-Case
- OW Mid March: Avg Worst-Case
- OW Late March: Avg Best-Case
- OW Late March: Avg Worst-Case
- Columbia Late March

Closing Schools

Closing Bars & Restaurants

State of Emergency

10 to 14-day delay in effect

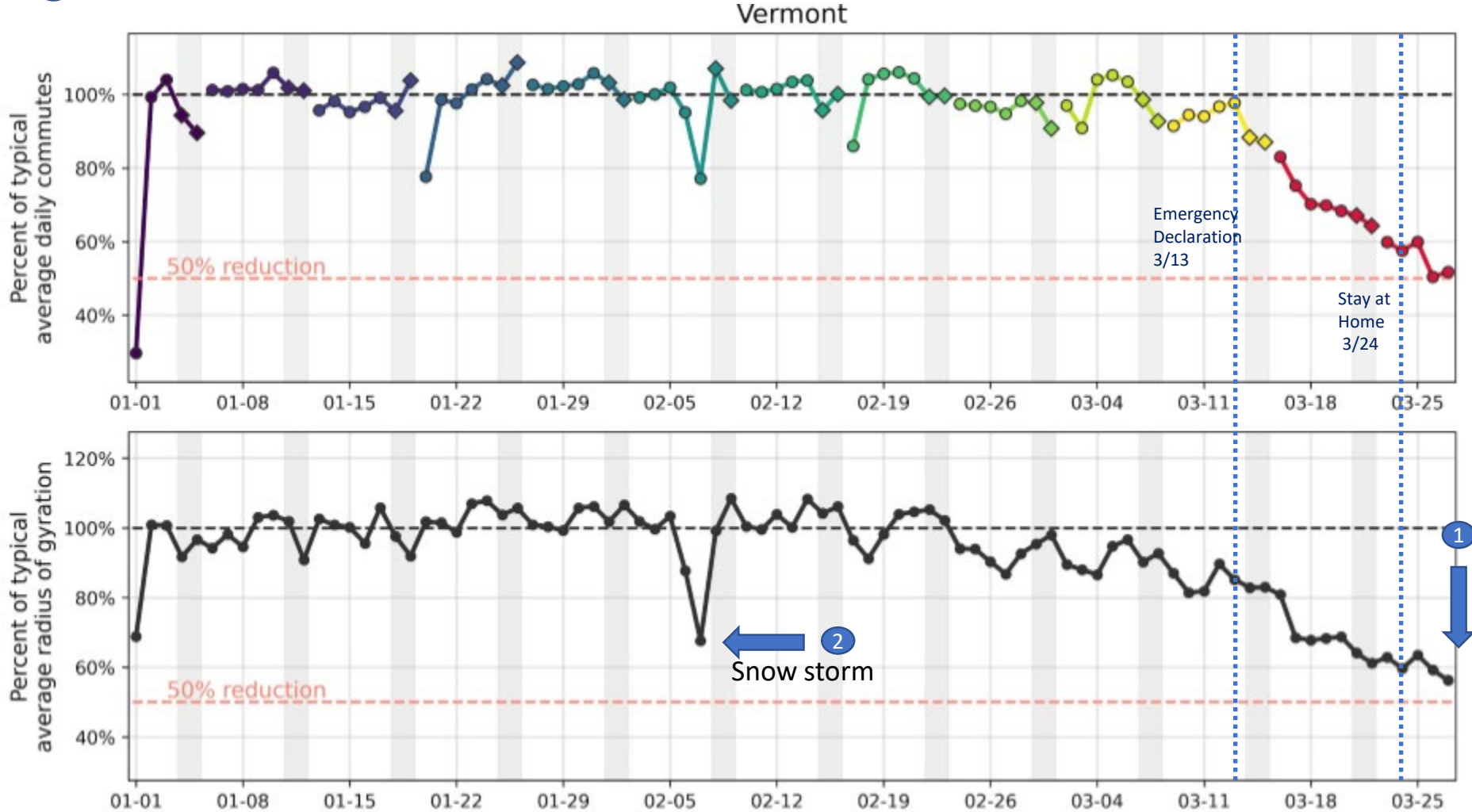Stay Safe Stay Home – 14 days
March 24th – April 8th

Total Vermont Testing Over Time

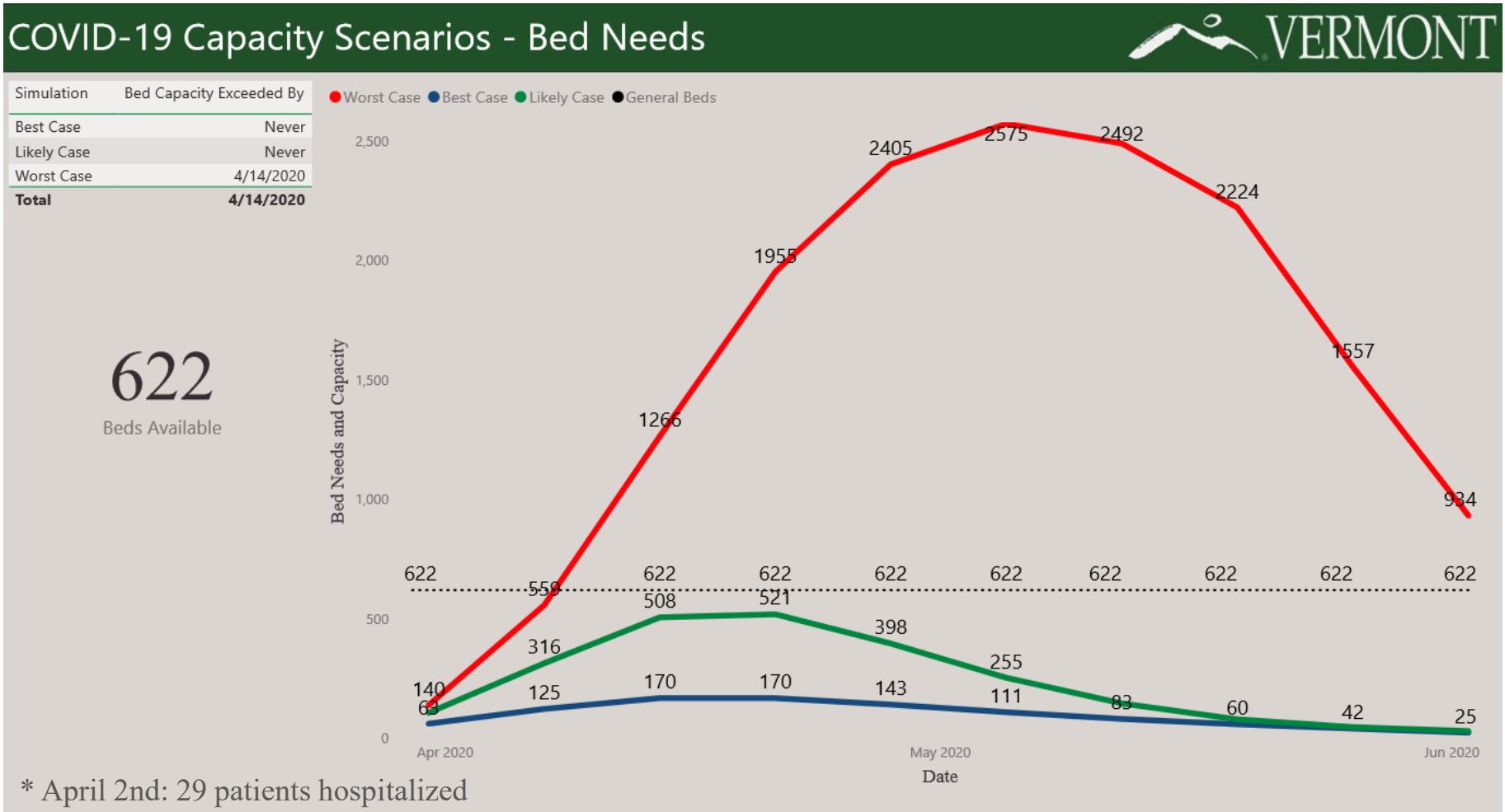# Vermont's Mobility Reductions

Key Points:

- ① 50% Reduction in physical movement with mitigation policies in place
- ② Dip on Feb 7 is the snowstorm; this means people are moving around LESS than they did during the big snowstorm → this is very good

Source: Dr. Vespignani, Northeastern University
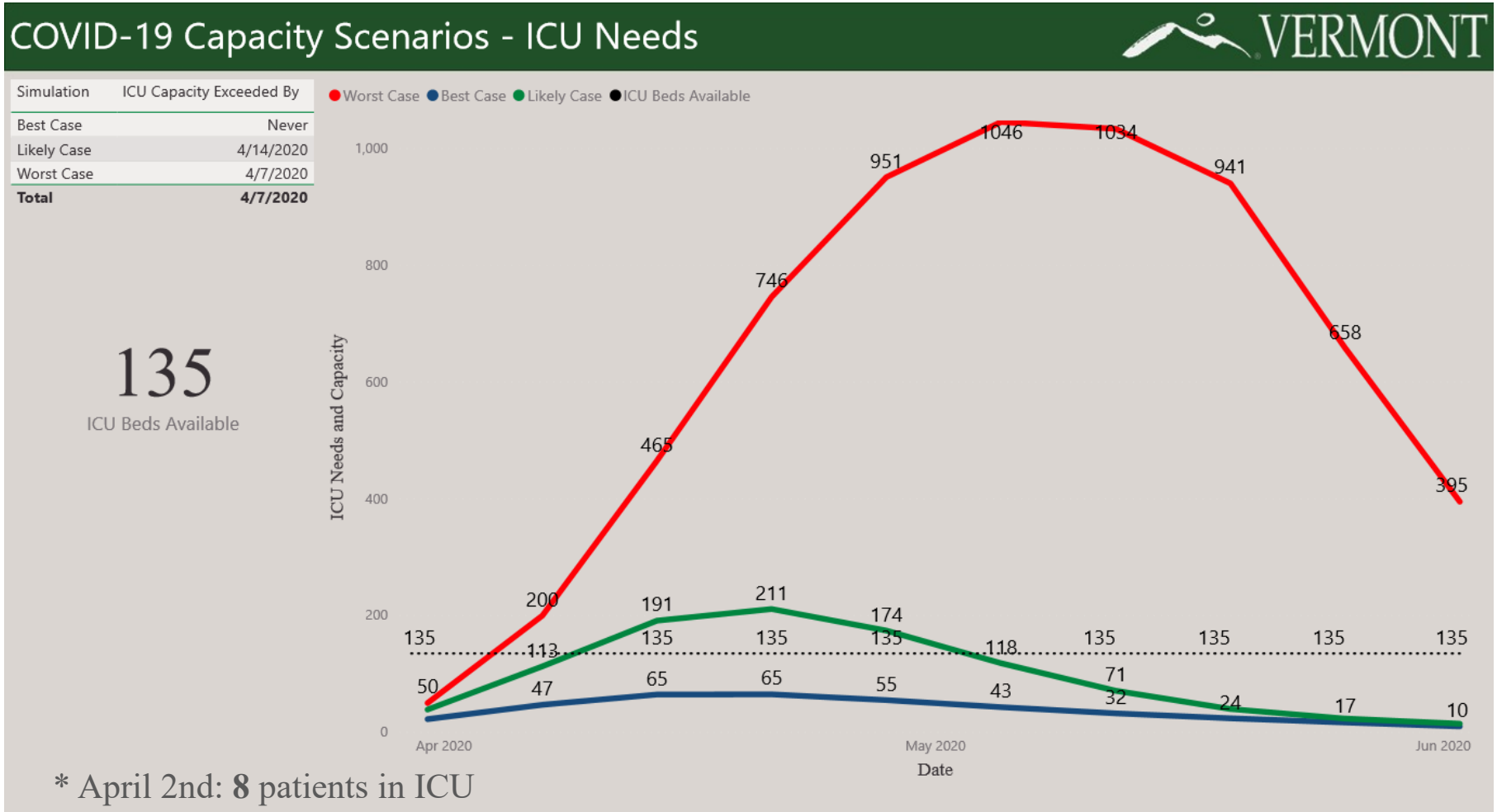
Hospitalization Needs – Likely, Best & Worst
Note – Late March Trajectory

COVID-19 Capacity Scenarios - Bed Needs

VERMONT

Simulation	Bed Capacity Exceeded By
Best Case	Never
Likely Case	Never
Worst Case	4/14/2020
Total	**4/14/2020**

● Worst Case ● Best Case ● Likely Case ● General Beds

622 Beds Available

* April 2nd: 29 patients hospitalized

Worst Case values: 63, 140, 559, 1266, 1955, 2405, 2575, 2492, 2224, 1557, 934

Likely Case values: 316, 508, 521, 398, 255, 83, 60, 42, 25

Best Case values: 63, 125, 170, 170, 143, 111

General Beds (capacity): 622

Modeling is for planning purposes only
Not representative of definitive outcomes.

13

ICU Needs – Likely, Best & Worst
Note – Late March Trajectory

Modeling is for planning purposes only
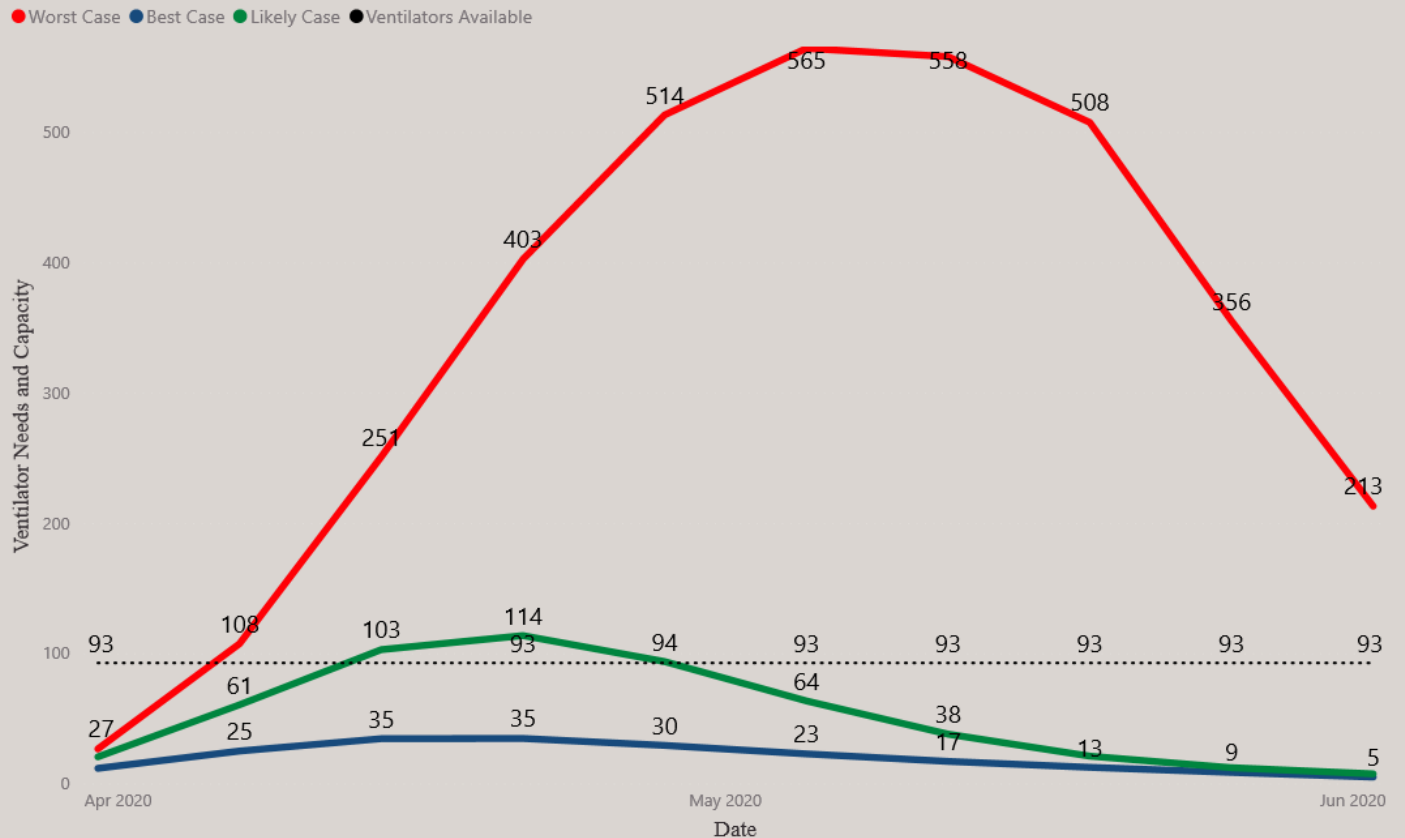Not representative of definitive outcomes.

Ventilator Needs – Likely, Best & Worst
Note – Late March Trajectory

COVID-19 Capacity Scenarios - Ventilator Needs

VERMONT

Simulation	Vent Capacity Exceeded By
Best Case	Never
Likely Case	4/14/2020
Worst Case	4/7/2020
Total	**4/7/2020**

● Worst Case ● Best Case ● Likely Case ● Ventilators Available

93
Ventilators Available

Ventilator Needs and Capacity

Worst Case values: 27, 108, 251, 403, 514, 565, 558, 508, 356, 213

Likely Case values: 93, 61, 103, 114, 94, 93, 93, 64, 38, 17, 13, 9, 5

Best Case values: 27, 25, 35, 35, 30, 23

Ventilators Available: 93 (constant)

Apr 2020   May 2020   Jun 2020
Date

*April 2nd: **1** patient needing ventilation

Modeling is for planning purposes only
Not representative of definitive outcomes.

15