Can we predict ICU/hospital capacity overflow by fitting an exponential curve to recent data?

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August 11, 2020

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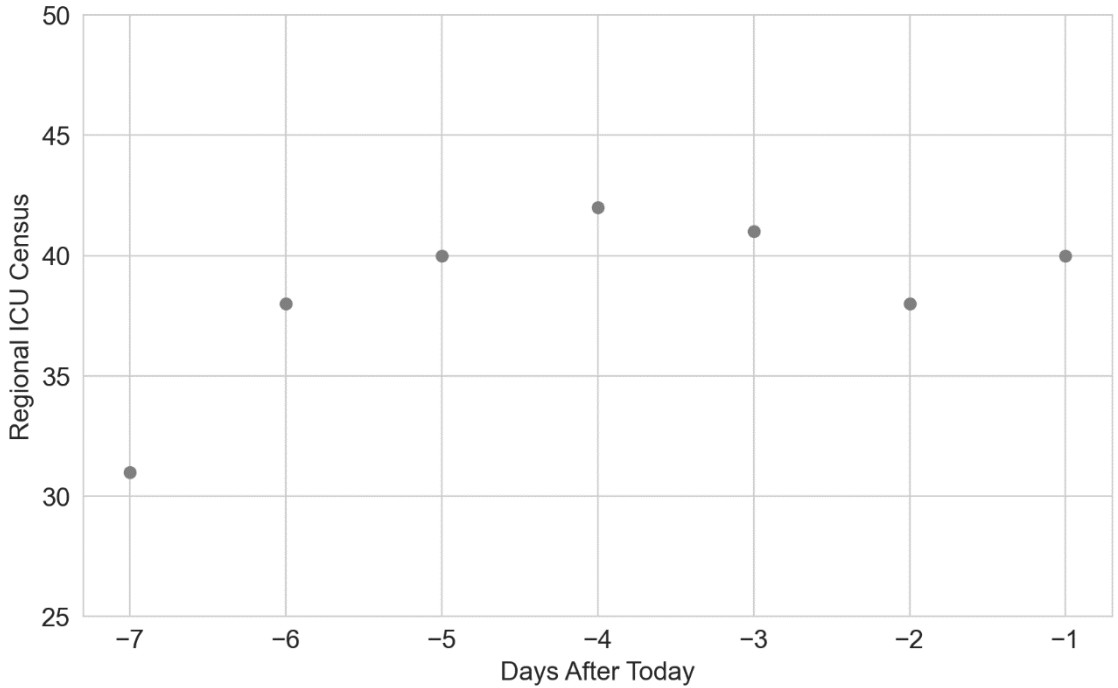
Northwestern

Let’s use our simulation model’s outputs, where we know the truth of whether capacity gets exceeded, to stress-test the “doubling time” method.

Method: Observe recent COVID ICU census…



Simulation of daily regional COVID ICU census

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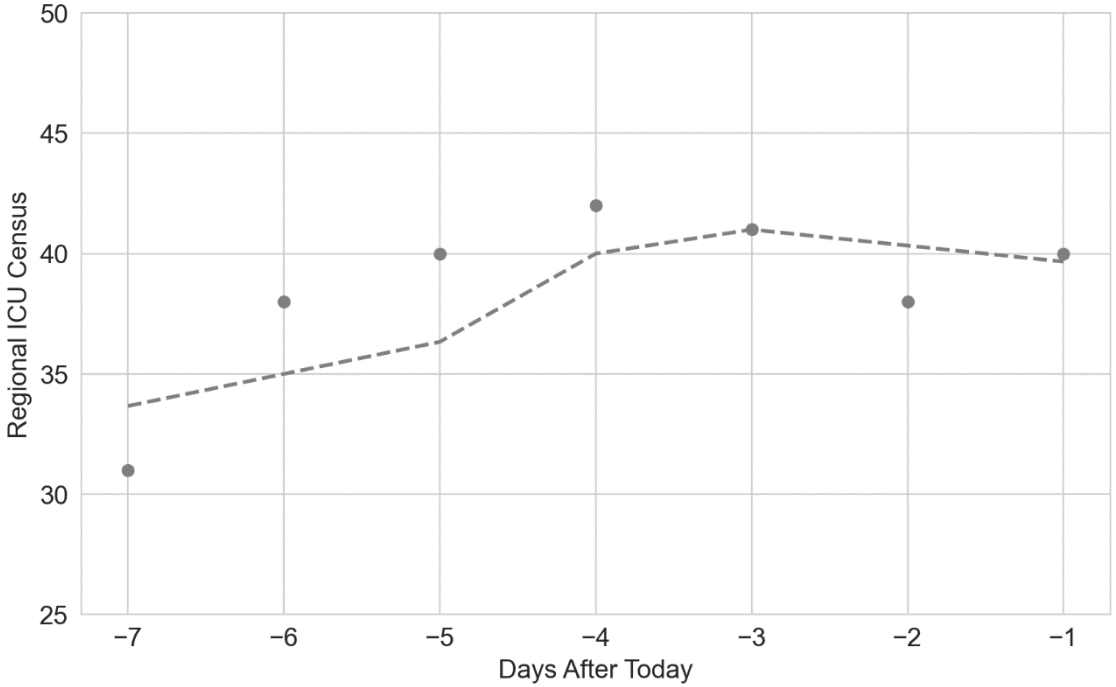
Method: Observe recent COVID ICU census, take the 3-day moving average…



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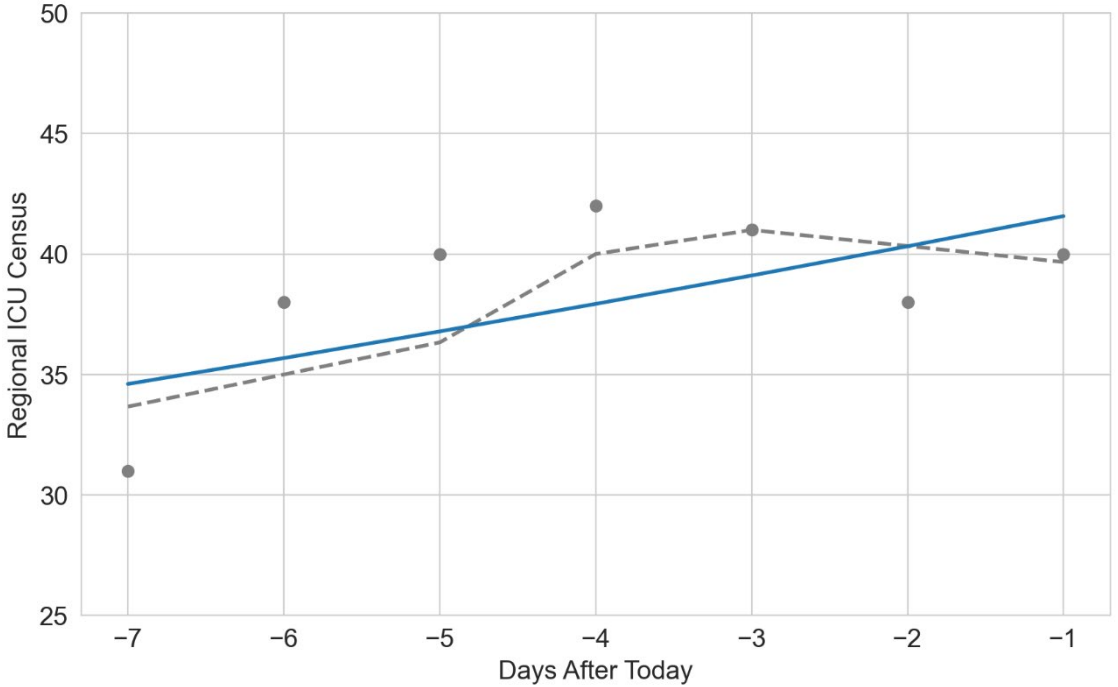

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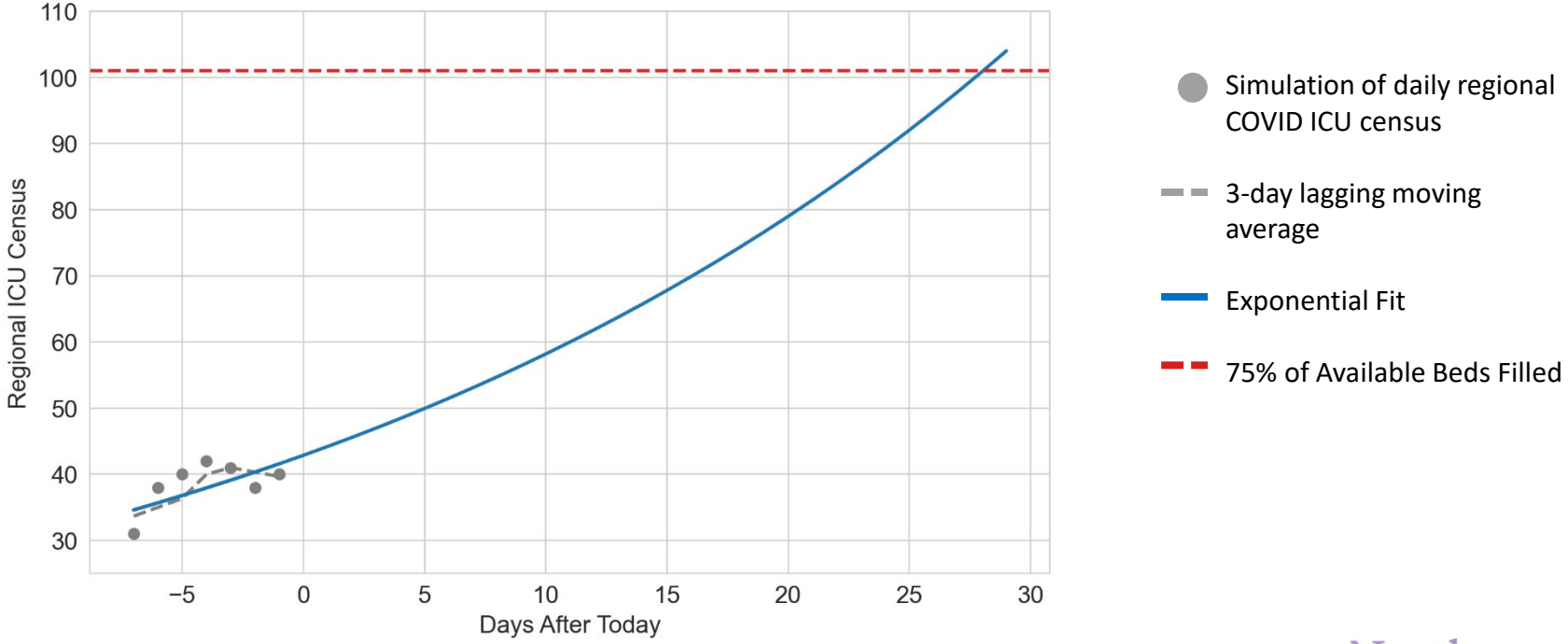
Method: Observe recent COVID ICU census, take the 3-day moving average, fit an exponential curve to data from the last week, and extrapolate this curve out for the next 30 days to see if it crosses the threshold (e.g., 75% of available beds filled).



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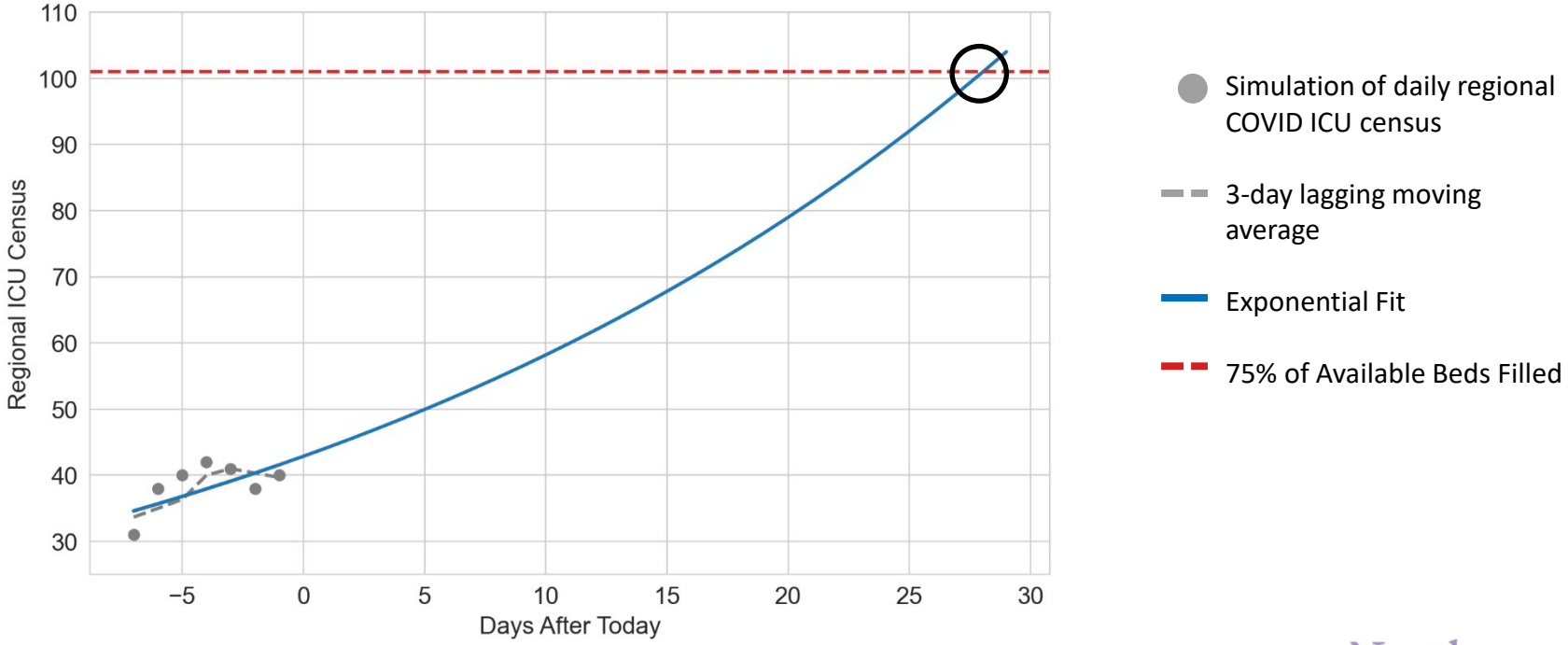

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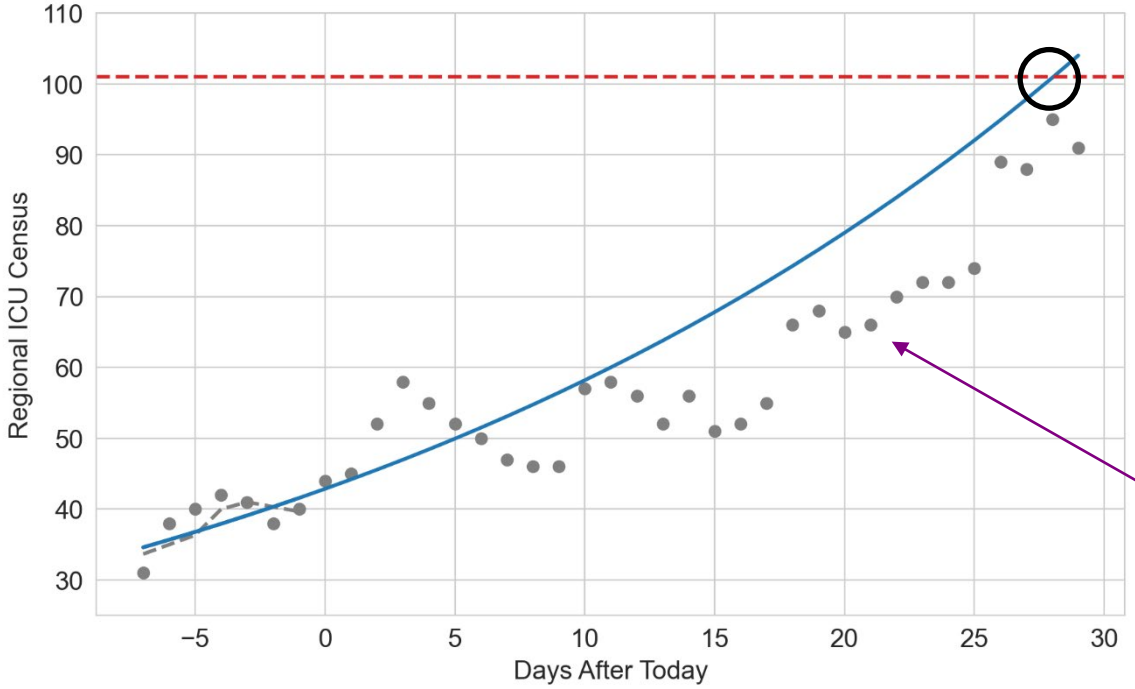

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3-day lagging moving average

Exponential Fit

75% of Available Beds Filled

Fitting to data from the last 7 days may not accurately predict the trajectory of the next 30 days.

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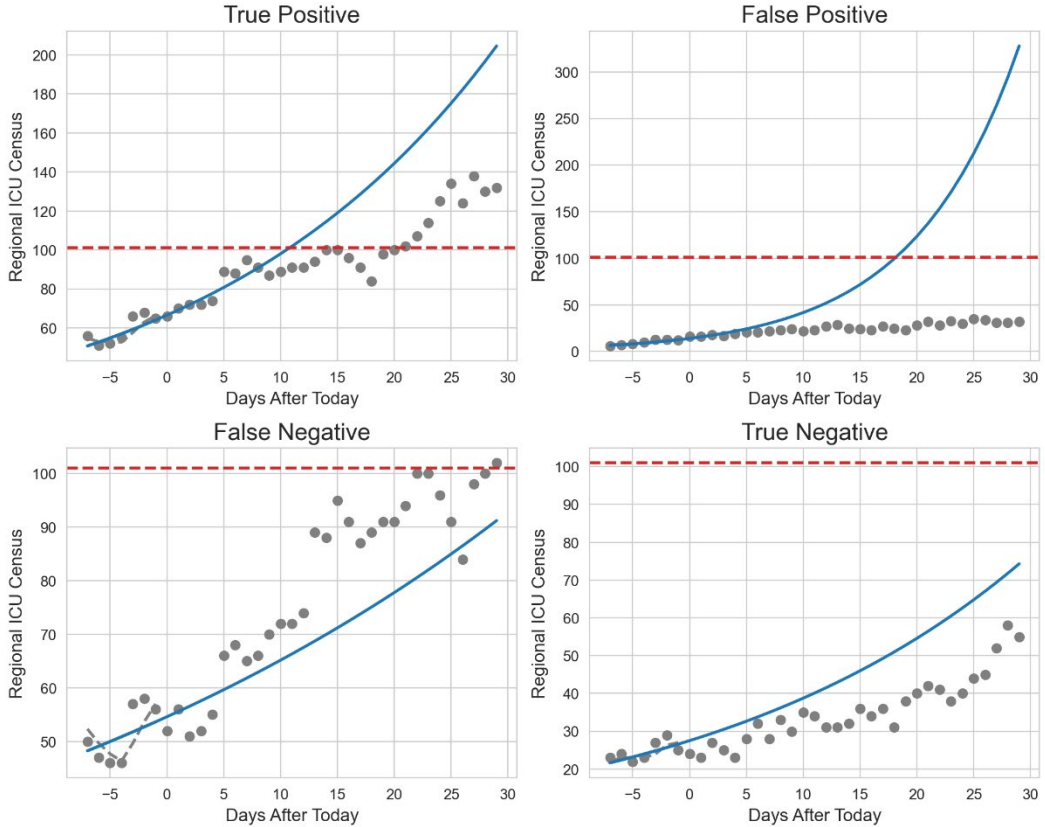
There are four possible prediction outcomes:

Region will actually exceed capacity ↓

Region will *not* actually exceed capacity ↓



← Exponential curve suggests region will exceed capacity

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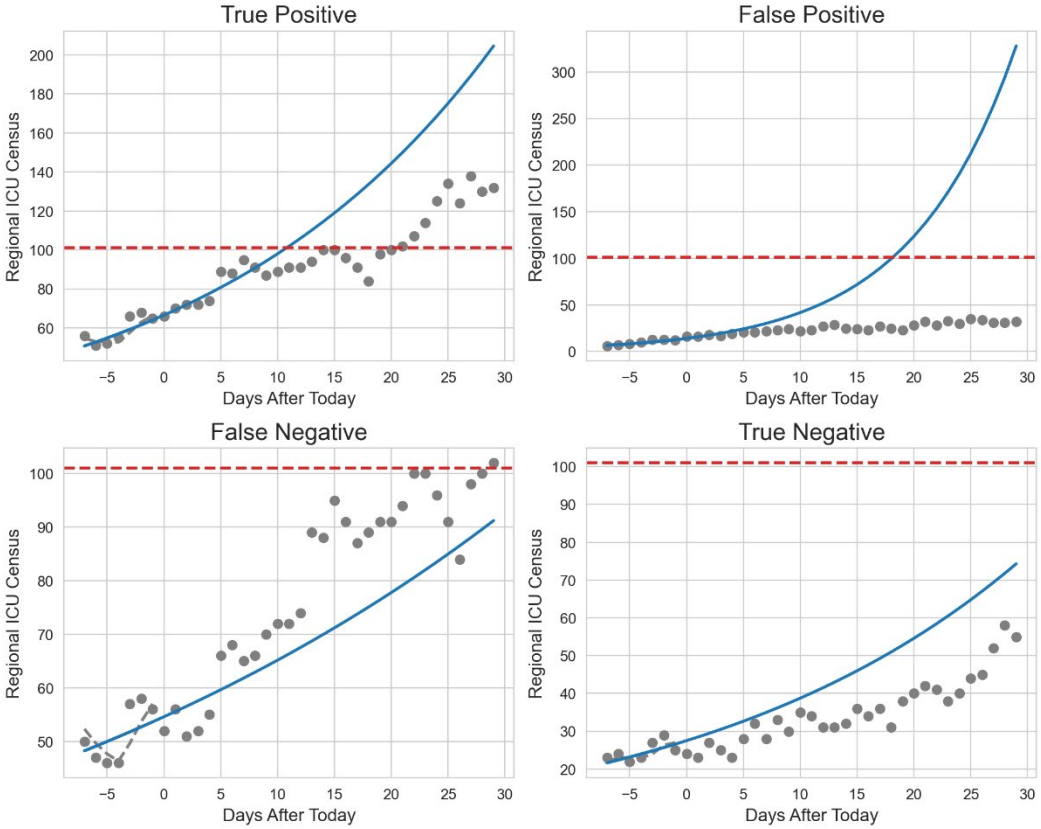

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To know how sensitive and effective this method is for predictive purposes, we will need to estimate its PPV and NPV for each region.

Positive Predictive Value (PPV):

$$\frac{\text{\# True Positives}}{\text{\# Total Positives}}$$

Negative Predictive Value (NPV):

$$\frac{\text{\# True Negatives}}{\text{\# Total Negatives}}$$

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For each region, we applied this method to the simulated ICU census on every simulation day in which ICU capacity had not already been exceeded.

The method was applied roughly 10,000 times for each region, across 54 different sets of model parameters.

Results:

	NU transmission model: Probability and median date a region will exceed ICU capacity if current trends continue		performance of "doubling time" model with NU model as truth: negative predictive value	positive predictive value
Region 1	4%	Nov 25	0.996	0.031
Region 2	100%	Oct 17	0.834	0.661
Region 3	100%	Oct 16	0.758	0.604
Region 4	100%	Oct 7	0.711	0.559
Region 5	24%	Jan 2	0.965	0.106
Region 6	44%	Dec 15	0.945	0.194
Region 7	6%	Feb 16	0.993	0.032
Region 8	0%		1.0	0.0
Region 9	6%	Jan 11	0.995	0.036
Region 10	0%		1.0	0.0
Region 11	0%		1.0	0.0

regions most likely to overflow according to 20.08.05 model

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***Many* false positive calls**

Metric loses its ability to accurately make positive calls in regions with slower increases in ICU census

Preliminary Conclusions

- Using this method in high-risk regions, **you can’t be very sure of the truth behind a positive call *or* a negative call**. It’s only a bit better than a coin toss.
- Using this method in low-risk regions, although you can be pretty sure of the truth behind a negative call, **a positive call will almost always be false**.

What if we use a linear fit instead of exponential?

	NU transmission model: Probability and median date a region will exceed ICU capacity if current trends continue		performance of "doubling time" model with NU model as truth			
			exponential fit		linear fit	
			negative predictive value	positive predictive value	negative predictive value	positive predictive value
Region 1	4%	Nov 25	0.996	0.031	0.996	0.110
Region 2	100%	Oct 17	0.834	0.661	0.796	0.965
Region 3	100%	Oct 16	0.758	0.604	0.762	0.929
Region 4	100%	Oct 7	0.711	0.559	0.750	0.801
Region 5	24%	Jan 2	0.965	0.106	0.971	0.400
Region 6	44%	Dec 15	0.945	0.194	0.951	0.500
Region 7	6%	Feb 16	0.993	0.032	0.994	0.152
Region 8	0%		1.0	0.0	1.0	0.0
Region 9	6%	Jan 11	0.995	0.036	0.995	0.131
Region 10	0%		1.0	0.0	1.0	0.0
Region 11	0%		1.0	0.0	1.0	0.0

improved PPV, little change in NPV

PPV still not good

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Assessment of linear version

- PPV is improved compared with the exponential version but is **still low** except for the most endangered areas.
- In a region similar to Region 5, such low PPV means that even a positive call was made **3 weeks in a row**, there is a **94.6% chance that at least one of those calls is false** and a **64.8% chance that two or more are**.
- NPV stays put around 75-80% for the most endangered areas and remains excellent for lower-risk areas.
- Linear fit is still **a poor predictor in areas with slower rise in census**.