SARS-CoV-2 (COVID-19) Modeling (Version 3.0),
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Overview

- Overview of changes in Version 3 and their impacts
- Three key scenarios/new model capabilities
  - Stay-at-home order
  - Testing
  - CDC criteria for return (and medical advancement)
- Supplemental information

Timeline of Minnesota COVID-19 Model

- Version 1: March 2020
  - Based on early data available at the time
- Version 2: April 2020
  - Included more specifics about Minnesota cases, factors
- Version 3: May 2020
  - Integrates new details and capabilities
- Ongoing model updates planned within available capacity

Introduction

- The University of Minnesota and MDH created the Minnesota COVID-19 model as a tool to inform response strategies and resource planning
- Updated model documentation is available online [Minnesota COVID-19 Modeling (https://mn.gov/covid19/data/modeling)] including:
  - References for parameter values
  - Underlying data
  - Model equations governing transitions of the population through COVID-19 health states
- Programming code posted at GitHub - UMN/MDH Minnesota COVID-19 Modeling Collaboration (https://github.com/MN-COVID19-Model)

Why the Need for New Model Versions?

- COVID-19 remains **in early stages** and new evidence is emerging
- Ongoing model updates are needed to:
  - Reflect the **growing understanding** of COVID-19 transmission and outcomes
  - Incorporate newly emerging **data from the U.S. and Minnesota**
  - Refine projections by fitting model **Minnesota data on observed mortality and hospitalization data**
  - Add **new model capabilities** to illustrate potential mitigation strategies

Data Considerations

- Epidemic and evidence **still very new**
- Extent and impact of **key metrics** uncertain
- Evolving **clinical protocols** with halting dissemination of evidence
- **U.S. case data are limited and incomplete,** affecting availability of robust estimates

Data Considerations

Limited U.S. data

- First studies with U.S. patients in late **March and April**
  - 4,226 cases in U.S. study: **outcomes (illness & death) were unknown** for 2,001
  - 5,700 patients hospitalized with COVID-19 in NYC area: **discharge or death status was only known for 46%**
  - Among hospitalized Minnesota COVID-19 patients: **nearly 32% remain in the hospital**

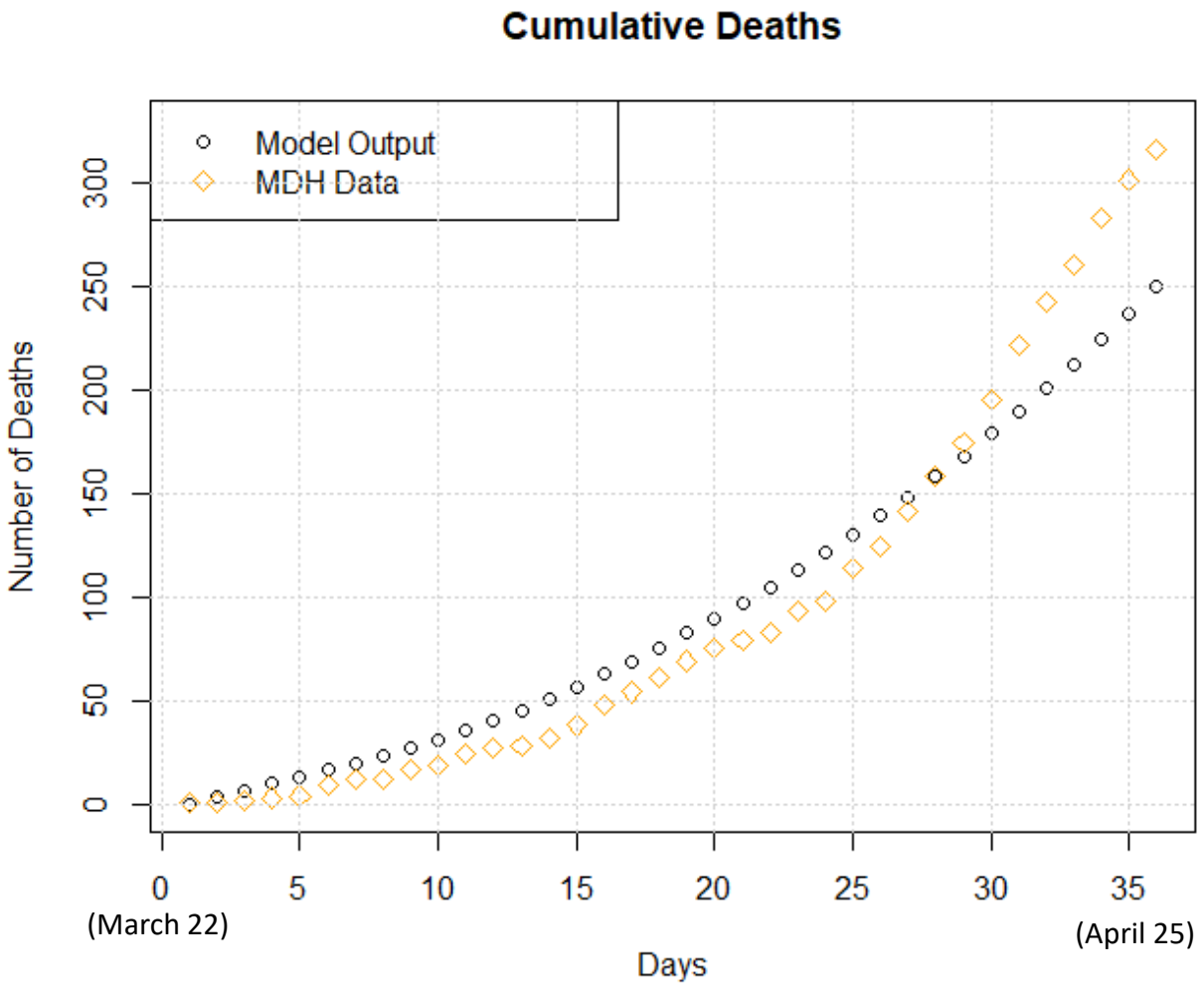
Five Key Changes to Model Version 3

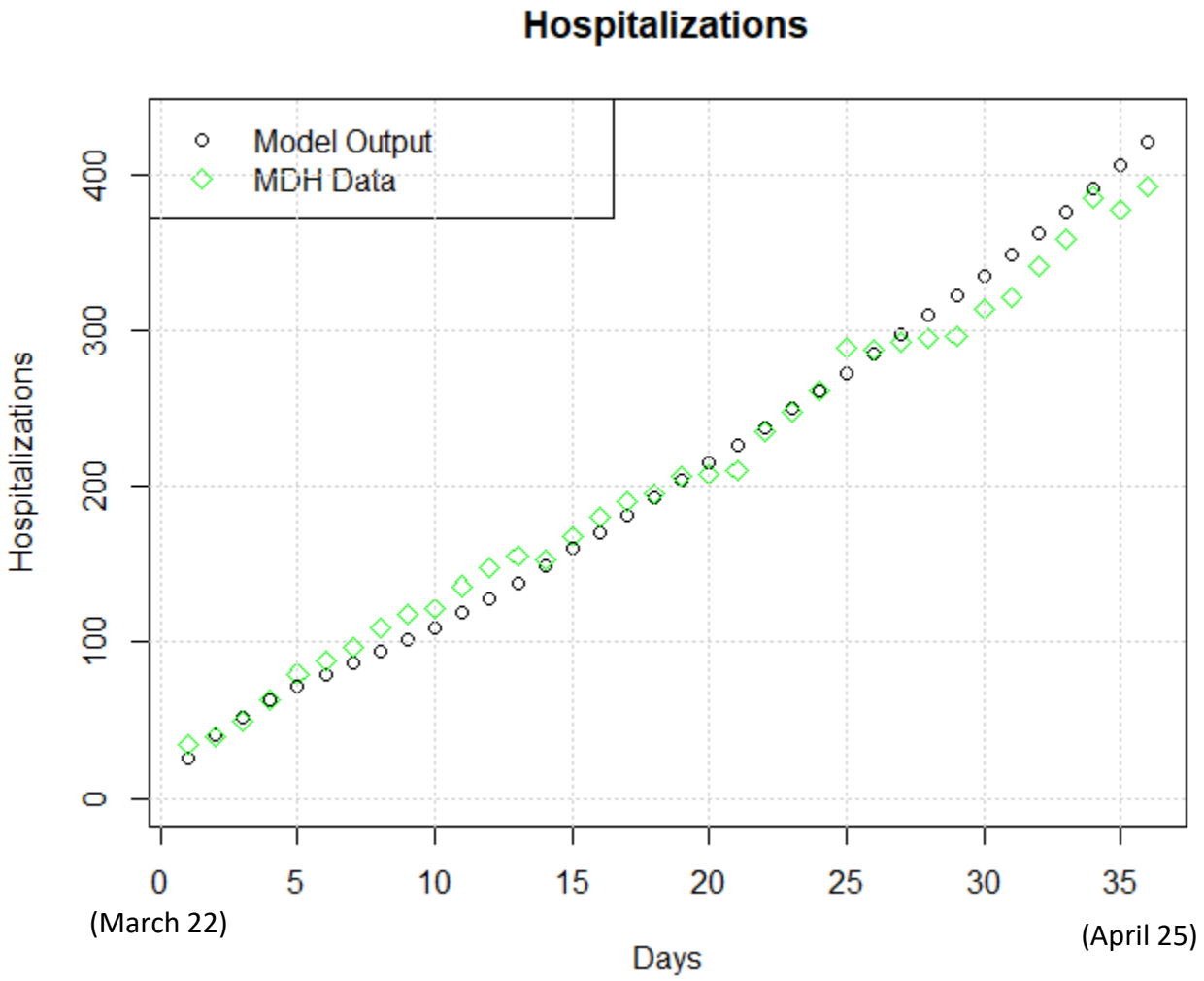
1. Structural changes to address
   - **Asymptomat**ic infections
   - Deaths occurring **outside of hospital**
2. Restricted ICU metric to **ventilated cases**
3. Updated parameter estimates using **newly available US data**

Overview of Model Changes in Version 3

4. Incorporated new calibrated parameters, including
   - Proportion of 70+ year olds **dying in non-hospital settings**
   - **Reduction in contacts** under social distancing and under stay-at-home order
5. Fitted model to Minnesota deaths and hospitalizations through April 25

Model Fit to Observed Cumulative Deaths (through 4/25)





MN COVID-19 Model v.3: Outputs

What?

- **Less time** to peak epidemic
- Some **upward movement** in estimates for:
  - ICU demand, and
  - Full-epidemic mortality

Why?

- Calibration to **rising MN deaths**
- **Mitigation less effective** than assumed for:
  - Initial physical distancing (38%, not 50%
  - Stay-at-home order (59.5%, not 80%)
- Changes to **ICU mortality** assumptions & data

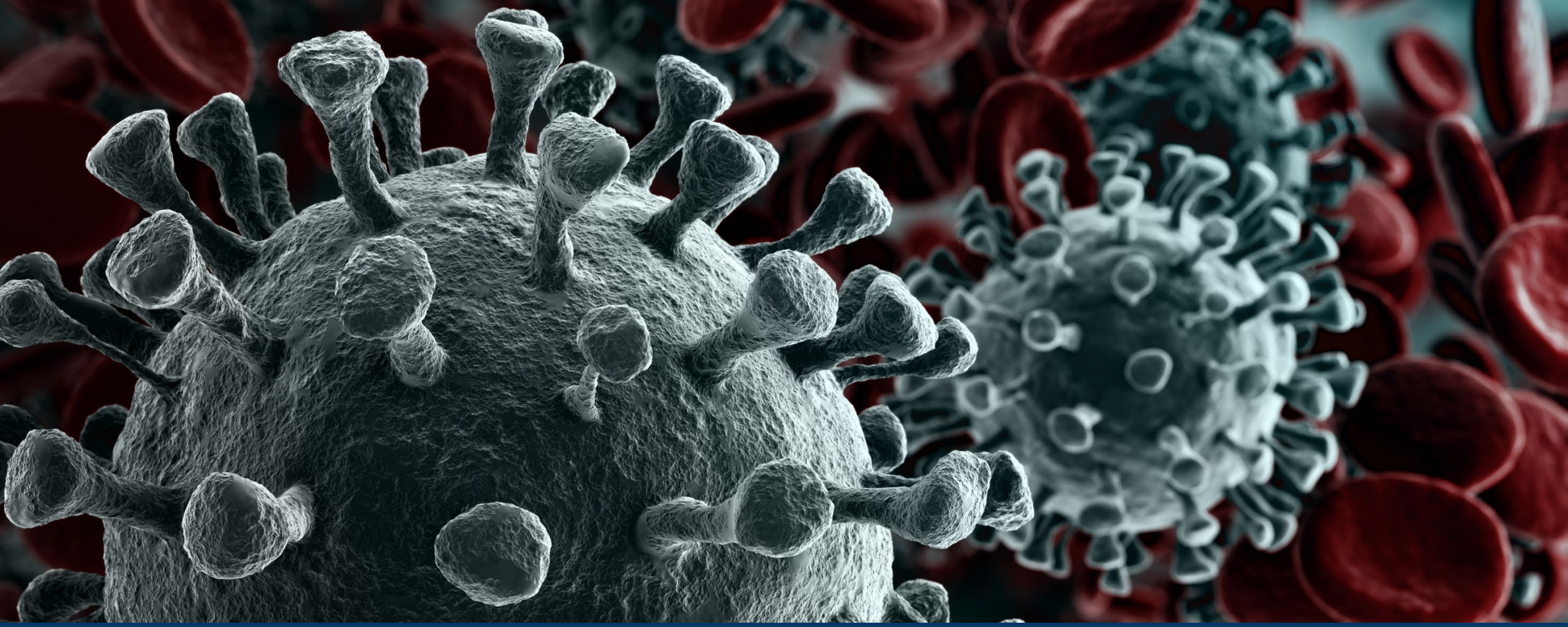
Model Changes: "Stay-at-Home Order in Place for 6 Weeks"

Scenario 4*	V 2.0 (incl. uncertainty)	V 3.0 (incl. uncertainty)
Weeks until peak	16 (13 to 21)	13 (11 to 13)
Weeks until ICU capacity reached	16 (13 to 21)	13 (12 to 13)
Top ICU (ventilator) demand	3,700 (2,700 to 4,900)	3,600 (2,000 to 5,200)§
Mortality (cumulative for 12 months)	21,800 (9,900 to 36,000)	29,000 (16,000 to 44,000)
Mortality (through end of May)	N/A	1,700 (1,400 to 2,000)

* Same as Scenario 3 except shelter-in-place policy remains in force for 6 weeks

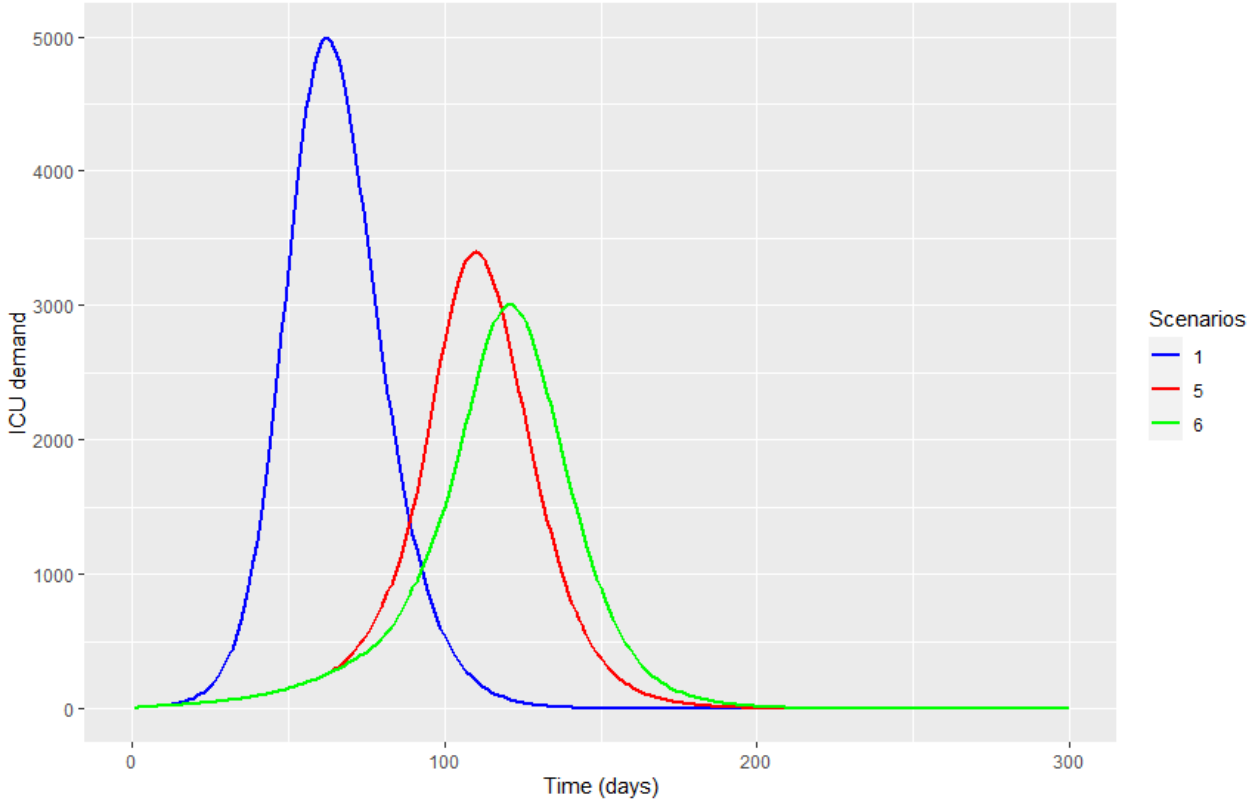
§ Assuming no ICU capacity constraints

DEPARTMENT OF HEALTH



Scenarios & Model Capabilities: An Illustration of Trade-offs

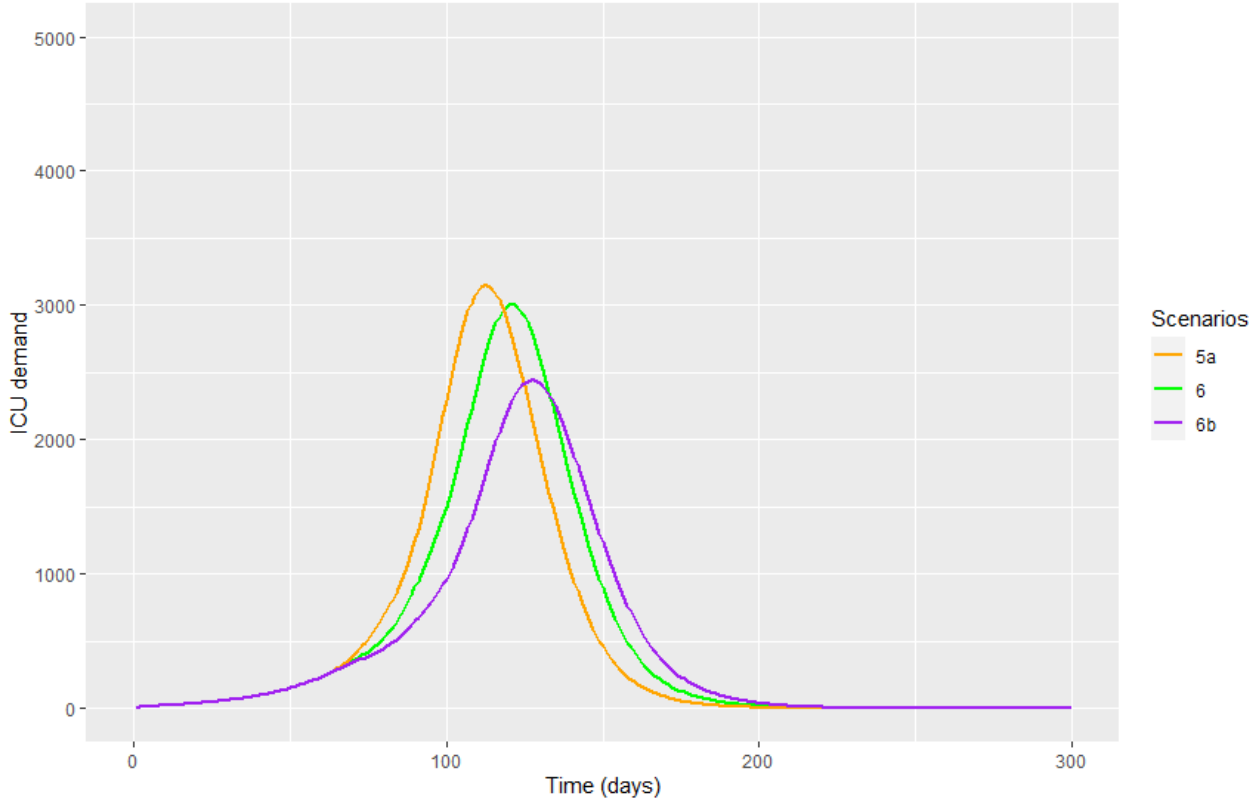
Unmitigated and Extended Stay-at-Home Orders



	Scenario 1 Unmitigated (blue)	Scenario 5 SHO till 5/18 (red)	Scenario 6 SHO till 5/31 (green)
Weeks till peak	May 11	June 29	July 6
Top ICU/vent demand	4,991	3,397	3,006
Mortality (full pand.)	57,035	29,030	28,231
Mortality (thru May)	42,032	1,441	1,388

Stay-at-home order followed by three weeks soft opening (reduction of contacts by 38pct and ongoing physical distancing for vulnerable.

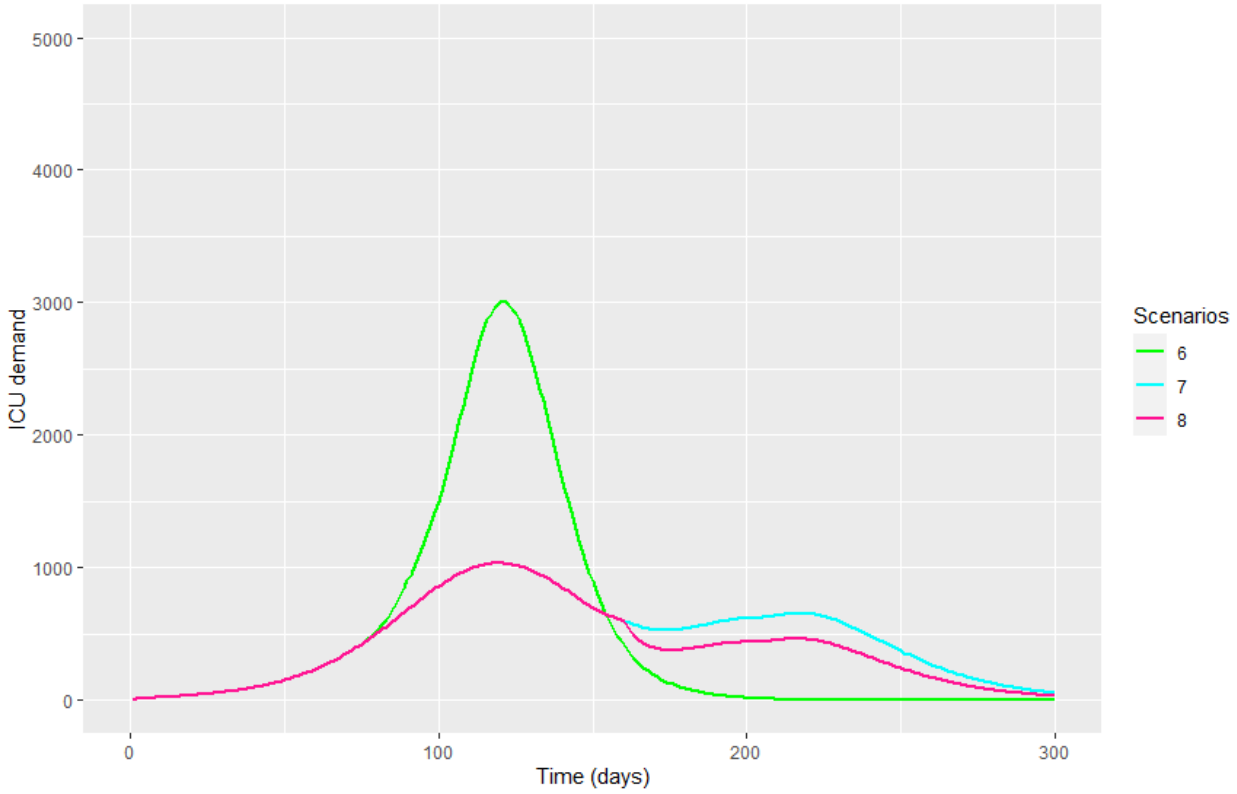
Extended Stay-at-Home Orders & Testing



	Scenario 6 SHO till 5/31 (green)	Scenario 5a worst testg: 70% sens 10k tests (orange)	Scenario 6b best testg: 95% sens 20k tests (purple)
Weeks till peak	July 6	June 29	July 13
Top ICU/vent demand	3,006	3,150	2,444
Mortality (full epid.)	28,231	26,914	22,589
Mortality (thru May)	1,388	1,430	1,375

At this point the impact of testing applies only to tested individual by reducing their rate of contact (assuming social distancing for positives); tests are distributed to "I" states and non-"I" states, through probabilities of testing access.
Reduced contact through contact tracing is currently not built into the model.

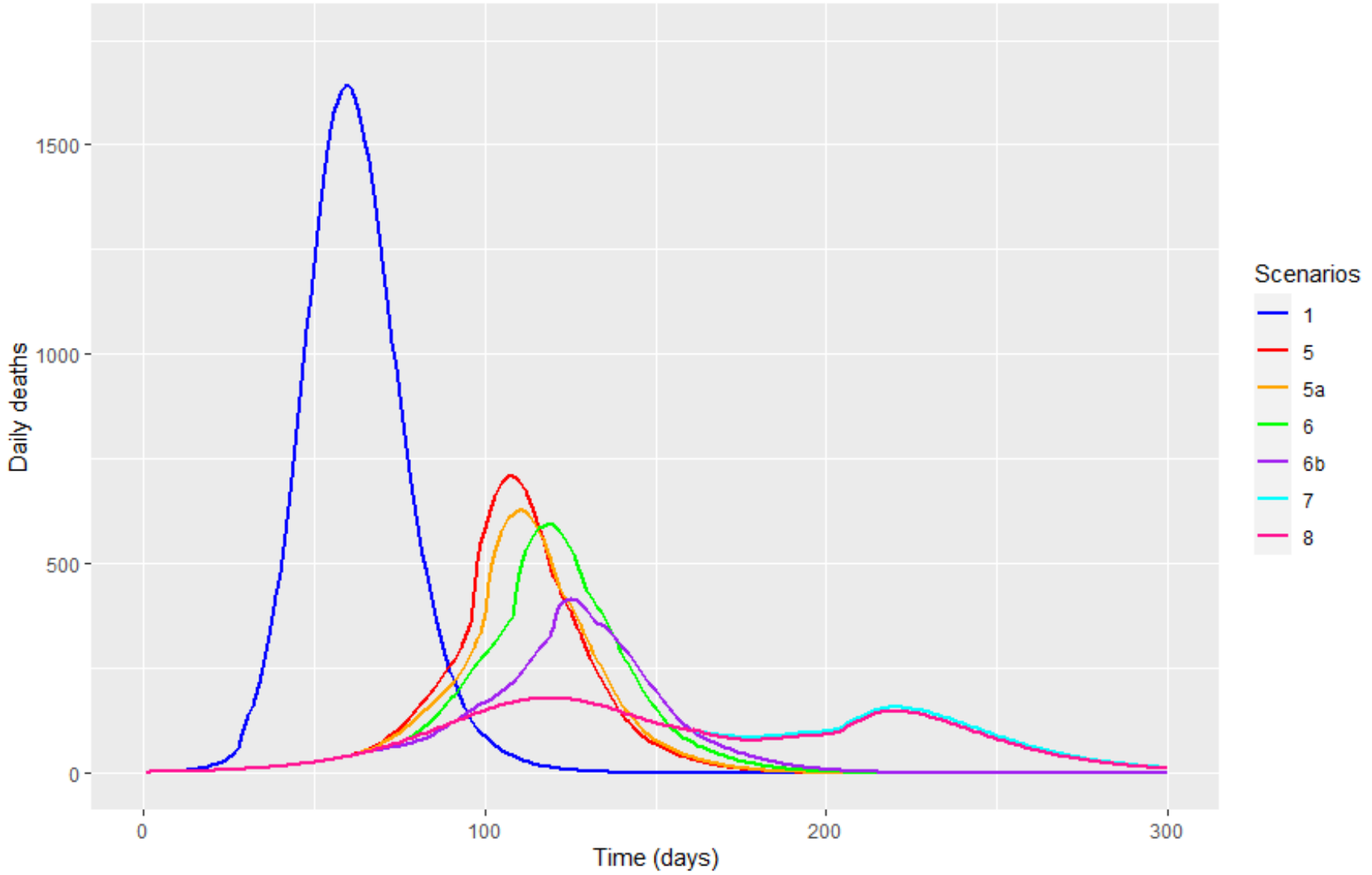
Extended Stay-at-Home Order, CDC Guidelines for "Opening Up" and Medical Advancement



	Scenario 6 SHO till 5/31 (green)	Scenario 7 CDC Opening (aqua)	Scenario 8 CDC Opening + Tx (pink)
Weeks till peak	July 6	July 6	July 6
Top ICU/vent demand	3,006	1,034	1,034
Mortality (full epid.)	28,231	26,294	25,392
Mortality (thru May)	1,388	1,388	1,388

Source: Guidelines: Opening Up America Again, White House/CDC, slide deck; assumes downward trajectory of hospitalizations for 14 days following the peak (or through Sept. 7, 2020). [https://www.whitehouse.gov/openingamerica/ 5/8/2020, 11:43:00PM]
Rx treatment (Tx) only for hospitalized patients, 30% reduction in LOS & mortality

Daily Deaths – All Scenarios



Consideration for Next Steps

- More and better data from U.S. epidemic
- Refined scenarios
  - Treatment: evidence on home treatment
  - Testing: incorporate impact of contact tracing
- Enhancements: cycling mitigation

Thank You!

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More on COVID-19 in MN
mn.gov/covid19/ | https://mn.gov/covid19/data/modeling.jsp |

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Input Parameters

Parameter	V1	V2	V3
Basic reproduction number (R0)	2.38	3.87	3.87
Transmission probability (per contact between infected/susceptible persons)	0.009¶	0.035◆ (0.025-0.045)	0.0295◆
Latent period	5 days	5 days	5.2 days
Infectious period	8 days	8 days	7.8 days
ICU duration	22.6 days	10.3 days	8 days
Hospitalization duration	8 days	13.3 days	11 days
Increased mortality factor with ≥ 1 comorbidity	7.6	7.6	1.0 (not used)
Increased mortality factor if ICU capacity exceeded	1.5 to 16.5	1.5 to 16.5	Assume death
Hospitalized cases requiring ICU (age ranges)	5.0% to 70.9%	5.0% to 70.9%	11.9% to 29.6%*
ICU mortality rate (age ranges)	0.000 to 0.111	0.000 to 0.111	0.0005 to 0.779§

¶ Corresponds to an R0 of 2.38; ◆Corresponds to an R0 of 3.87; * Restricted to ventilated cases

§ Probability of dying

Model Parameters Estimated Through Calibration

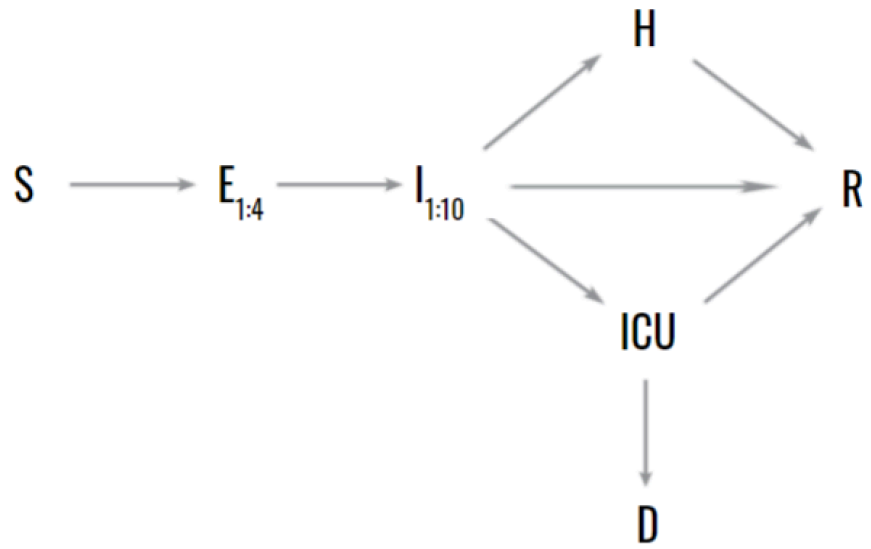
Parameter	V1	V2	V3
Proportion of cases detected prior to start of model simulation*	0.119 (input)	0.01	0.021
Hospitalized infections (age ranges)	0.1% to 27.3%	0.1% to 27.3%	10.3%**
Proportion of people aged 70 or older with a symptomatic infection die at home	N/A	N/A	0.139
Proportion of infections which are asymptomatic	0.0 (input)	0.25 (input)	0.41
Estimated contact reduction caused by the social distancing	0.5 (input)	0.5 (input)	37.6%
Estimated contact reduction caused by the stay at home order	0.8 (input)	0.8 (input)	55.1%

*case detection rate only used for model initialization

**calculate age-specific hospitalization probabilities, prophosp, the relative proportion of symptomatic cases by age is multiplied by the calibrated values for the probability of 80+ year-olds who are hospitalized.

Model Structure

V1 and V2



S-Susceptible

E-Exposed

I-Infected

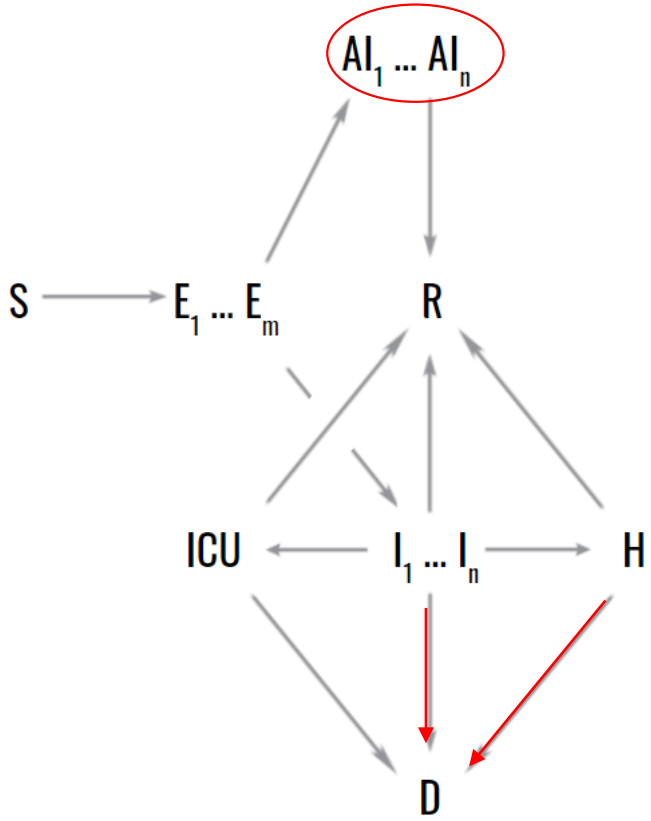
H-Hospitalized

ICU-In ICU

R-Recovered

D-Dead

V3



S-Susceptible

E-Exposed

AI-Asymptomatic Infection

I-Infected

H-Hospitalized

ICU-ICU Eligible

R-Recovered

D-Dead