



SARS-CoV-2 (COVID-19) Modeling (Version 2.0), April 10, 2020 – updated April 28, 2020

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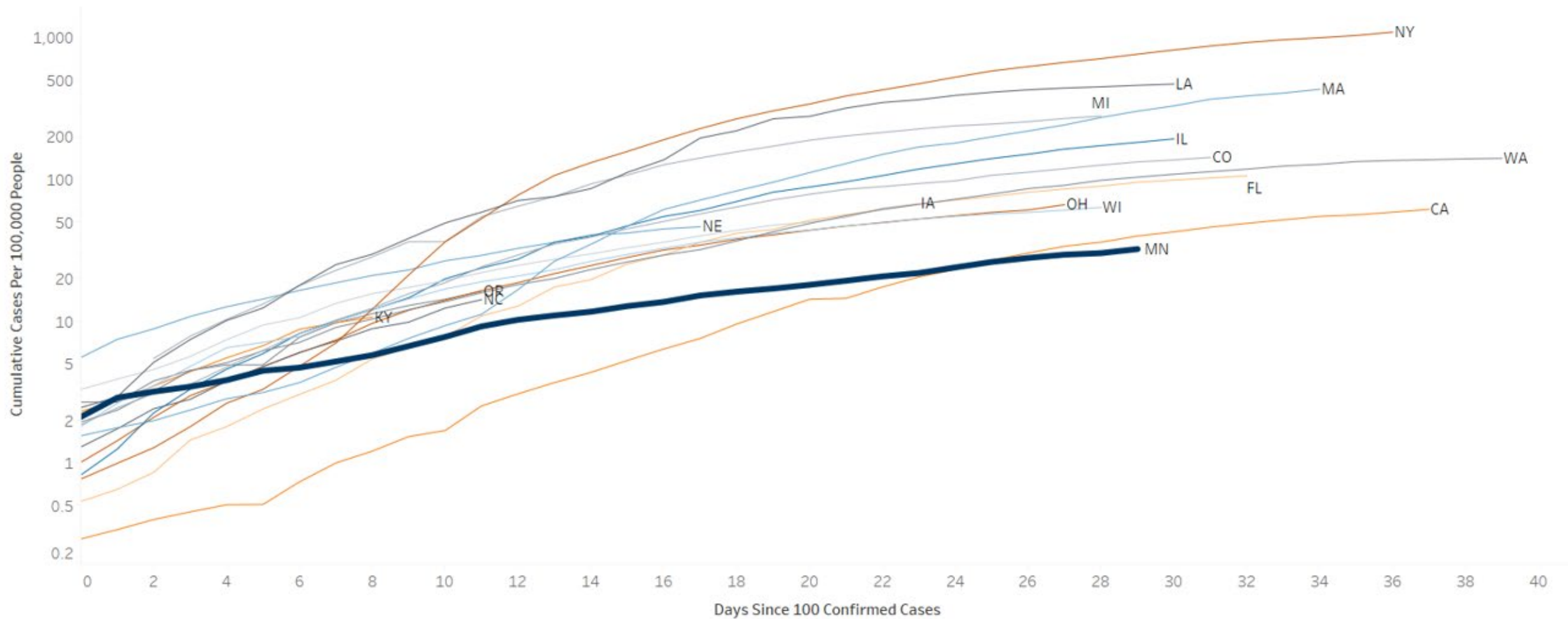
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- Data that helps inform Minnesota's epidemic response
- Updates to the Minnesota COVID-19 model
- Findings
- Detail from four scenarios
- Limitations and next steps

Data that Informs Epidemic Response

- Traditional public health data
 - Syndromic surveillance – health care/surveys/more
 - ILI/flu like symptoms
 - Death records
 - Persons tested
- Data on health care capacity (PPE, ICU/vents, health care workers)
- Information from other states
- Evidence from the literature/CDC
- Output from mathematical disease modeling

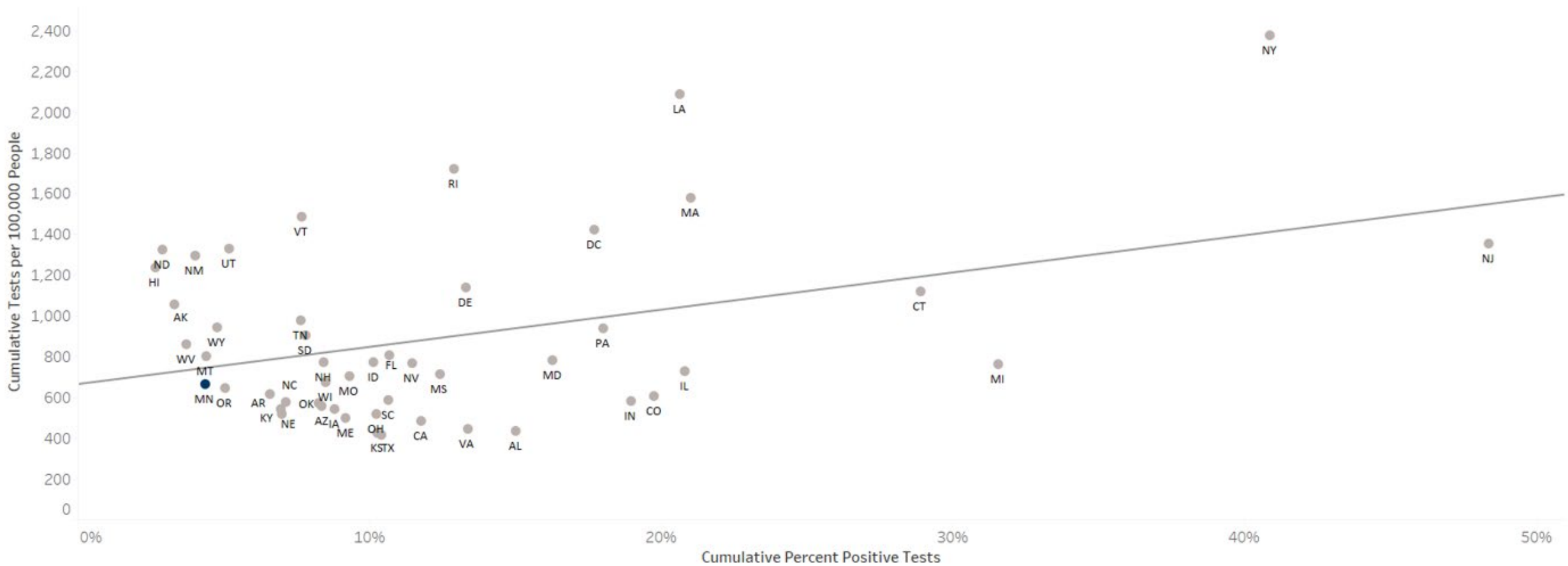
Cases per 100k People After First 100 Confirmed Cases, MN and Select States (Based on MDH Report Date, Cumulative, updated: 4/16/20)



Source: MDH Health Economics Program analysis of several state's department of public health, covidtracking.com, and publicly accessed news source COVID-19 reporting. Information is as a point in time and can vary by source. State resident population is based on Table 1. Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2019 (NST-EST2019-01); U.S. Census Bureau, Population Division; December 2019.

Day 0 is based on first date state reported having 100 COVID-19 cases, resulting in different time durations by state. Cases may include non-residents of the state.

Percent of Positive COVID-19 Tests and Tests per 100k People, All States (Cumulative, updated: 4/13/20)



Source: MDH Health Economics Program analysis of several state's department of public health, covidtracking.com, and publicly accessed news source COVID-19 reporting. Information is as a point in time as of 4/11/2020 and can vary by source. Cases and numbers of tests may include non-residents of the state. State resident population is based on Table 1. Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2019 (NST-EST2019-01); U.S. Census Bureau, Population Division; December 2019.

Based on data from all states as of 4/11/2020. Some of the differences between states are due to where they are in the disease curve, the age and health distribution of the state, and mitigation steps taken by the states. This graph cannot determine which of these factors is impacting where states are on this scatterplot. Percent of positive tests is calculated as cases divided by number of tests. The number of tests is assumed to include private and public lab testing; however, not all private labs submit testing data. WA is not shown due to lag in reporting of cumulative tests.



Minnesota's COVID-19 Model

A Partnership with the School of Public Health

Susceptible, Exposed, Infected, Recovered (SEIR)

- Model structure has been used to forecast outcomes for other coronaviruses - SARS and MERS
- Same structure used by the most sophisticated COVID-19 models, because it:
 - Accounts for mechanism of COVID 19 disease spread, or its natural history
 - Accommodates biologic evidence of incubation period prior to infectious period
- Not based solely on curve-fitting to observed deaths (IHME)

- Latent period: 5 days
- Infectious period: 8 days
- R_0 : ~3.87 (2.5-4.7)
- Days in hospital: 13.3 (7-23 days)
- Days in ICU: 10.3 days (4-17 days)
- If no ICU bed available, mortality risk 1.5x – 16.5x higher (depends on age)
- Increased mortality factor with ≥ 1 comorbidity: 7.6x
- Available ICU beds: 2,200

Age group	Cases needing hospitalization	Hospitalized cases requiring ICU	ICU mortality rate (per 10 person-days)
0-9 years	0.1%	5.0%	0.000
10-19 yrs	0.3%	5.0%	0.002
20-29 yrs	1.2%	5.0%	0.001
30-39 yrs	3.2%	5.0%	0.002
40-49 yrs	4.9%	6.3%	0.003
50-59 yrs	10.2%	12.2%	0.009
60-69 yrs	16.6%	27.4%	0.024
70-79 yrs	24.3%	43.2%	0.056
80+ yrs	27.3%	70.9%	0.111

Refinements in Model, v.2 Drive Changes in Estimates

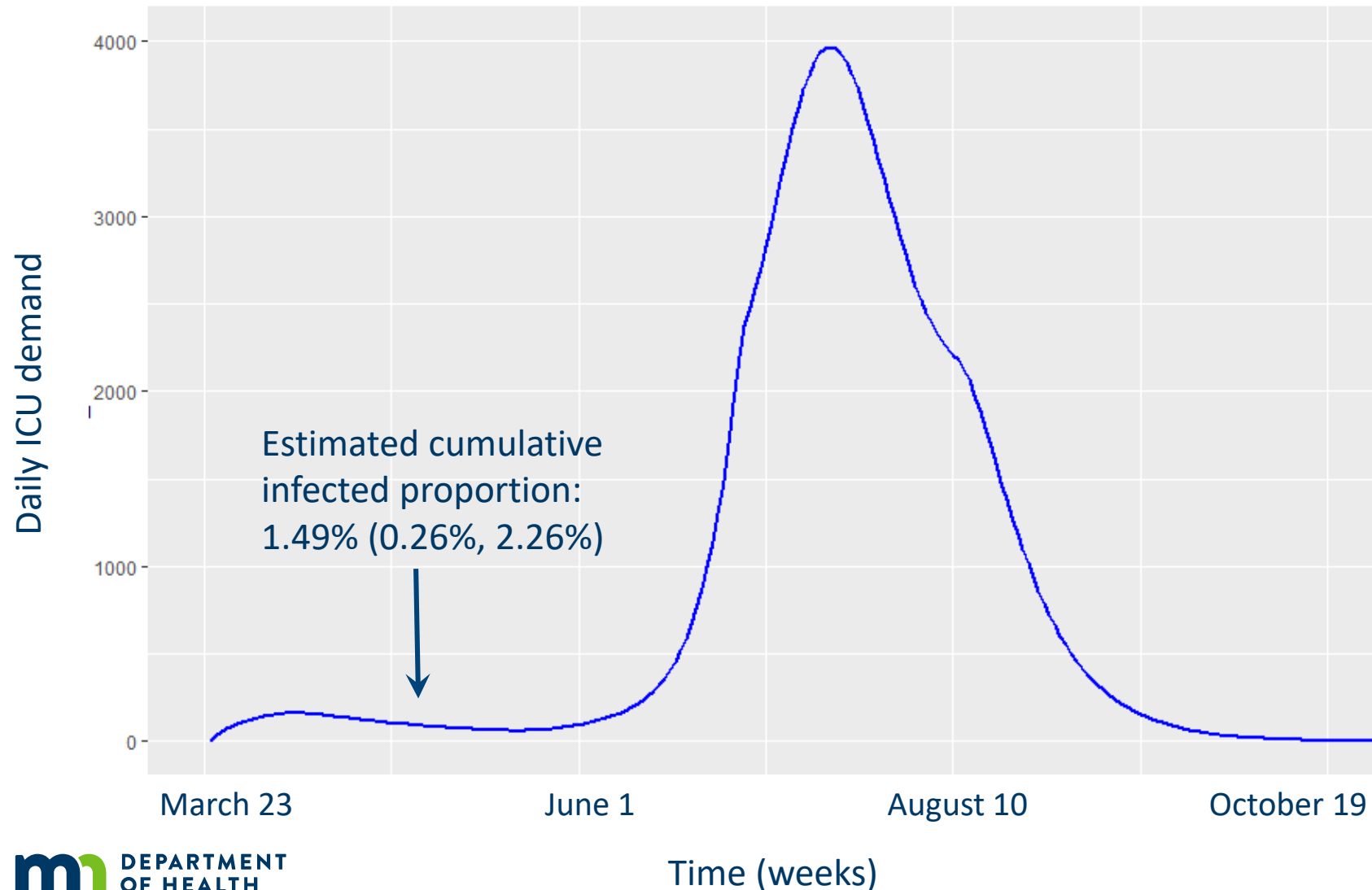
- Fitted model to **actual MN COVID-19 deaths** (starting w/March 23, 2020)
→ further along in the epidemic?
- Updated **parameter estimates using newly available data, incl. US**
 - Lower proportion of cases requiring hospitalization (asymptomatic patient role) → lower expected hospitalizations
 - Higher R0 than previously thought → faster spread & quicker time to peak
 - Lower length of hospital stay
 - Updated **age & comorbidity distribution** of MN population
- Incorporated uncertainty estimates

- Model & data changes since model v.1 resulted in:
 - Modestly **shortened time to peak** infection/capacity
 - **Fewer estimated deaths**
- Most effective factors to **reduce mortality**:
 - Increased ICU capacity (surge capacity coming online)
 - Asking vulnerable to stay home
- Extending Stay-at-Home order would **extend time to peak**
- Forms of longer-term reduction in contacts can **further reduce deaths & ICU demand**

Some Reflections on the MN Epidemic

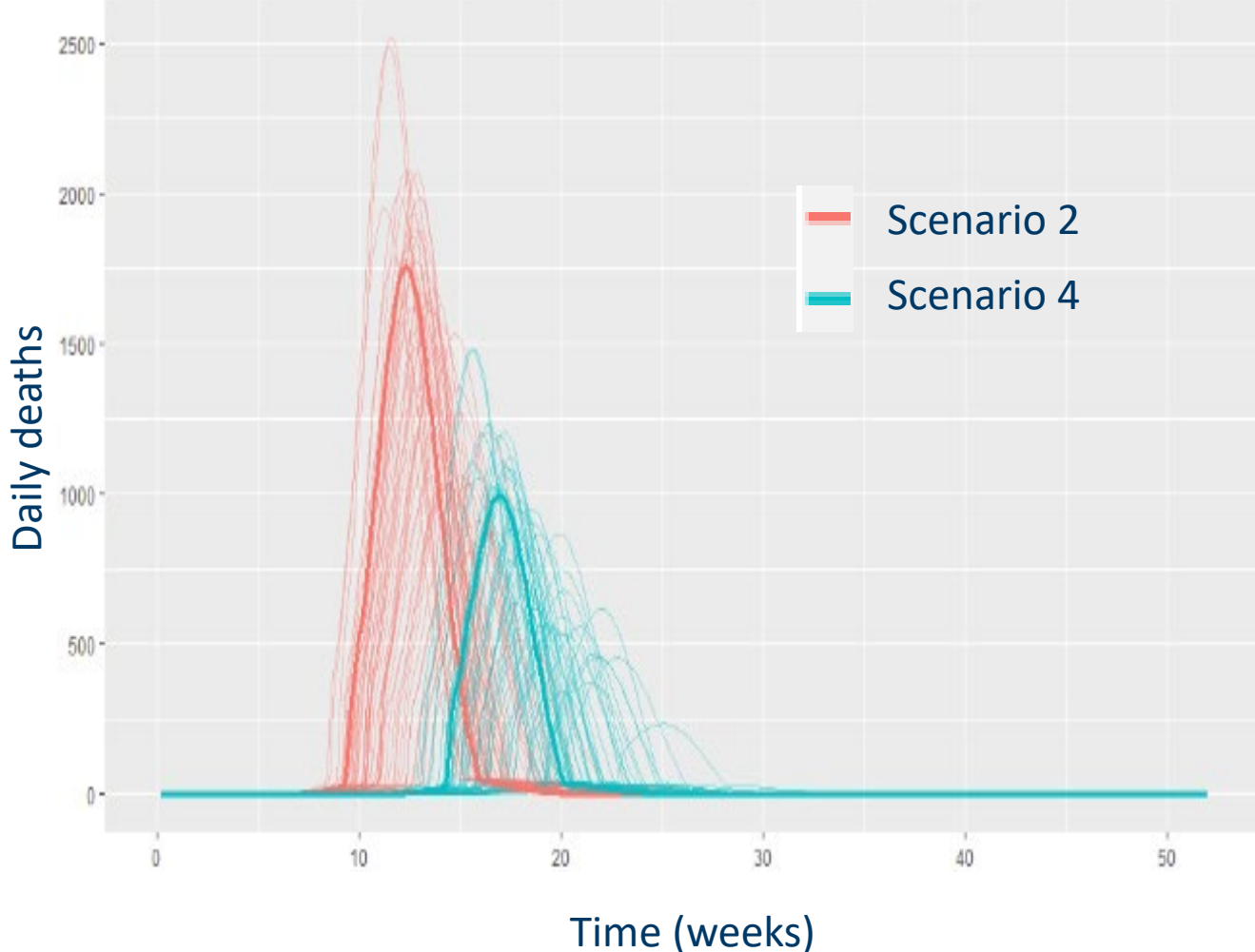
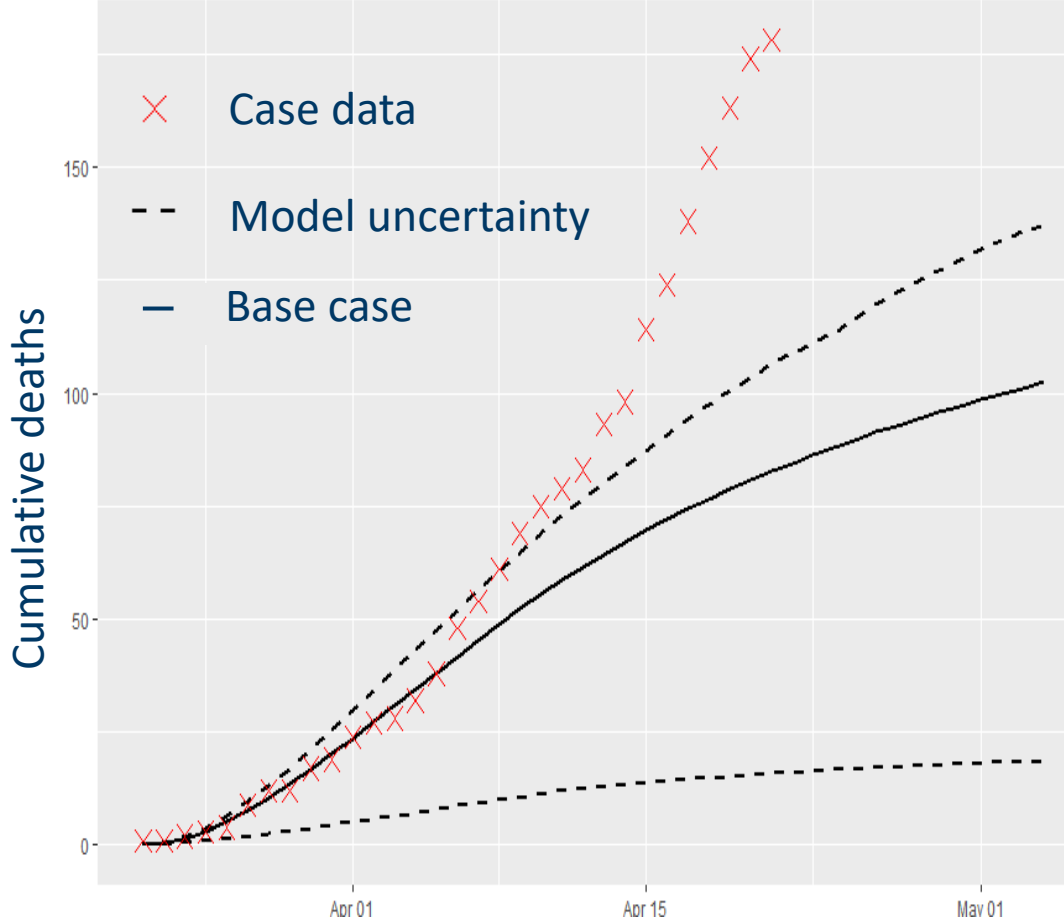
But a Large Share of the Population Remains Susceptible to COVID-19

Strategy 4 (SHO through early May)



- We flattened the health care curve (ICU demand)
- Estimate that a small share of the population has gained immunity
- Epidemic will continue ... spanning time horizons longer than the “bounded” scenarios we have been exploring
- **For consideration:** model the outcome and work back from it?

Mortality is Expected to Rise in the Short & the Long Term (Scenario 4 and Scenarios 2 and 4)



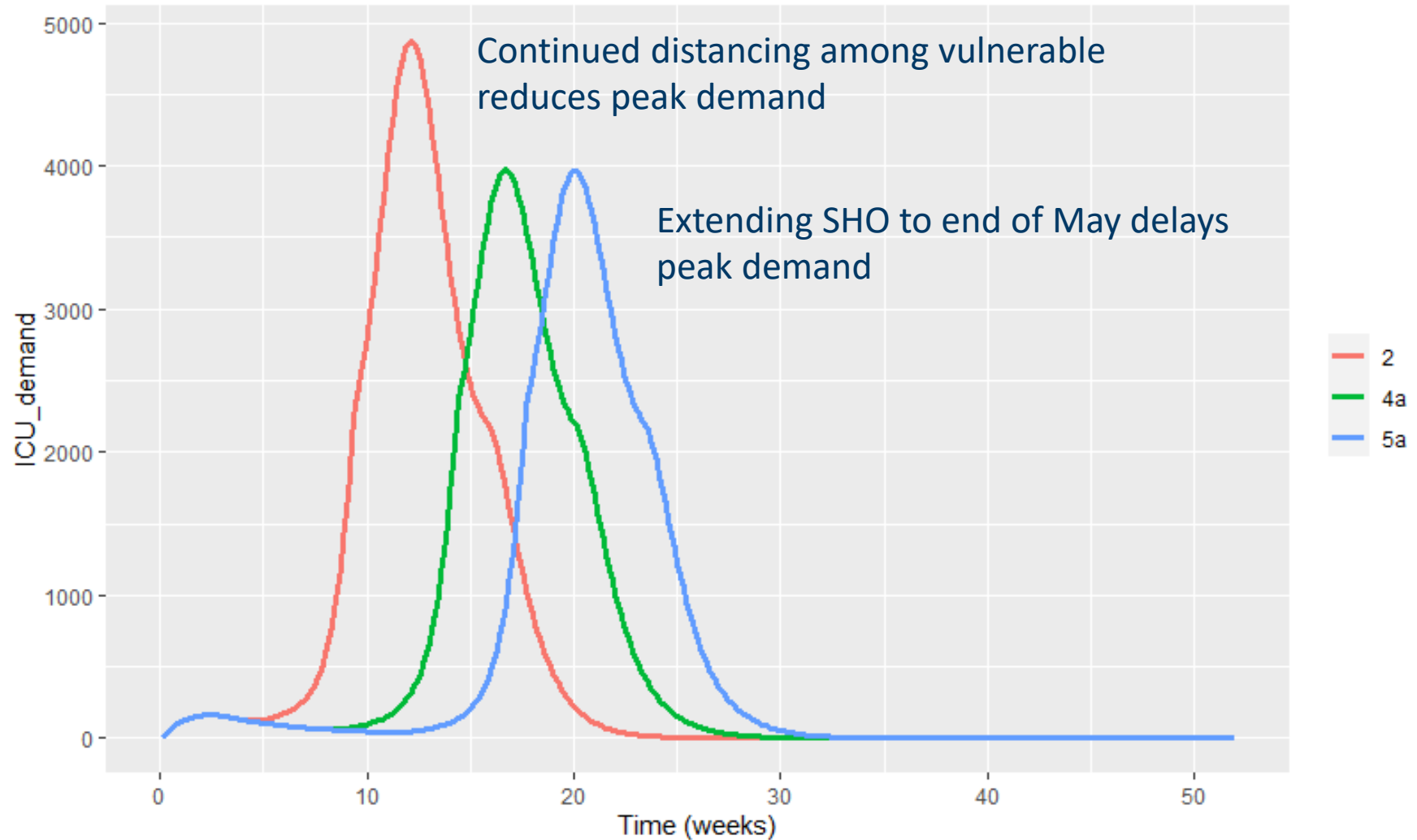
All Outcome Estimates by Scenario

		Days till Peak	Days till ICU	Top ICU Demand	Mortality
Where We Started	Scenario 1 (235 ICU) [#]	7 weeks (May 11)	4 weeks (April 20)	3,300	50,000
	Scenario 2 (2,200 ICU) [*]	11 weeks (June 8)	11 week (June 8)	4,500	41,000
Long term SHO for most vulnerable	Scenario 3	11 weeks (June 8)	11 weeks (June 8)	3,700	22,000
Extending SHO for all (by 4 weeks)	Scenario 4	16 weeks (July 13)	16 weeks (July 13)	3,700	22,000
Extending physical distancing (by 6 weeks)	Scenario 3.1	15 weeks (July 6)	14 week (June 29)	3,300	20,000
Long-term slowed contacts for all	Scenario 3.2	12 weeks (June 15)	12 weeks (June 15)	3,400	22,000
Extending SHO for all till end of May	Scenario 5	18 weeks (July 27)	18 weeks (July 27)	4,000	25,000

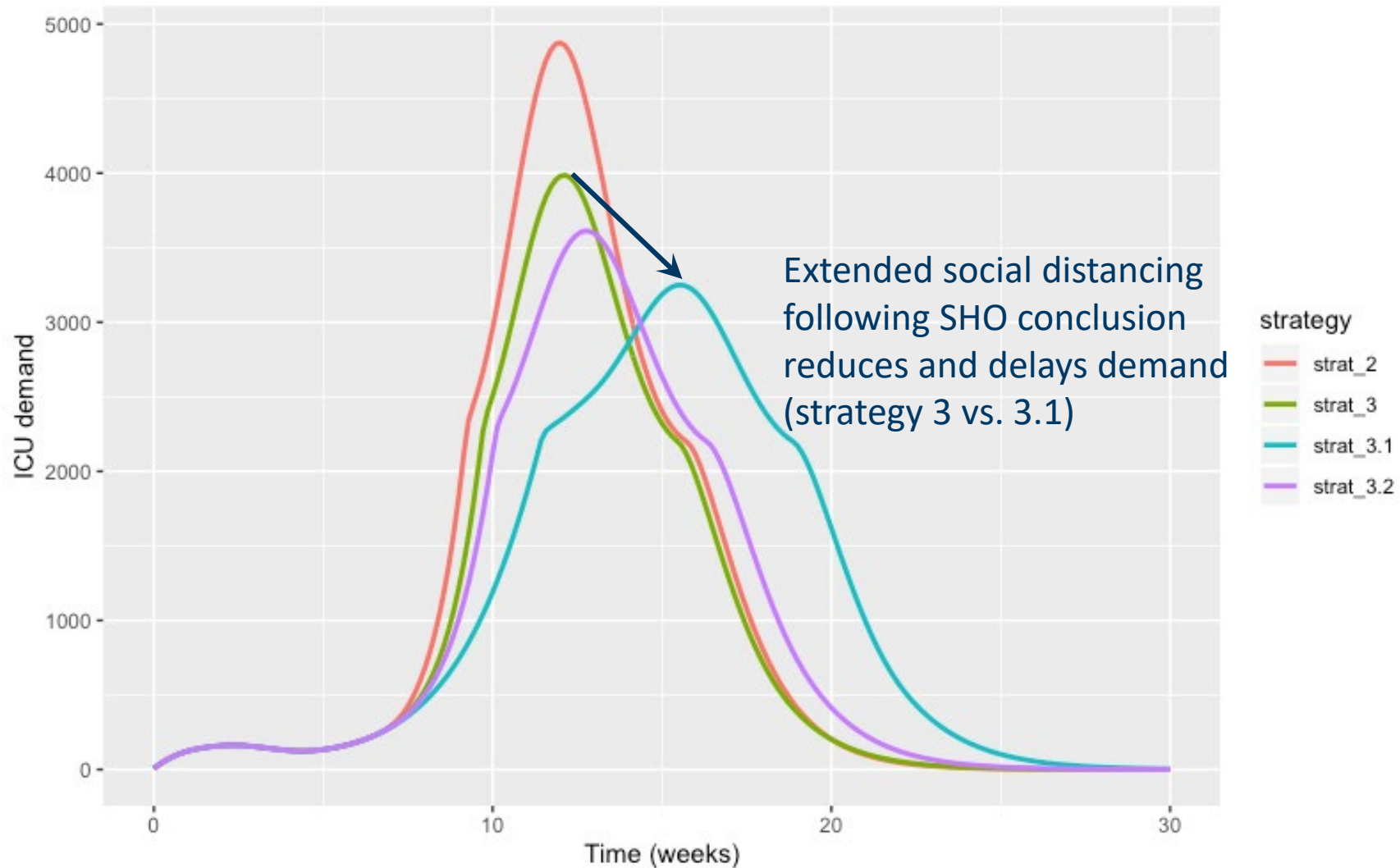
[#]Volume of available ICU beds in early March

^{*}Estimated volume of ICU beds (including vents) available for COVID-19 patients only.

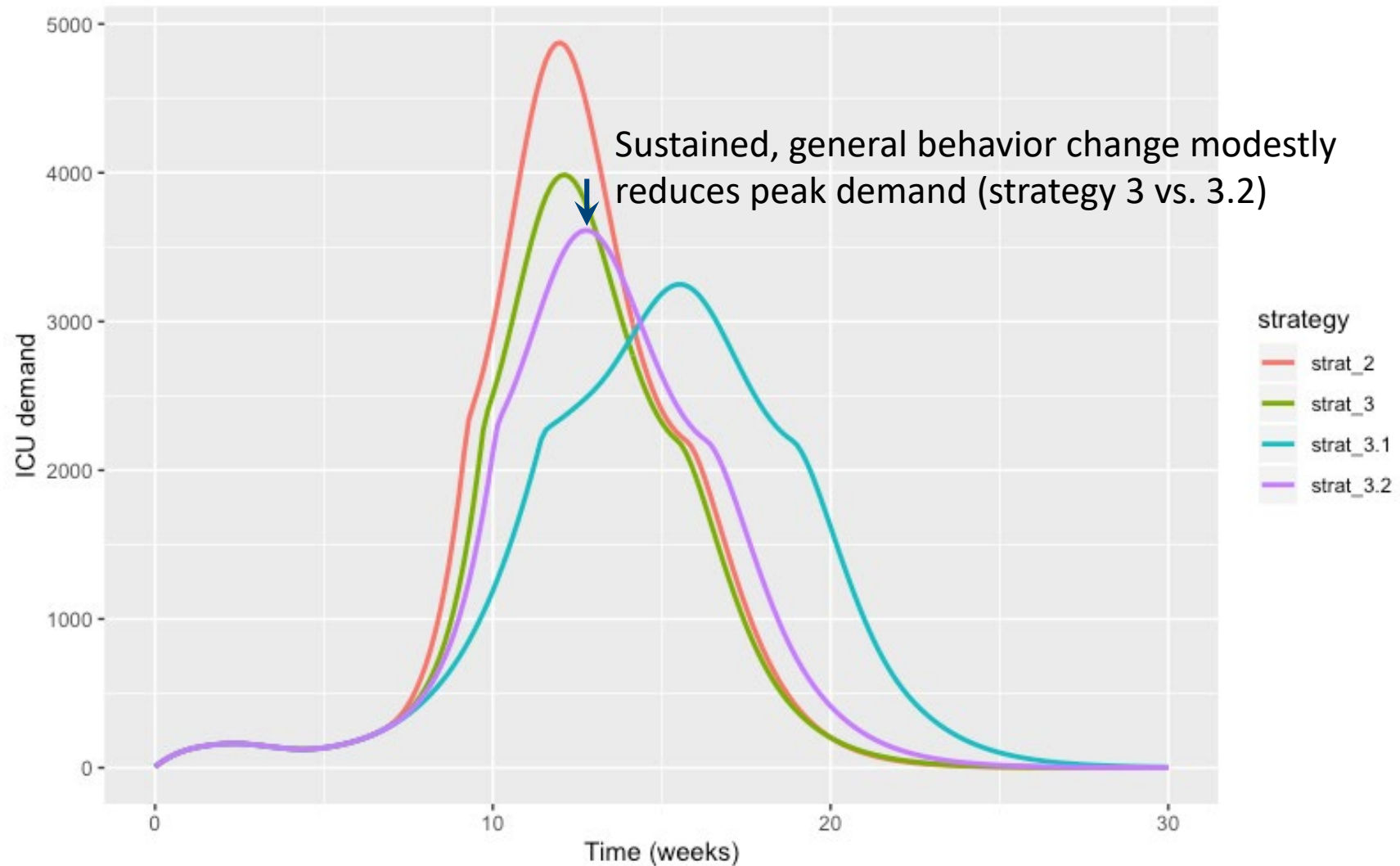
ICU Demand, Scenarios 2 vs 4 vs 5



ICU Demand, Scenarios 2 vs 3, 3.1, 3.2



ICU Demand, Scenarios 2 vs. 3, 3.1, 3.2



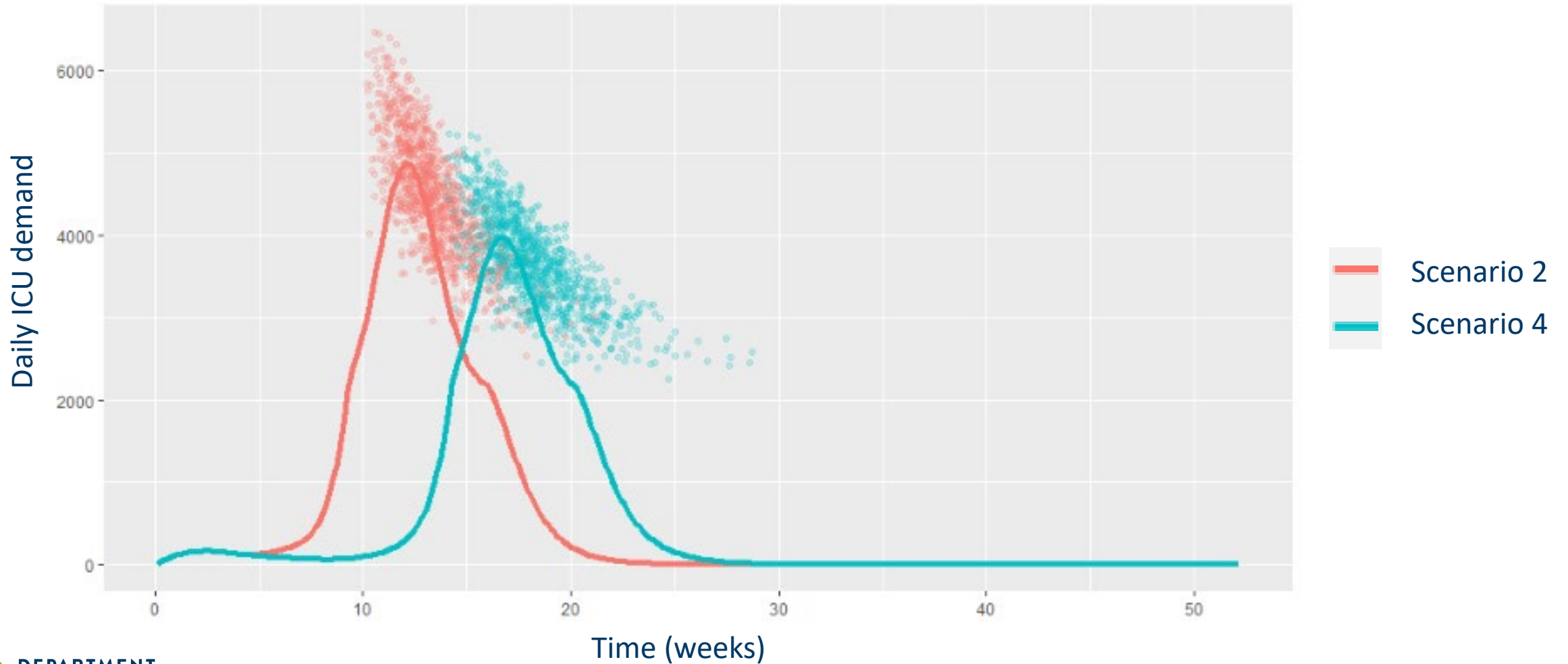
All Outcome Estimates by Scenario [with Estimates of Uncertainty]

		Days till Peak	Days till ICU	Top ICU Demand	Mortality
Where We Started	Scenario 1 (235 ICU) [#]	7 weeks (May 11) [5 to 10 weeks]	4 weeks (April 20) [2 to 5 weeks]	3,300 [2,000 to 4,800]	50,000 [34,000 to 68,000]
	Scenario 2 (2,200 ICU)*	11 weeks (June 8) [9 to 15 weeks]	11 week (June 8) [8 to 14 weeks]	4,500 [3,200 to 6,000]	41,000 [22,000 to 59,000]
Long term SHO for most vulnerable	Scenario 3	11 weeks (June 8) [9 to 15 weeks]	11 weeks (June 8) [9 to 15 weeks]	3,700 [2,700 to 4,900]	22,000 [9,000 to 36,000]
Extending SHO for all (by 4 weeks)	Scenario 4	16 weeks (July 13) [13 to 21 weeks]	16 weeks (July 13) [12 to 21 weeks]	3,700 [2,700 to 4,800]	22,000 [9,000 to 36,000]
Extending physical distancing (by 6 weeks)	Scenario 3.1	15 weeks (July 6) [10 to 20 weeks]	14 week (June 29) [9 to 19 weeks]	3,300 [2,600 to 4,000]	20,000 [9,000 to 33,000]
Long-term slowed contacts for all	Scenario 3.2	12 weeks (June 15) [9 to 18 months]	12 weeks (June 15) [9 to 17 weeks]	3,400 [2,400 to 4,600]	22,000 [6,000 to 35,000]
Extending SHO for all till end of May	Scenario 5	18 weeks (July 27) [16 to 26 weeks]	18 weeks (July 27) [16 to 25 weeks]	4,000 [3,000 to 5,000]	25,000 [10,000 to 36,000]

[#]Volume of available ICU beds in early March

*Estimated volume of ICU beds (including vents) available for COVID-19 patients only.

Illustration of Uncertainty in Peak ICU Demand, Scenarios 2 vs 4



Next Steps: Model Refinement/Enhancement

- Continue to update model based on Minnesota data
 - Fit to observed deaths
 - New data on contact pattern changes (in the field now)
- Model on/off scenarios of mitigation
- Incorporate asymptomatic infection (data dependent)
- Evaluate robustness of peak ICU demand and incorporate deaths via hospitalization and infections (data dependent)
- Examine geographic variability in the epidemic using local/county data

Next Steps: Documentation & Release

- Documentation released April 10
 - Technical documentation
 - FAQ on key questions
 - Infographic
- Additional model refinement and enhancement: within next two weeks
- Release of model interface and code: aiming for late April

- Deaths in MN may be due to clustering in congregate setting -- the shape of the curve could change considerably over the next few weeks
- Deaths from hospitalizations or infections that weren't diagnosed aren't accounted for currently
- Role of asymptomatic infection in transmission is unclear
- Much is still unknown about the pathogen & data on key parameters are often from international settings or are missing
- Analysis does not account for economic costs or other side effects of mitigation (e.g., psychological effects, income, state's economy)

Team Acknowledgement

UMN

- Marina Kirkeide
- Abhinav Mehta
- Gregory Knowlton
- Richard MacLehose
- Kumi Smith
- Kelly Searle
- Ran Zhao

MDH

- Pam Mink
- Alisha Simon
- Erinn Sanstead
- Plus a large team of epidemiologists

Thank You!

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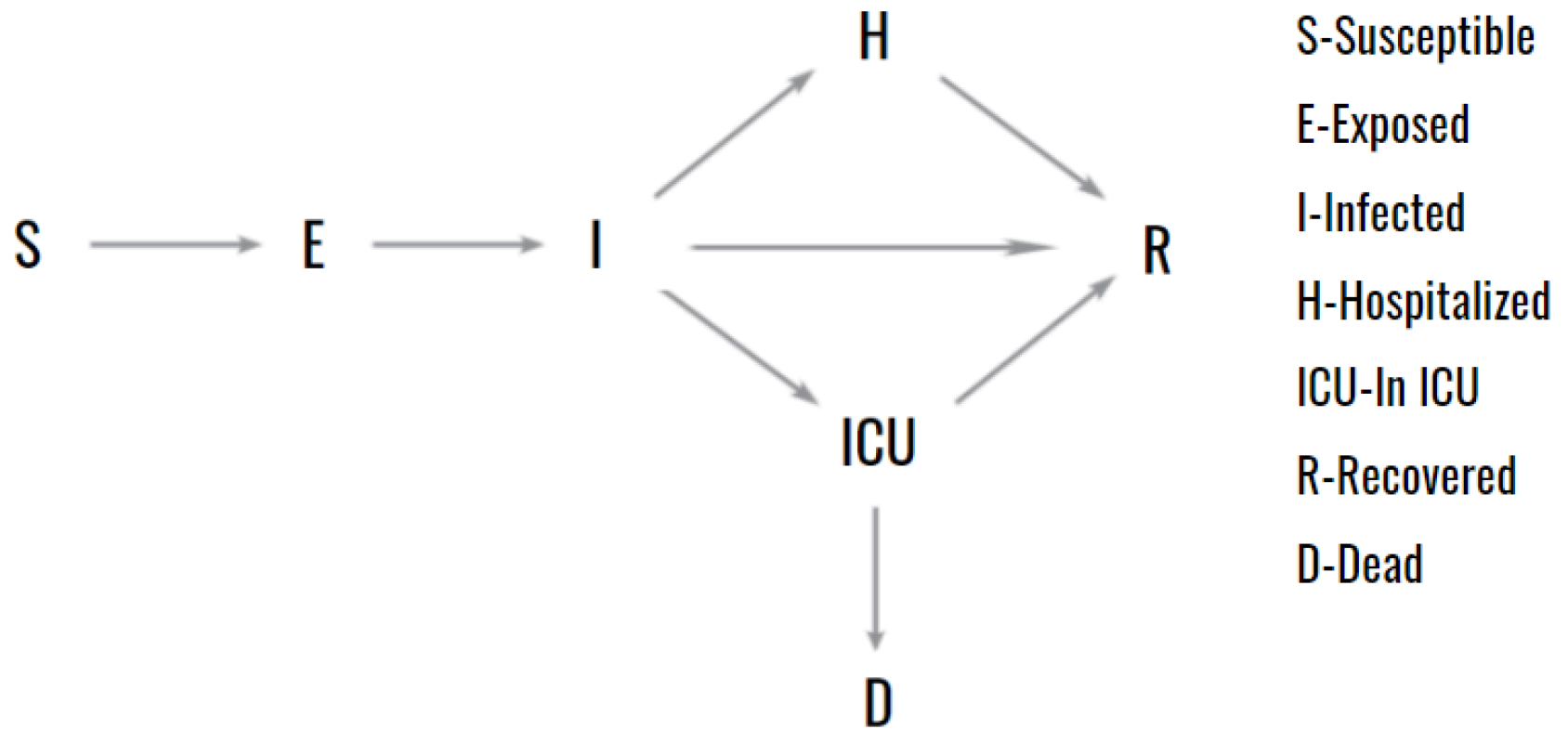
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More on COVID-19 in MN

mn.gov/covid19/ | <https://mn.gov/covid19/data/modeling.jsp>

Model Overview



- Hypothetical scenario of no reduction in person-to-person contact
- Outcomes (uncertainty at 95% CI):
 - Week of peak infections: 7 (5 to 10) weeks
 - Week ICU bed capacity reached (235 beds): 4 (2 to 5) weeks
 - Max ICU demand: 3,200 (2,200 to 4,800) ICU/vents
 - Overall deaths: 50,000 (34,000 to 68,000) individuals

Scenario 2: Stay at Home Order (Ends May 1)

- Change in person-to-person contacts:
 - Significant mitigation (2 weeks), reduction by 80%
 - Followed by physical distancing (3 weeks), reduction by 50% percent
- Outcomes (uncertainty at 95% CI):
 - Week of peak infections: 11 (9 to 15) weeks
 - Week ICU bed capacity reached (2,200 beds): 15 (8 to 14) weeks
 - Max ICU demand: 4,500 (3,200 to 6,000) ICU w/vents
 - Overall deaths: 41,000 (22,000 to 59,000) individuals

Scenario 3: Stay at Home Order Followed by Extended Stay at Home for Vulnerable

- Change in person-to-person contacts:
 - Significant mitigation (2 weeks), reduction by 80%
 - Followed by physical distancing (3 weeks), reduction by 50%
 - Extended reduced contact for vulnerable, **30 days** past the peak of deaths, reduction 50%
- Outcomes (**uncertainty at 95% CI**):
 - Week of peak infections: 11 (**9 to 15**) weeks
 - Week ICU bed capacity reached (2,200 beds): 11 (**9 to 15**) weeks
 - Max ICU demand: 3,700 (**2,700 to 4,900**) ICU/vents
 - Overall deaths: 22,000 (**9,000 - 36,000**) individuals

Scenario 4: Extended Stay at Home Order (Total 9 Weeks)

- Change in person-to-person contacts:
 - Stay at Home order (6 weeks), reduction by 80%
 - Followed by physical distancing (3 weeks), reduction by 50%
 - Extended reduced contact for vulnerable, **30 days** past the peak of deaths, reduction 50%
- Outcomes (**uncertainty at 95% CI**):
 - Week of peak infections: 14 (**11 to 19**) weeks
 - Week ICU bed capacity reached (2,200 beds): 16 (**13 to 21**) weeks
 - Max ICU demand: 3,700 (**2,600 to 4,800**) ICU/vents
 - Overall deaths: 22,000 (**9,000 - 35,000**) individuals

Scenario 3.1: Stay at Home Order with Extended Distancing

- Change in person-to-person contacts:
 - Stay at Home order (9 weeks), reduction by 80%
 - Followed by extended distancing (9 weeks), reduction by 50%
 - Extended reduced contact for vulnerable, **30 days** past the peak of deaths (reduction 50%)
- Outcomes (**uncertainty at 95 CI**):
 - Week of peak infections: 15 (**10 to 20**) weeks
 - Week ICU bed capacity reached (2,200 beds): 14 (**9 to 19**) weeks
 - Max ICU demand: 3,300 (**2,600 to 4,000**) ICU/vents
 - Overall deaths: 20,000 (**9,000 to 33,000**) individuals

Scenario 3.2: Stay at Home order with Permanent Lower Levels of Contact

- Change in person-to-person contacts:
 - Stay at Home order, reduction by 80%
 - Followed by physical distancing (3 weeks), reduction by 50%
 - Continued Stay at Home order for vulnerable), extended 30 days past the peak deaths (reduction 50%) **and** permanent reduction in contacts (20%)
- Outcomes (**uncertainty at 95% CI**):
 - Week of peak infections: 12 (**9 to 18**) weeks
 - Week ICU bed capacity reached (2,200 beds): 12 (**9 to 17**) weeks
 - Max ICU demand: 3,400 (**2,400 to 4,600**) ICU/vents
 - Overall deaths: 20,000 (**6,000 to 35,000**) individuals