SARS-CoV-2 (COVID-19) Modeling (Version 2.0),
April 10th, 2020 – updated 4/16/20

Stefan Gildemeister, State Health Economist
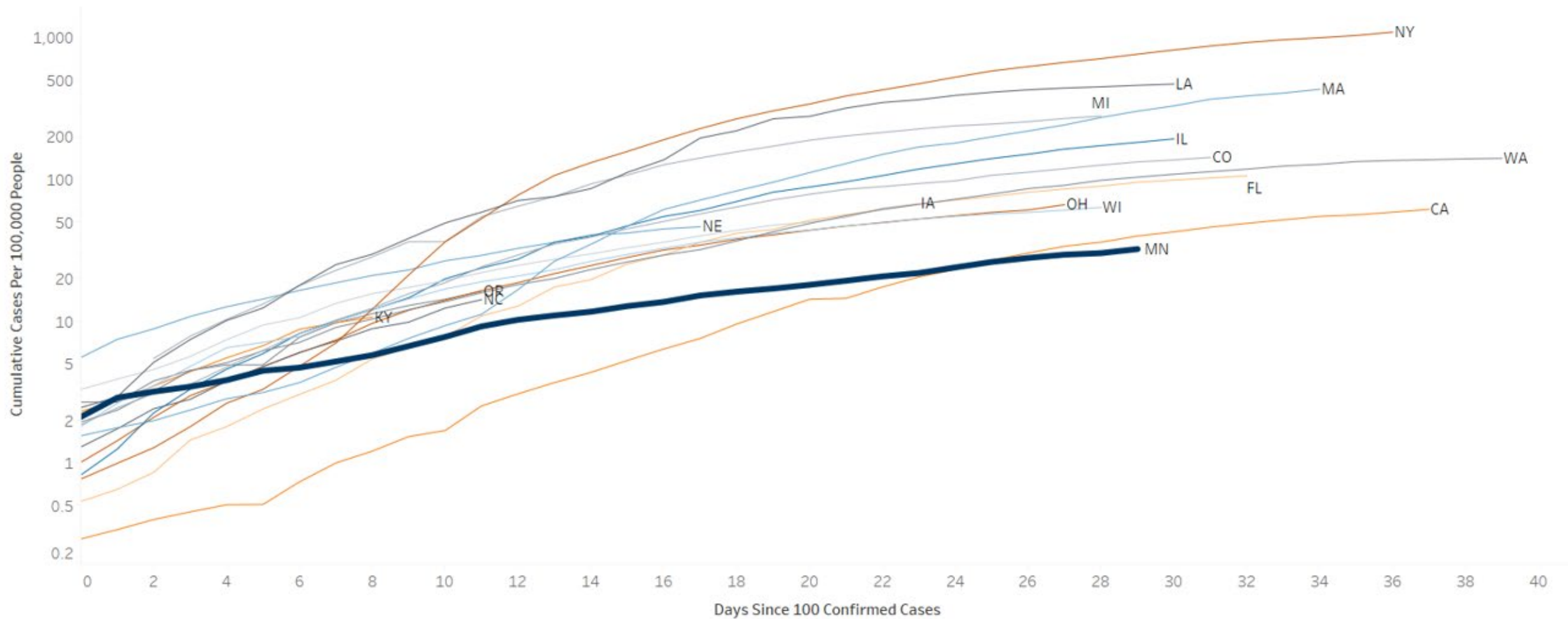
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PROTECTING, MAINTAINING AND IMPROVING THE HEALTH OF ALL MINNESOTANS

- 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
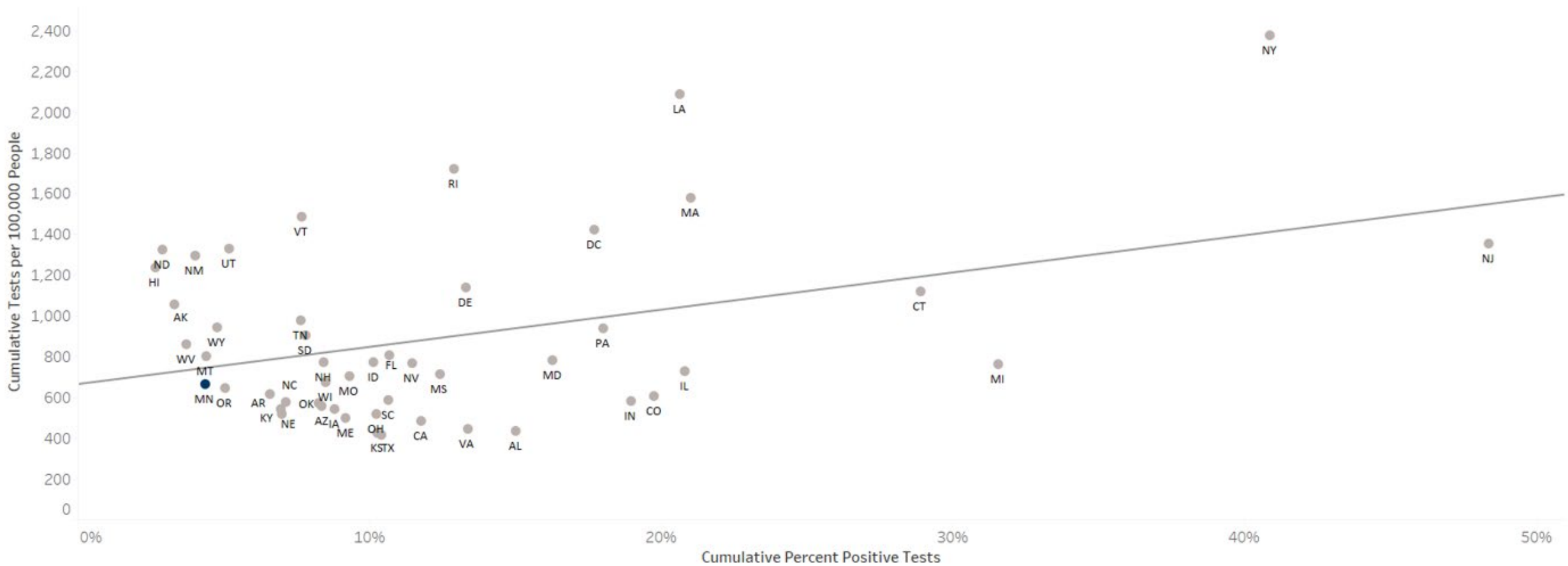- Output from mathematical disease modeling

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

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

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Detailed documentation is available online: Minnesota COVID-19 Modeling (https://mn.gov/covid19/data/modeling.jsp)

- 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**

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Modeled Scenarios

one cell = approximately 5 days

- low form of social distancing requiring businesses to accommodate employees/customers, reduction of contacts by **20pct**
- physical distancing, reduction in contacts by **50pct**
- requirement for vulnerable people to remain at home, reduction of contacts by **50pct**
- stay-at-home order, reduction of contacts by **80pct**

Type and Duration of Mitigation

	Scenario 1 — No mitigation	Scenario 2 — SHO + physical distancing (ends May 1)		Scenario 3 — Long-term SHO for most vulnerable	Scenario 4 — Extending SHO for all (by 4 weeks)		Scenario 3.1 — Extending physical distancing (by 6 weeks)		Scenario 3.2 — Long-term slowed contacts for all	
		3/17 to 3/26 (10 days)		3/17 to 3/26 (10 days)	3/17 to 3/26 (10 days)		3/17 to 3/26 (10 days)		3/17 to 3/26 (10 days)	
		3/27 to 4/10 (14 days)		3/27 to 4/10 (14 days)	3/27 to 5/8 (6 weeks/42 days)		3/27 to 4/10 (14 days)		3/27 to 4/10 (14 days)	
		4/10 to 5/1 (21 days)	4/10 to 5/1 (21 days)	4/10 to 5/1 (21 days)			4/10 to 6/12 (9 weeks/63 days)		4/10 to 5/1 (21 days)	
				5/2 to 7/10 (10 weeks/69 days or 30 days after peak deaths)	5/9 to 5/30 (21 days)	5/9 to 8/15 (14 weeks/ 112 days or 30 days after peak deaths)		6/13 to 8/14 (9 weeks/ 62 days or 30 days after peak deaths)	**Permanent modest reduction** in contacts until end of epidemic or treatment	5/2 to 7/31 (13 weeks/ 90 days or 30 days after peak deaths)
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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

#Volume of available ICU beds in early March

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

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Continued distancing among vulnerable reduces peak demand (strategy 2 vs. 3)

Extending SHO delays peak demand (strategy 3 vs. 4)

Extended social distancing following SHO conclusion reduces and delays demand (strategy 3 vs. 3.1)

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Sustained, general behavior change modestly reduces peak demand (strategy 3 vs. 3.2)

All Outcome Estimates by Scenario [with Estimates of Uncertainty]

[with Estimates of Uncertainty]

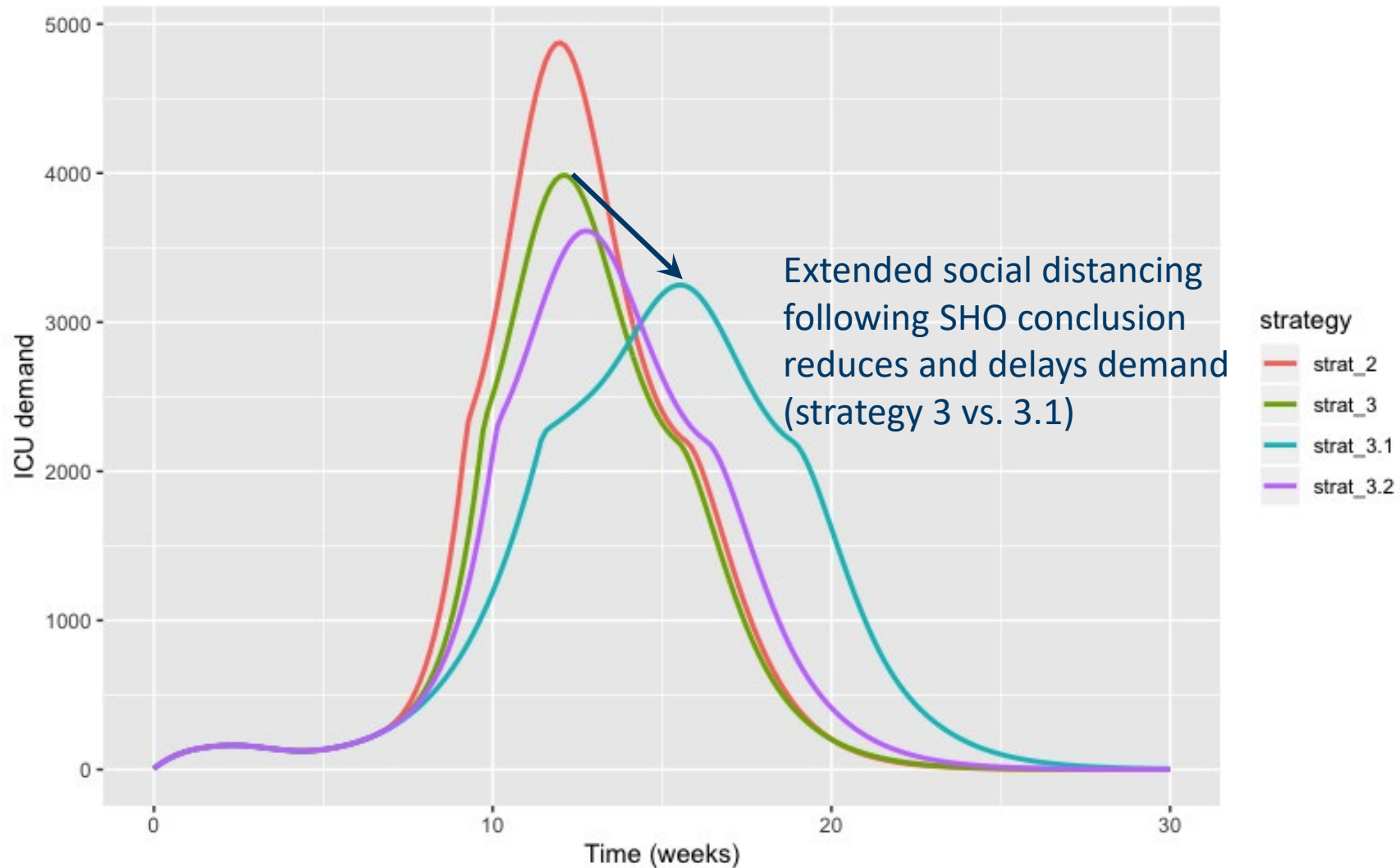|		Days till Peak	Days till ICU	Top ICU Demand	Mortality
Where We Started	Scenario 1 (235 ICU)#	7 weeks (May 11) [5 to 10 weeks]	4 weeks (April 20) [2 to 5 weeks]	3,300 [2,000 to 4,800]	50,000 [34,000 to 68,000]
	Scenario 2 (2,200 ICU)*	11 weeks (June 8) [9 to 15 weeks]	11 week (June 8) [8 to 14 weeks]	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}

#Volume of available ICU beds in early March
*Estimated volume of ICU beds (including vents) available for COVID-19 patients only.

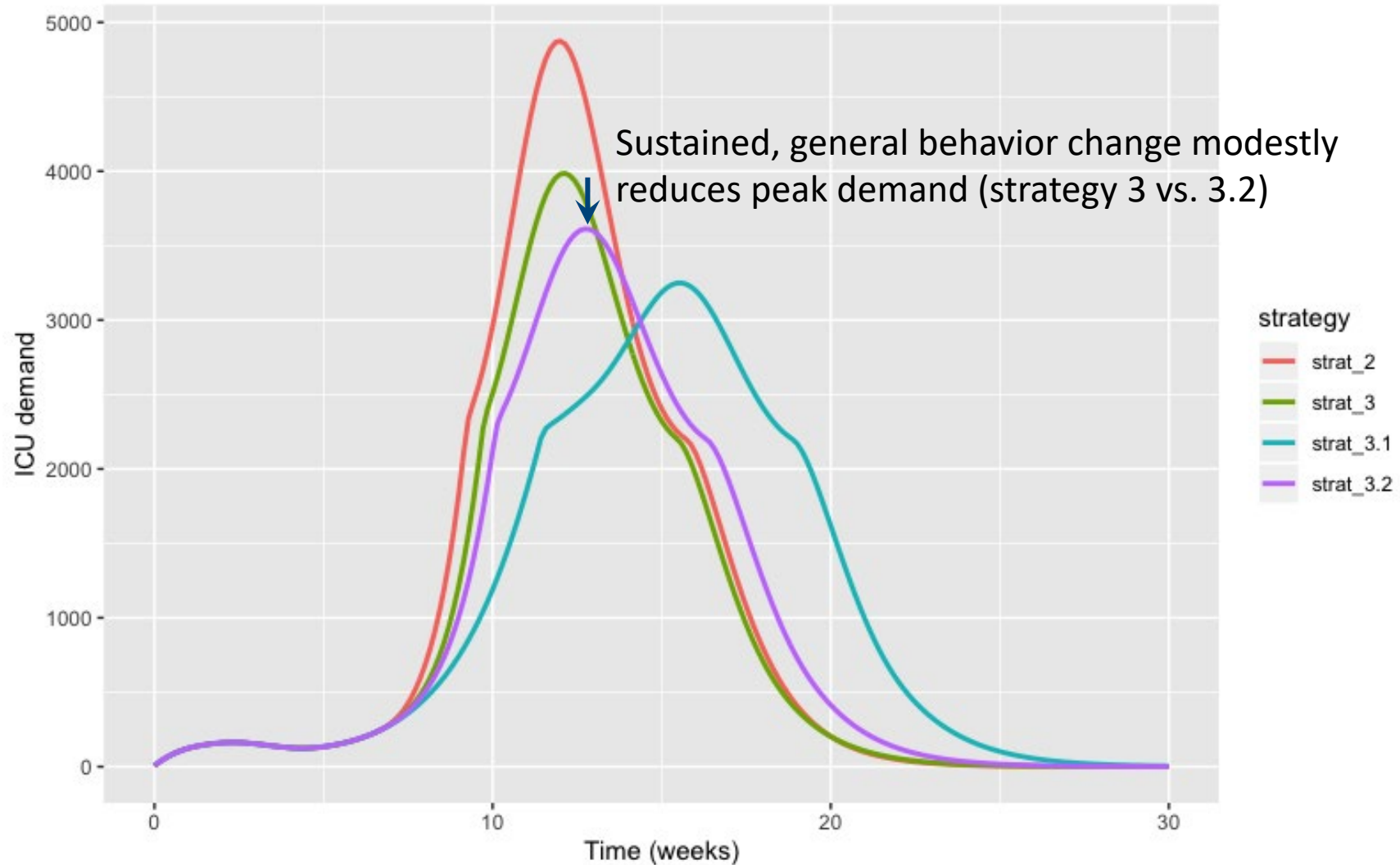DEPARTMENT OF HEALTH

Illustration of Uncertainty in Peak ICU Demand, Scenarios 2 vs 4
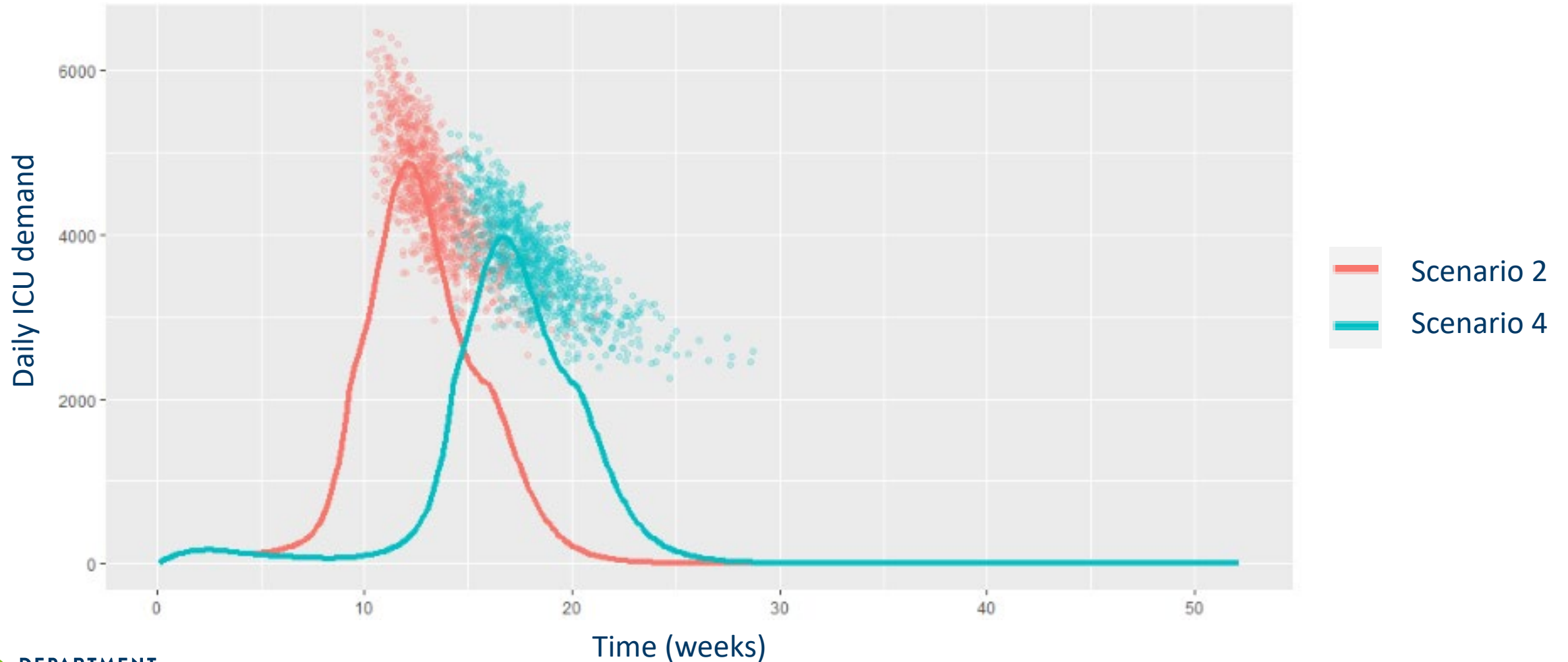
Illustration of Uncertainty in Death Estimates, Scenarios 2 vs 4
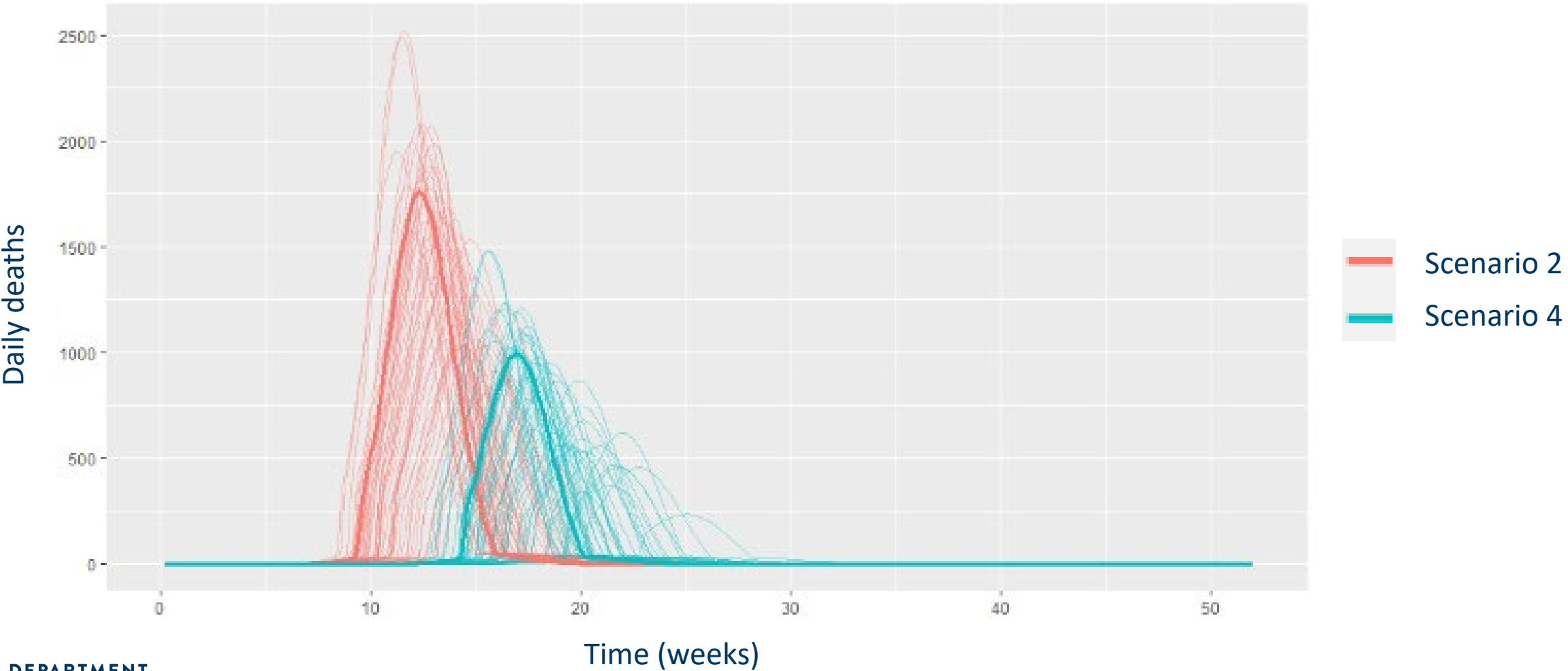
- Continue to update model based on Minnesota data
  - Fit to observed deaths
  - New data on contact pattern changes (in the field now)
- Model on/off scenarios of mitigation
- Incorporate asymptomatic infection (data dependent)
- Evaluate robustness of peak ICU demand and incorporate deaths via hospitalization and infections (data dependent)
- Examine geographic variability in the epidemic using local/county data

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- 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

Additional documentation available at: Coronavirus Disease in Minnesota (https://mn.gov/covid19/)

- 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)

UMN:

- Marina Kirkeide

- Abhinav Mehta

- Gregory Knowlton

- Richard MacLehose

- Kumi Smith

- Kelly Searle

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MDH:

- Pam Mink

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- Plus a large team of epidemiologists

Thank You!

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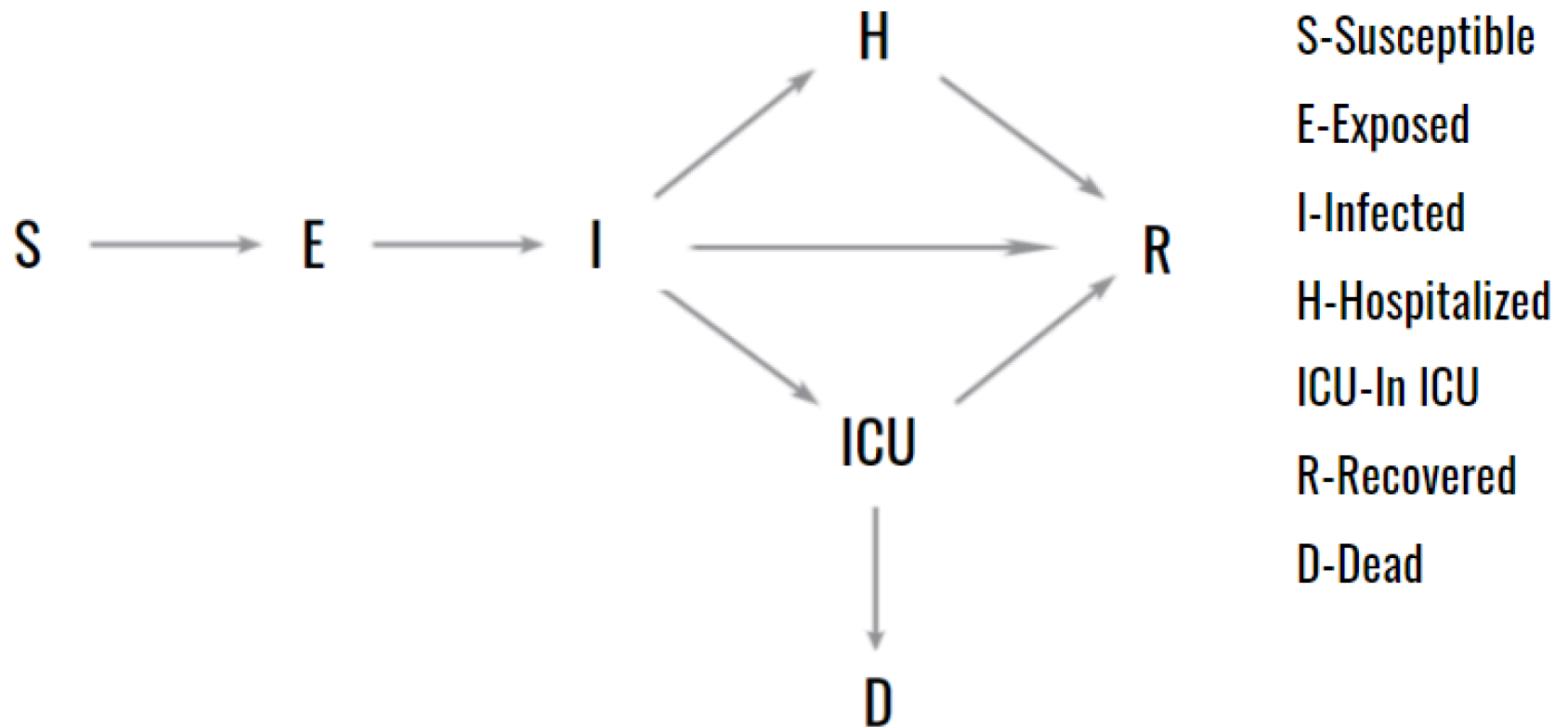Stefan Gildemeister (Stefan.Gildemeister@state.mn.us)
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More on COVID-19 in MN
mn.gov/covid19/ | https://mn.gov/covid19/data/modeling.jsp

S-Susceptible

E-Exposed

I-Infected

H-Hospitalized

ICU-In ICU

R-Recovered

D-Dead

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- 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

- 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

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- 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, <u>30 days</u> 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

- 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, <u>30 days</u> 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

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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, <u>30 days</u> 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%) <u>and</u> 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

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