

Modeling COVID-19 in Colorado

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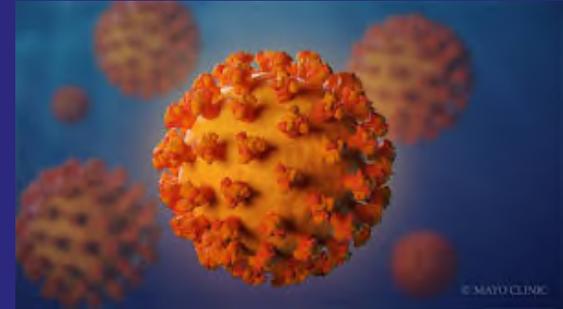
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Objectives

- Describe what we know about COVID-19 that is relevant to modeling
- Describe and interpret current models for predicting transmission
- Explain the general framework for the susceptible, exposed, infected, recovered (SEIR) model we developed for Colorado
- Present results and compare them to existing models and real data

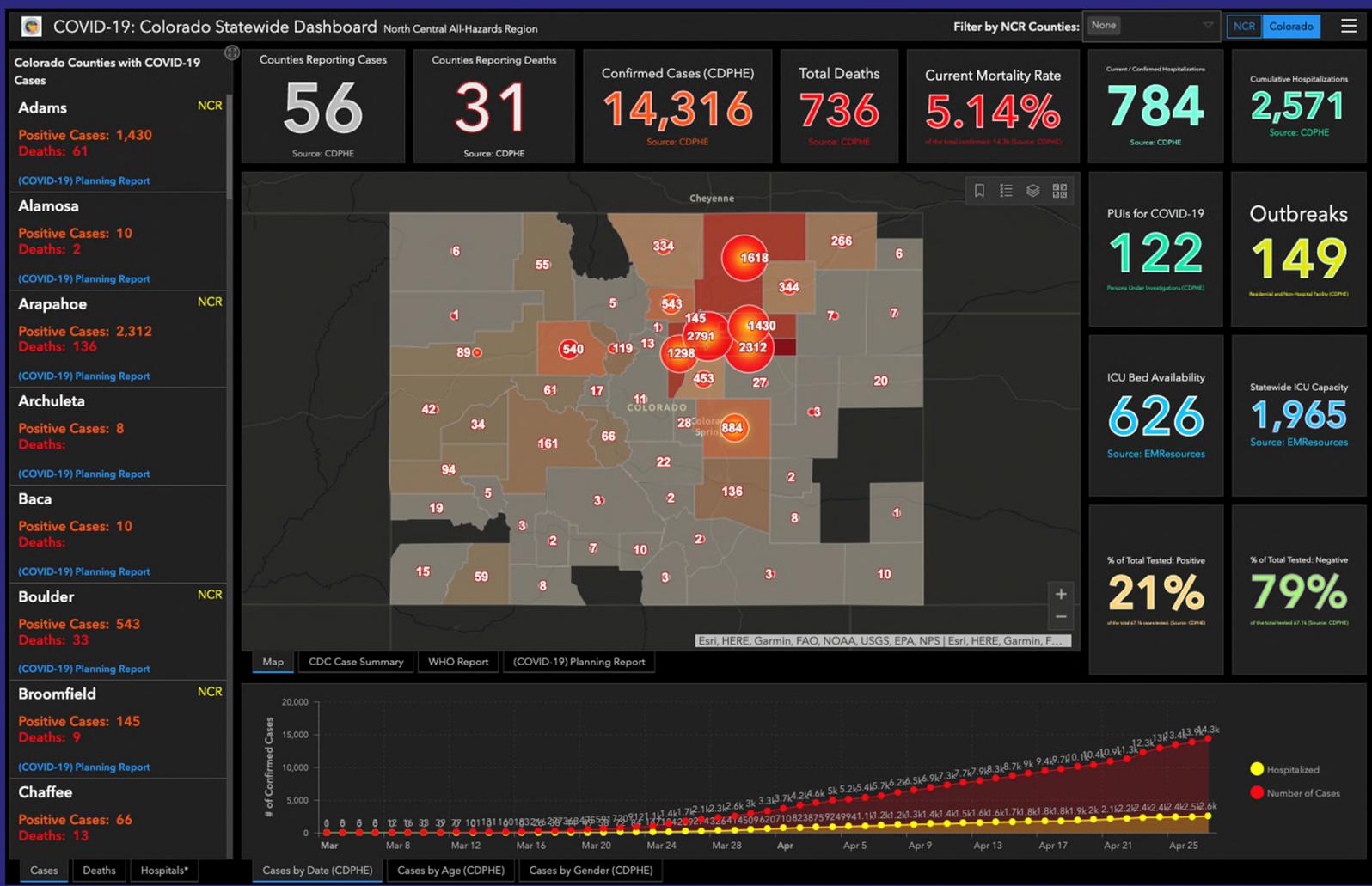


What we know



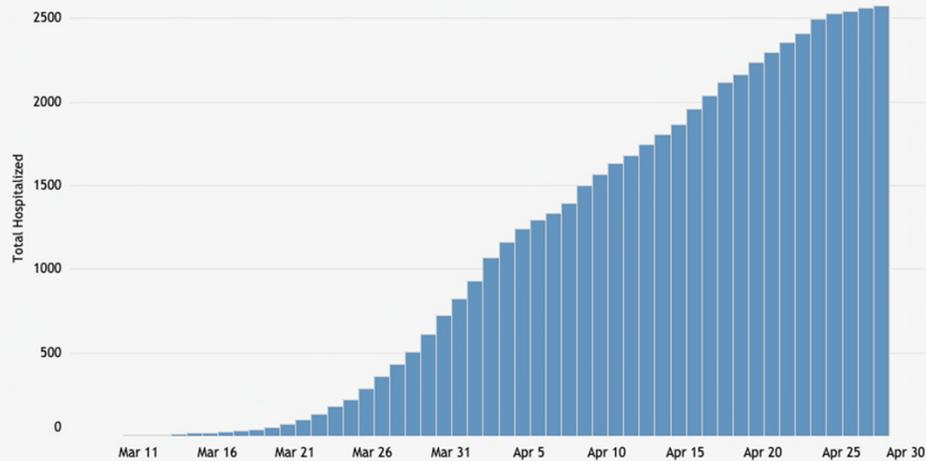
- Period between exposure and infectiousness: 5.1 days
- Infectious period of an individual: 8-10 days
- Probability of symptoms, hospitalization and needing critical care are age-dependent
 - Overall ~4.4% hospitalized; of those, ~30-50% need critical care
- About half of ICU patients might die
- Patients will remain hospitalized for 8-10 days
- Up to 40% of cases are asymptomatic





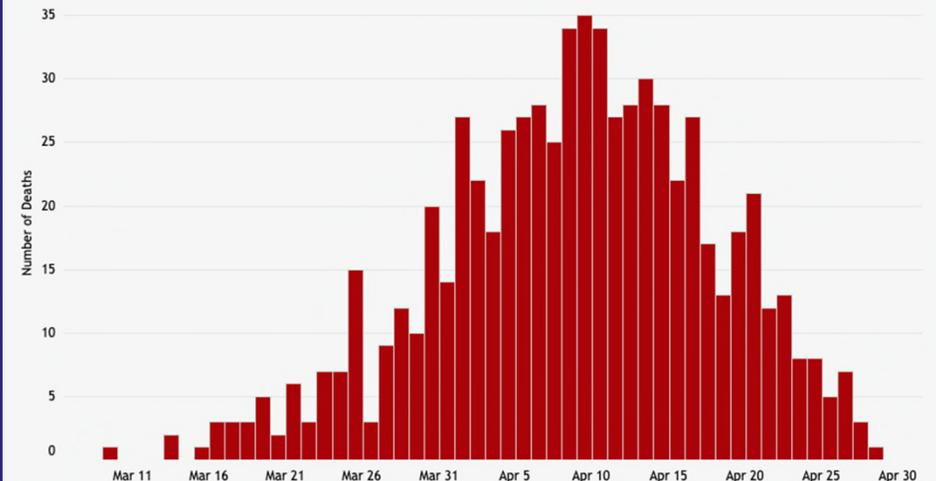
Colorado COVID statistics

Cumulative Number of Hospitalized Cases of COVID-19 in Colorado by Date Reported to the State



* Data reported daily around 4PM, subsequent days data may show differences as cases are reported after this time.

Number of Deaths From COVID-19 in Colorado by Date of Death



Why should we model transmission?

- To provide a forecast of the potential spread of the virus and its impact on the healthcare system
- To provide illustrations and statistics that can aid in decision making
- To explore the potential impact of interventions to prevent the spread of the virus

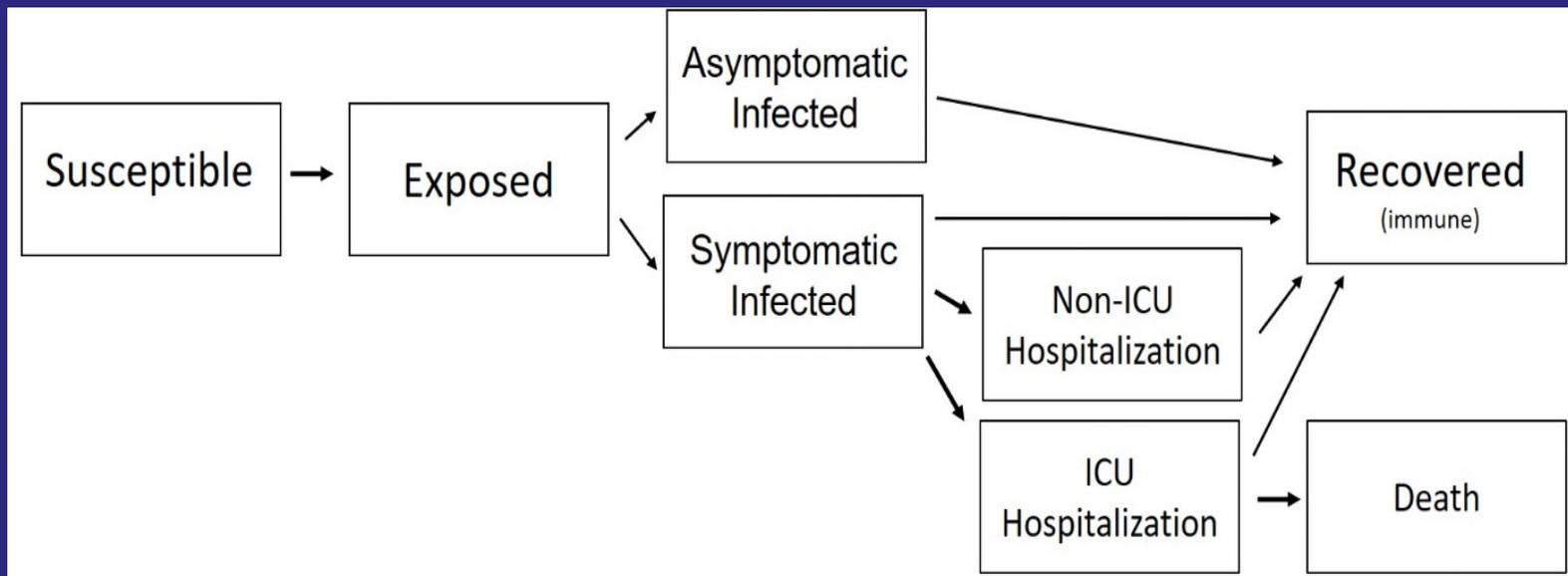


Models for COVID simulation or prediction

- SEIR mathematical models
 - COVID Act Now (SEIR)
 - **University of Colorado (SEIR)**
 - COVID-19 Hospital Impact Model for Epidemics (CHIME; PennMedicine; SIR)
- Statistical models
 - Institute for Health Metrics and Evaluation (IHME)
- Individual-based microsimulation models
 - Ferguson/Imperial College
- Agent-based models
 - Institute for Disease Modeling



University of Colorado model



University of Colorado model continued

	Range of possible values and sources	Fitted value
The rate of infection (beta)	0.2 - 0.6 (MIDAS)	0.413
Proportion of symptomatic individuals that self-isolate after March 5 (sil)	0.3 - 0.8 (Ferguson et al)	0.379
Ratio of infectiousness for symptomatic vs. asymptomatic individuals (lambda)	1.0 - 4.0 (Li et al, Zou et al)	2.268
Probability symptomatic cases are identified by state surveillance (pid)	0.05 - 0.6 (MIDAS)	0.277
Effectiveness of social distancing interventions implemented March 17	0.1 - 0.6	0.45
Date the first infection was introduced in Colorado	Jan 17-29	Jan 24

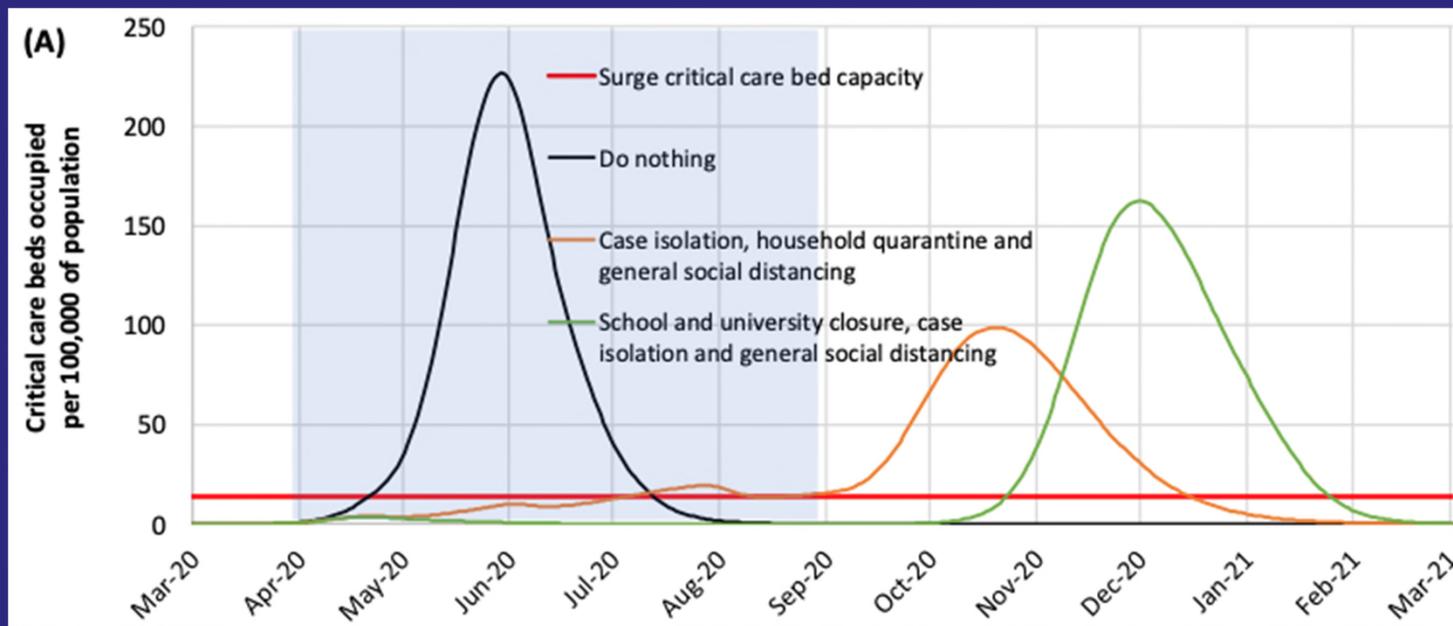


Model fitting

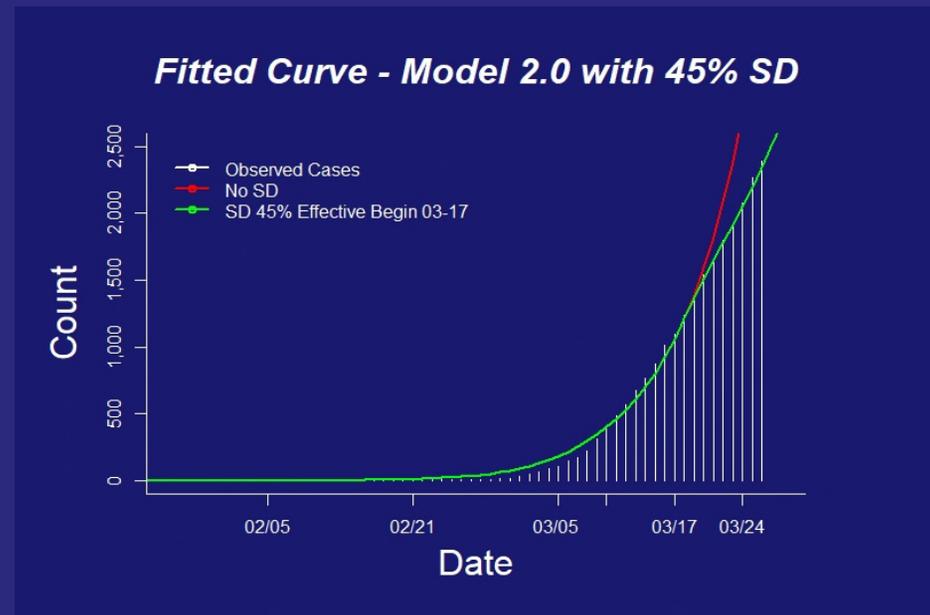
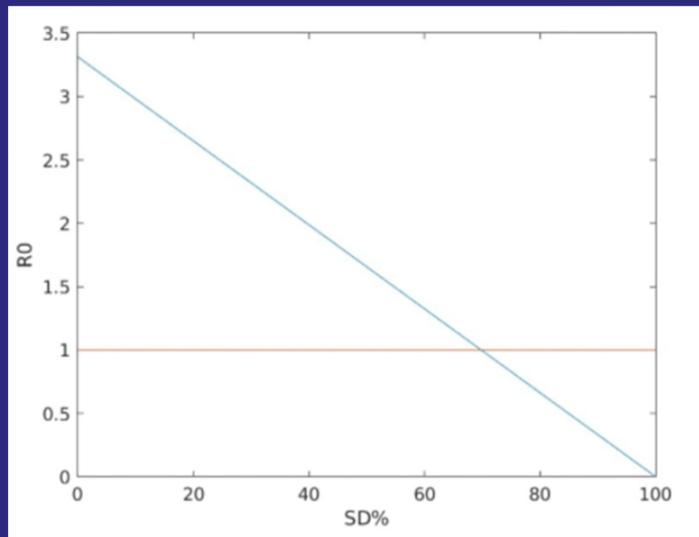
- The SEIR model is a set of differential equations written in R
- To obtain fitted values for the parameters, we use the 'modFit' function from the 'FME' package
- Supply lower and upper bounds to the values of the parameters
- Some iterations are required with a “pseudo” algorithm
- Optimization is achieved using method of choice



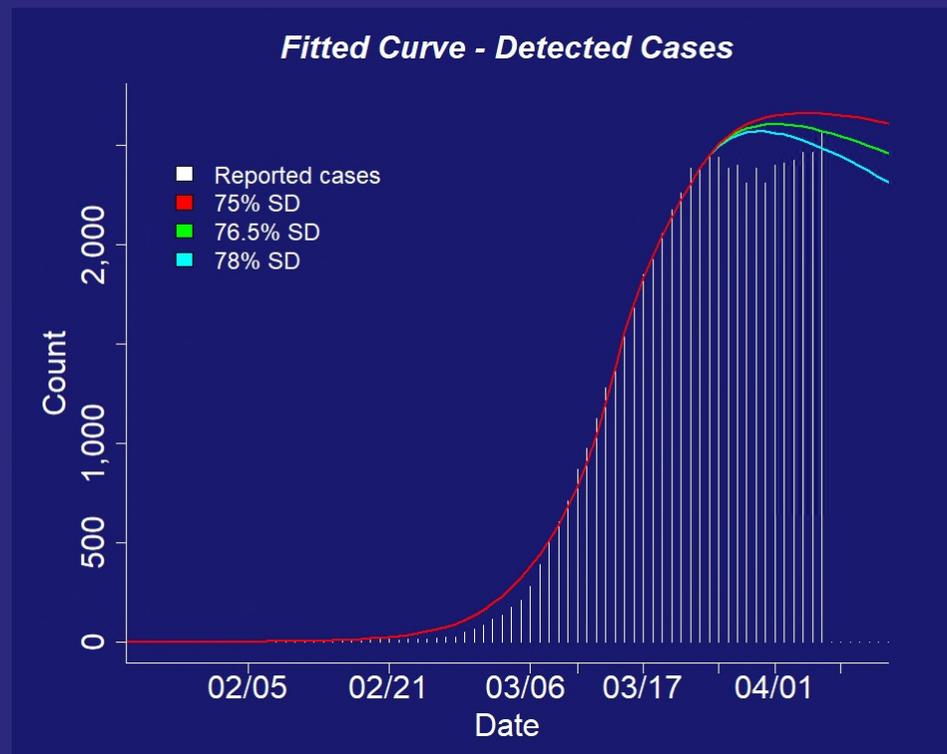
Ferguson et al. projections



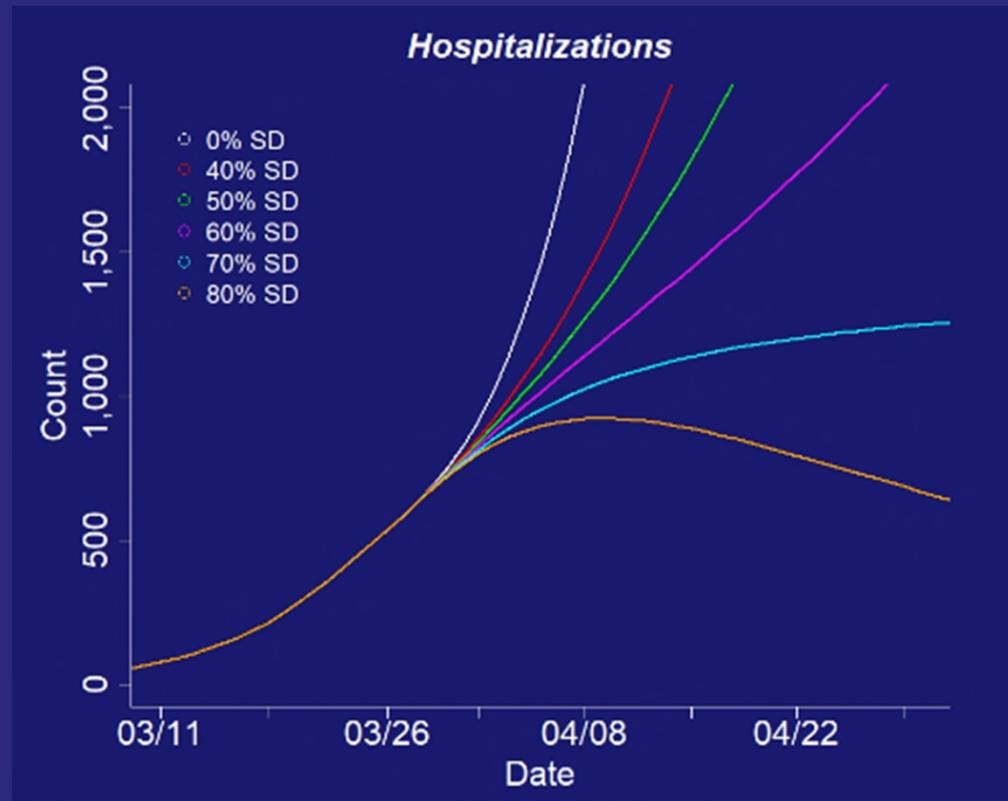
The role of social distancing



Social distancing under stay at home order



Expected impact of social distancing



Intervention scenarios

- **Scenario A.** Partially relax social distancing by the general public.
- **Scenario B.** Partially relax social distancing by the general public plus advise older adults (age>60) to maintain high levels of social distancing.
- **Scenario C.** Partially relax social distancing and promote mask wearing by the public
- **Scenario D.** Partially relax social distancing and pursue aggressive case detection and containment.
- **Scenario E.** Partially relax social distancing, promote mask wearing and pursue aggressive case detection/containment (scenarios A + C + D)
- **Scenario F.** Partially relax social distancing, promote mask wearing, pursue aggressive case detection/containment and recommend older adults maintain high levels of social distancing (scenarios A + B + C + D)



Intervention scenarios continued

	Relax social distancing to 45%		Relax social distancing to 55%		Relax social distancing to 65%	
	Est. peak ICU need*	Est. date of ICU peak	Est. peak ICU need*	Est. date of ICU peak	Est. peak ICU need*	Est date of ICU peak
Scenario A: Partial relaxation of social distancing (reference)	15,600	08/07/2020	9,670	09/06/2020	3,070	11/13/2020
Complementary interventions						
Scenario B: Older adults maintain social distancing at current high levels	7,530	8/28/2020	4,630	10/01/2020	1,380	12/11/2020
Scenario C: Mask wearing by the public	12,600	08/20/2020	6,770	09/28/2020	1,270	12/21/2020
Scenario D: Improved case detection and isolation	14,700	08/07/2020	7,980	09/03/2020	1,560	09/22/2020
Combinations of complementary interventions						
Scenario E: Mask wearing, and improved case detection and containment	11,200	08/20/2020	4,650	09/17/2020	653	08/24/2020
Scenario F: Mask wearing, improved case detection and containment, and older adults maintain current high levels of social distancing	4,100	09/10/2020	1,420	09/24/2020	355	04/21/2020



Resurgence



UPDATED: MAR 30, 2020 · ORIGINAL: MAR 3, 2020

Why the Second Wave of the 1918 Spanish Flu Was So Deadly

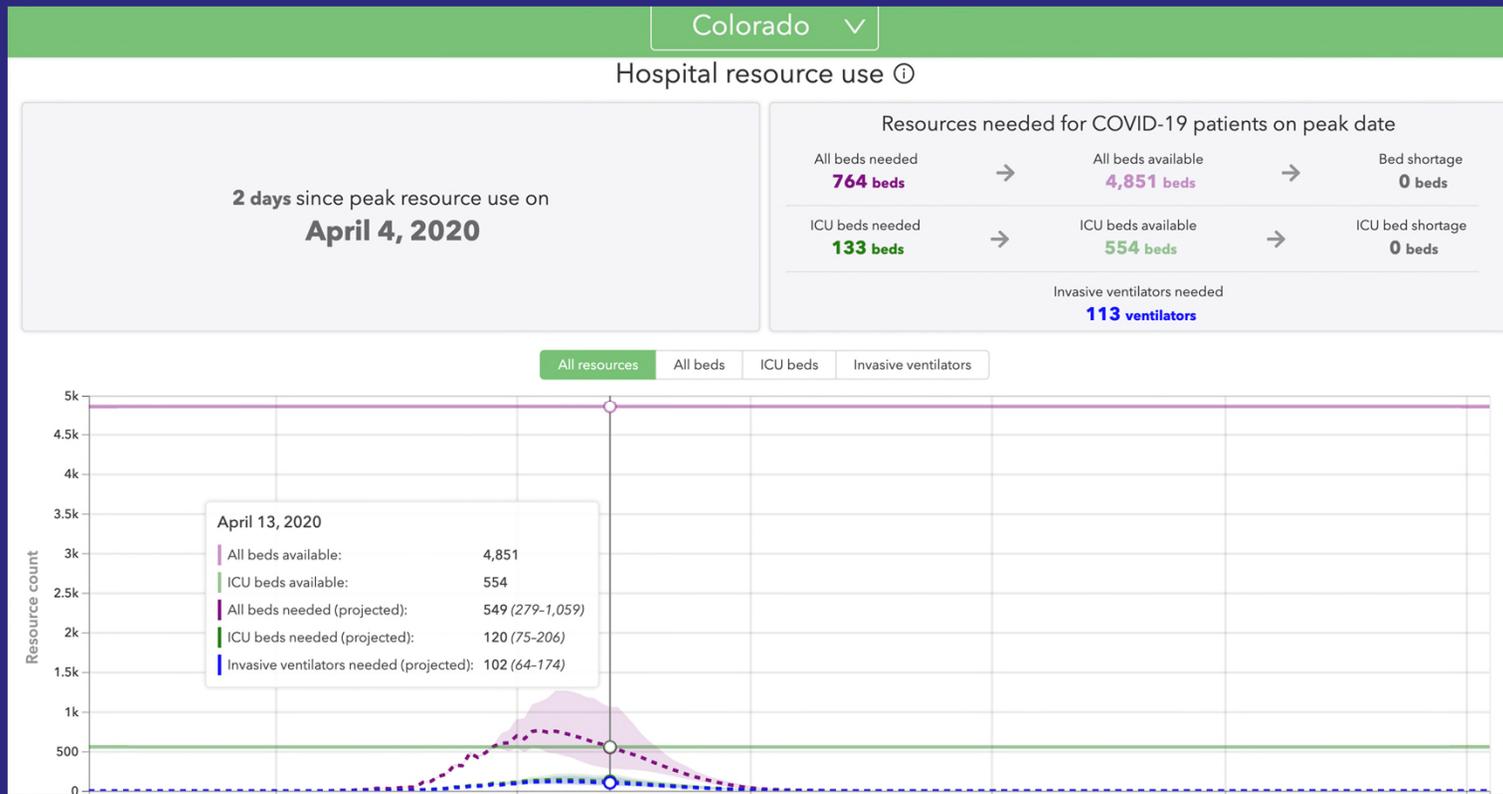
The first strain of the Spanish flu wasn't particularly deadly. Then it came back in the fall with a vengeance.

DAVE ROOS

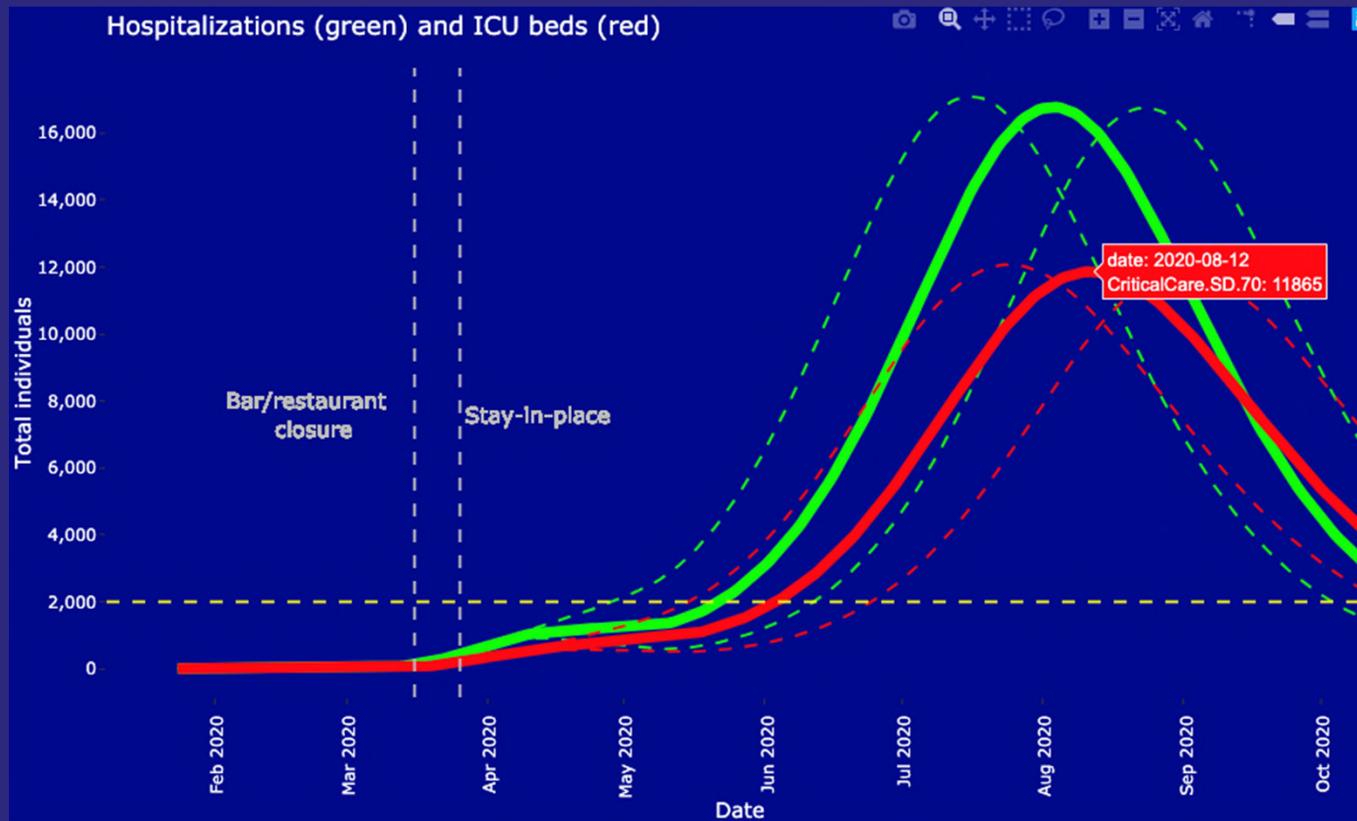


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IHME predictions for April 13 (accessed April 6)



Relaxed social distancing in Colorado



Secondary surge

- Models that do not predict a secondary surge might be wrong

The Asian Countries That Beat Covid-19 Have to Do It Again

Singapore, Hong Kong, South Korea, and Taiwan had flattened the curve. Then travelers from the US and Europe began reimporting the virus.



PHOTOGRAPH: STEFAN IRVINE/GETTY IMAGES

Why Asia's New Wave of Virus Cases Should Worry the World

After a surge in cases tied to international travelers, China, Hong Kong, Singapore and other places that seemed to have the epidemic under control have imposed stricter measures.

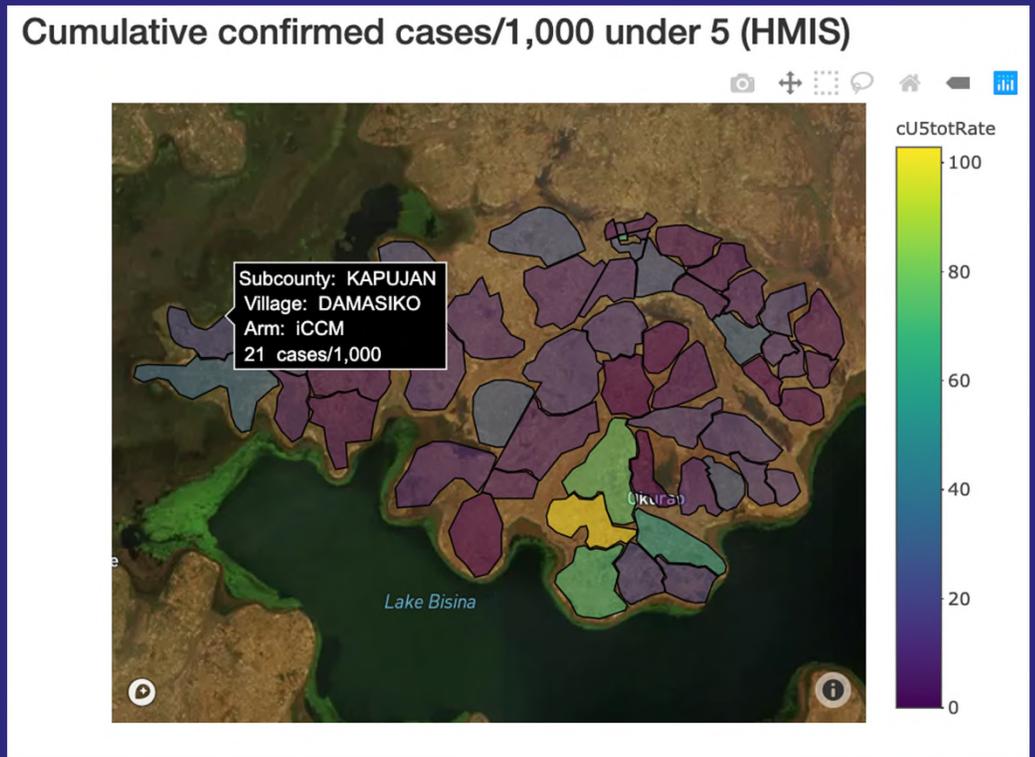
Coronavirus epidemic 'far from over' in Asia-Pacific, WHO warns

Every country needs to keep preparing for large-scale community transmission, says regional director

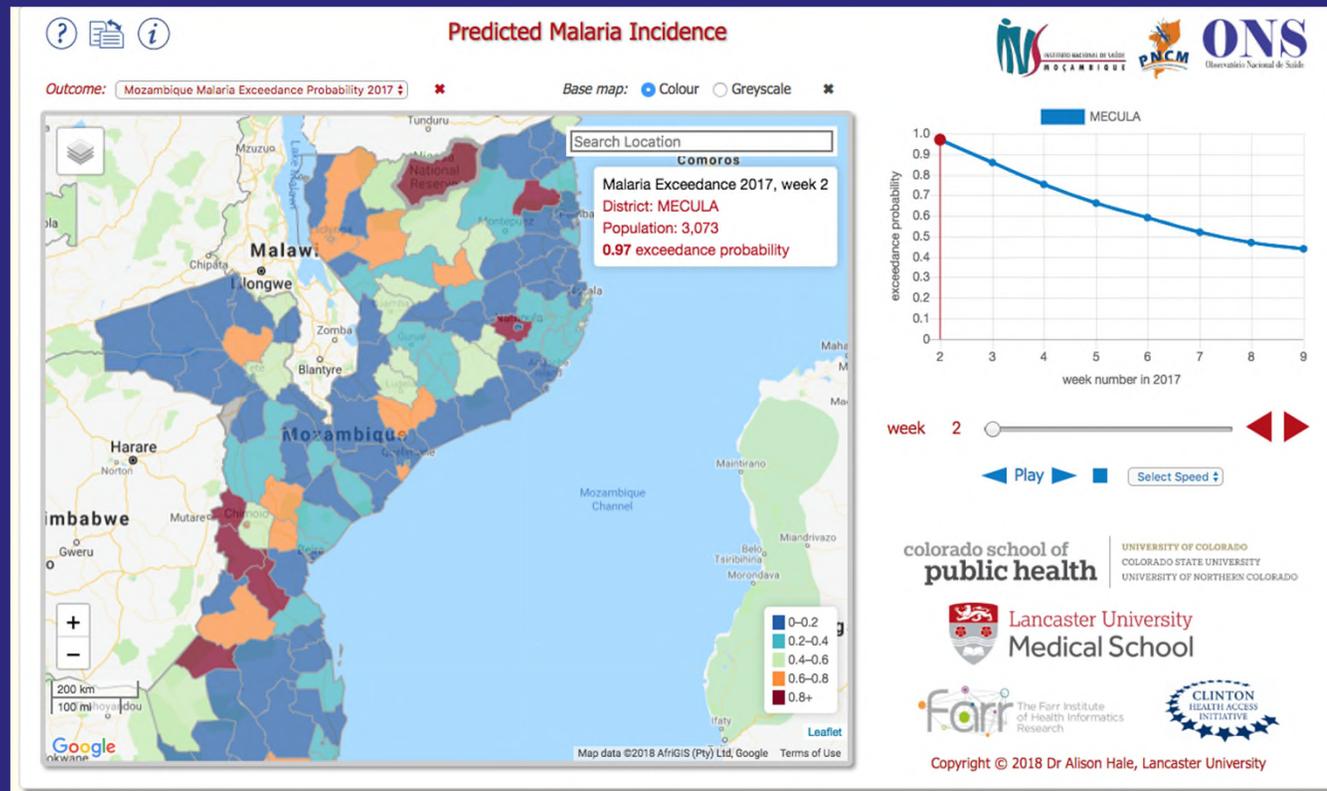


Strategies after stay-at-home inevitably ends

- Real-time surveillance and reporting
- Thresholds for triggering a response
- “Hammer and dance”
- Map shows malaria incidence in Ugandan villages for a current trial comparing intervention strategies



Surveillance plus forecasting



Comparison of predictions

- Our model is fit to the Colorado data and it is frequently updated, but it does not provide uncertainty (currently)
- IHME's statistical models provide uncertainty, but parametric models assume an unlikely distribution, and if we do not look like China or Italy, they will be wrong



Three coronavirus models have very different takes on how Colorado's outbreak will develop

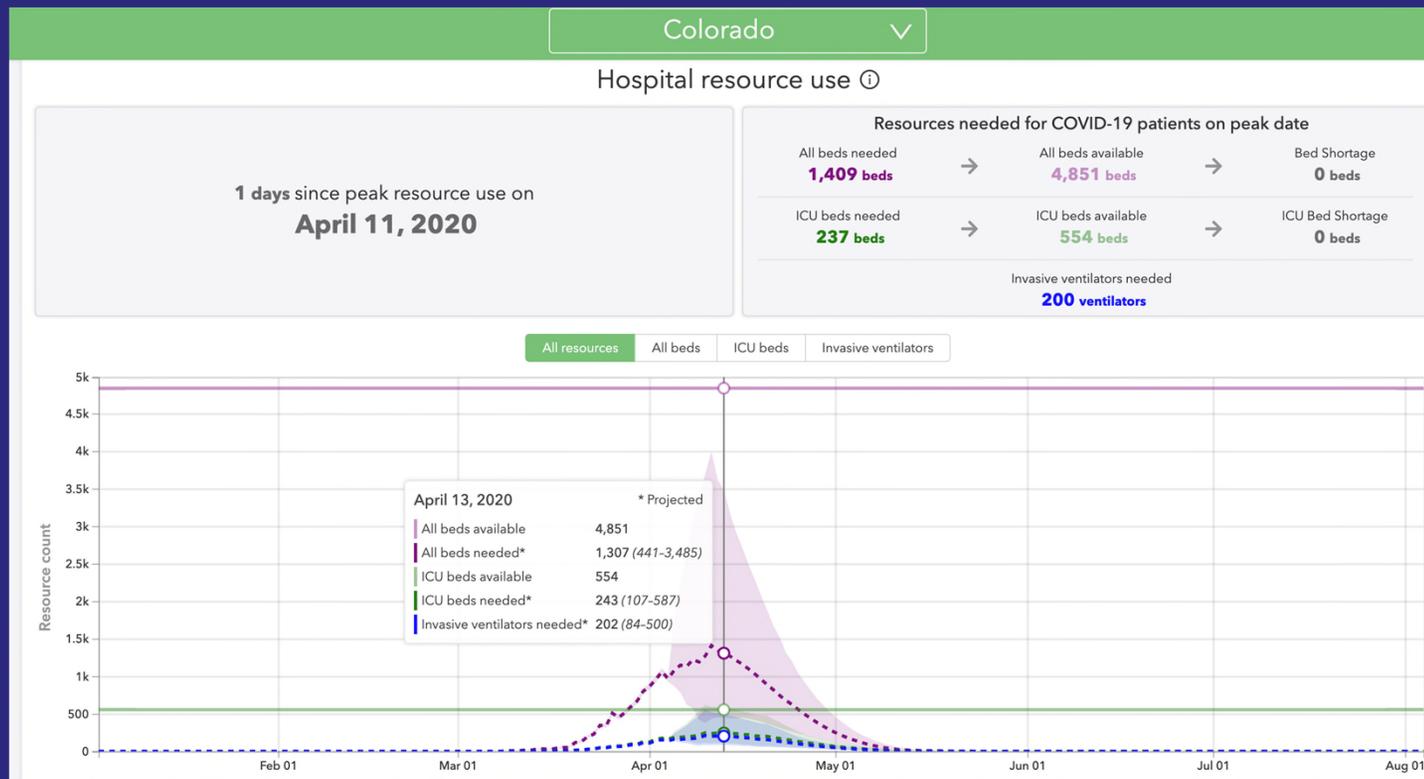
Projections on the spread of COVID-19 from researchers at the University of Colorado Anschutz Medical Campus say the worst is yet to come, while a model from the University of Washington says Colorado has already hit its peak.

Workers at a
Montrose. (H



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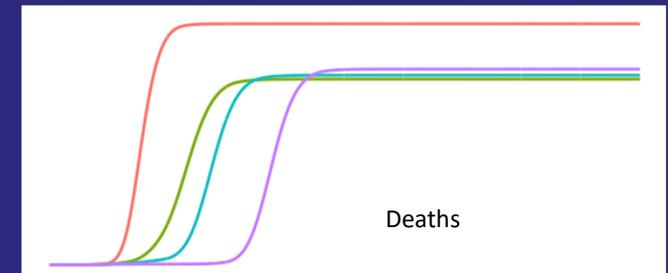
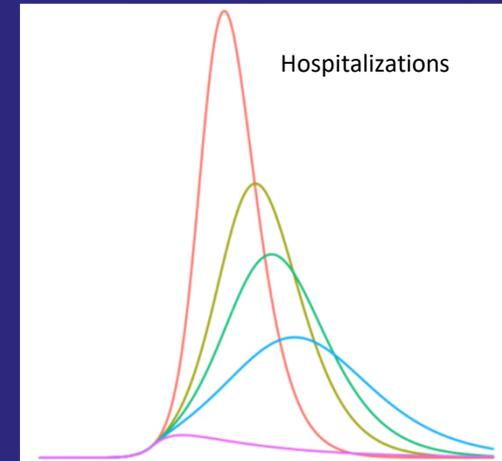
IHME predictions for April 13 (accessed April 12)



Perspectives

- Model simulations are often used to illustrate assumptions and hypotheses
- The exact predictions will never be perfect
- They are meant to aid in decision making

Impact of social distancing



Proceed with caution

- Inevitably, modelers will be asked for exact predictions on exact days

Table of ICU bed needs by specific dates.

SD efficacy	4/13/20	4/20/20	4/27/20	5/4/20	5/11/20	5/18/20
60%	755	972	1,214	1,487	1,797	2,146
70%	641	733	804	859	903	938
80%	545	554				

- We need to develop these models with attention to detail because they are often used to make major decisions with serious consequences

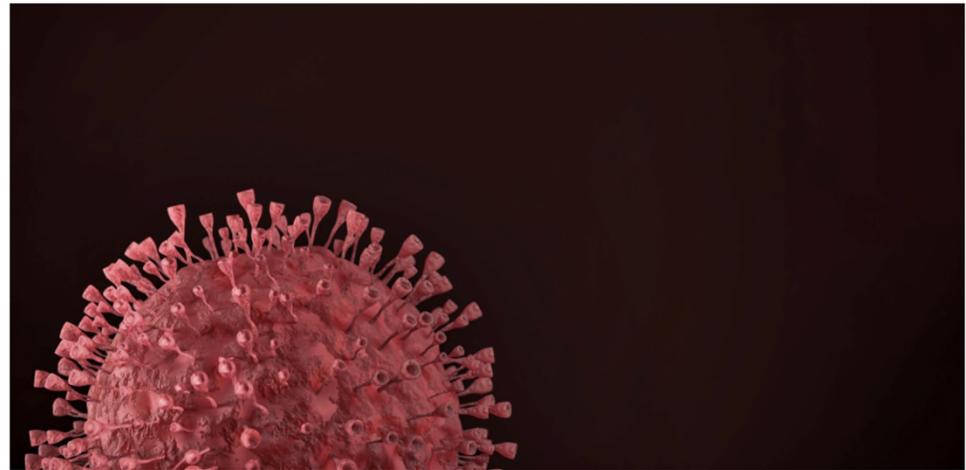


Perspectives continued

- To quote the late David Freedman (UC Berkeley), "something is not necessarily better than nothing"
- We need to be honest about our uncertainty, assumptions and the limitations of our approach

All models are wrong, but some are completely wrong

martingoodson March 31, 2020 Uncategorized



Media coverage



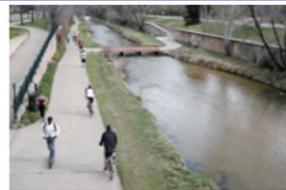
CORONAVIRUS

Colorado's governor says he is using data to guide the state's response to the coronavirus. But the numbers are incomplete.

Colorado researchers are building a model for when COVID-19 will peak in Colorado but say a lack of testing makes that harder

 John Ingold

MAR 27, 2020 3:05AM MDT



ARTICLE

Good News, Colorado: Social Distancing Is Likely Paying Off

But we still need to keep at it, Gov. Jared Polis and public health experts urge.

BY JENNY MCCOY | APRIL 6, 2020

Social Distancing: How Many People Is Too Many?

Schools and sports leagues are shutting down. But experts say it's still safe for most people to shop for groceries and meet in small groups.



PHOTOGRAPH: LAURENCE GRIFFITHS/GETTY IMAGES

Coronavirus cases in Colorado still expected climb even as officials tighten social distancing measures

Experts warn the number of cases can still reach a level that strains hospitals



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- CSU
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