Planning for Inpatient Bed Capacity During The COVID-19 Crisis – Executive Summary

Speaker:
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Why did you build this model, who built it, and who's using it?
We wanted to provide Penn Medicine's clinical and operational leaders with demand projections for hospital beds, ICU beds, and ventilators over the coming weeks for COVID-19 response planning. Penn Medicine's Predictive Healthcare Team of data scientists, software engineers, and Code for Philly created this model along with input from Penn Medicine physician partners and professors of Biostatistics, Epidemiology, and Informatics at the Perlman School of Medicine.

Since the first version of the model was made available a couple of weeks ago, it has been used by thousands of users in over 20 countries, and has sparked lots of collaboration with others building models to predict the spread of COVID-19.

What is an "SIR" model, and what can it be used for?
This is a mathematical model used in epidemics to predict the process of disease spread starting with a susceptible population. *S* = susceptible, *I* = infected, *R* = recovered.

It's simple in that it assumes that every person in the community has an equal chance of meeting any other person in the community, and that everyone will be infected at some point - broad assumptions that aren't fully true. Models of this type are useful for pre-planning, rather than making exact predictions, and are particularly relevant when there are many unknowns. In our current situation, it is hard to pinpoint the doubling rate of infectious spread given the lack of strong surveillance and high numbers of asymptomatic or very mild cases. It's also difficult to precisely estimate the actual implications of particular social distancing policies.

Agent-based and other higher fidelity models allow you to refine estimates based on additional disease and social parameters, but may be less applicable in cases of high uncertainty. The fidelity of an SIR model allows you to estimate the magnitude and peak within 1-2 weeks as well as relative impacts of social distancing policy.

SIR models work well for health system and regional planning, when there is large uncertainty and unknowns in our parameters and we seek to bound scenarios rather than create precise estimates. At Penn, this tool is being used to run a range of best and worst case scenarios.

Model Parameters

The Penn Medicine Predictive Healthcare Team, Code for Philly, and their collaborators, are continuing to improve the model and online tool as new research emerges, publishing new versions and corresponding release notes. They are also maintaining descriptive help pages, linked within the tool, that are updated as improvements are made. The parameter cheat sheet below is current as of 4/2/2020.

Note that the model estimates new COVID-19 admissions and uses LOS parameters to provide census contributions from COVID-19 patients. For practical use, these may need to be layered on top of expected admissions/census for other patients.

CHIME Variable	Where to Get the Input	Notes
Hospital Parameters		
Regional Population	https://www.census.gov/data/datasets/time-series/demo/popest/2010s-counties-total.html#par_textimage_70769902 https://atlasdata.dartmouth.edu/static/supp_research_data#boundaries	Use county # (more straightforward) Use zip code of selected hospital to locate population # in Hospital Referral Region (HRR)
Hospital Market Share	https://coronavirus-resources.esri.com/datasets/definitivehc::definitive-healthcare-usa-hospital-beds?geometry=52.207%2C-16.820%2C-77.168%2C72.123	# of beds in hospital / total # beds in region
Current Hospitalized Patients (COVID-19 +)	Use internal data - counts for your hospital/system	
Spread and Contact Parameters		
Doubling Time	https://code-for-philly.gitbook.io/chime/what-is-chime/parameters	Assumption: 5 days Likely range: 4-6 days If you know the date of the first COVID-19 + case at your site, the model will use that date to estimate this value

Social Distancing	http://predictivehealthcare.pennmedicine.org/2020/03/18/compare-chime.html	
Severity Parameters **only looking at COVID-19 + patients**		
Hospitalization %	https://www.medrxiv.org/content/10.1101/2020.03.09.20033357v1.full.pdf	Assumption: ~ 5% of symptomatic cases are hospitalized, varies by location; age adjustment can be made as needed, refer to table 1 The tool uses a default value of 2.5% assuming that 50% of all cases are mild or asymptomatic
ICU %	https://code-for-philly.gitbook.io/chime/what-is-chime/parameters#severity-parameters	Assumption: ~ .75% (30% of all COVID-19 + patients need ICU)
Ventilated %	https://code-for-philly.gitbook.io/chime/what-is-chime/parameters#severity-parameters	Assumption: ~ .5%
Infectious Days		Assumption: ~ 14 days, likely a high estimate; Penn team awaiting more research
Average Hospital LOS	Use internal data	For COVID-19 patients
Average Days in ICU	Use internal data	For COVID-19 patients
Average Days on Ventilator	Use internal data	For COVID-19 patients
Display Parameters		
Number of Days to Project	User preference	Default set to 100 days
Current Date	Match to date of hospitalized COVID-19 patient count	Default set to ‘today’s date’

How are the results being used for capacity planning at Penn Medicine?
Lead analysts across six Penn hospitals meet twice per day, first to discuss the parameters being used and current planning goals, then to compile the reports for the day. Some decisions that have been made using the results are:

- When to start converting some departments to critical care areas
- When to move some PPE supplies from one health system to another
- How long to continue to do some elective surgeries

In addition, the results have been used to obtain approval to continue building a hospital construction for which had previously been discontinued and as a means to provide some psychological relief to critical care teams. It's terrifying to know that a major surge is coming, but not to know when. Using this tool has helped articulate what's coming, when, and how we can prepare - and that we still have some time to rest and to plan.

Getting Help
- Access the online tool (no log-in or download needed): http://penn-chime.phl.io/
- Access tool documentation, with descriptions of parameters and links to detailed blog posts as well as citations: https://code-for-philly.gitbook.io/chime/what-is-chime/parameters
- Join Slack channel (create Code for Philly login): https://codeforphilly.org/chat?channel=covid19-chime-penn

- Ask questions by email
  - Reach the team who built the model (allow one-week turnaround): pennsignals@uphs.upenn.edu
  - Get quick help navigating the resources and answering questions specific to your institution (allow one-day turnaround): info@leantaas.com