Guide Your Organization through COVID-19

Using American Hospital Association Data and Epidemiologic Models
Our Presenters

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Ayrin Molefe, Ph.D., Director of Statistics and Data Science, American Hospital Association
AGENDA

- Introductions
- Interactive poll
- Introduction to AHA’s Compendium of COVID-19 Models
- Demonstration of AHA’s capacity maps
- Description and discussion of two models
- Q & A
AHA Compendium of COVID-19 Models

AHA Bed Capacity Maps

Select bed type and population age group

Sliders filter the results to show the selected ranges for poverty and uninsured rates

https://metricvu.aha.org/dashboard/covid-bed-shortage-detection-tool
AHA Bed Capacity Maps

Selected bed type, population group, and State(s) are reflected below

<table>
<thead>
<tr>
<th>State</th>
<th>Total Population</th>
<th>Number of Hospital Beds</th>
<th>Poverty Rate vs Uninsured Rate by State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon</td>
<td>4,081,943</td>
<td>7,900</td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td>7,294,336</td>
<td>15,235</td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>39,148,760</td>
<td>85,604</td>
<td></td>
</tr>
<tr>
<td>Utah</td>
<td>3,045,350</td>
<td>6,683</td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>5,531,141</td>
<td>12,438</td>
<td></td>
</tr>
<tr>
<td>New Hampshire</td>
<td>1,343,622</td>
<td>3,052</td>
<td></td>
</tr>
<tr>
<td>New Mexico</td>
<td>2,092,434</td>
<td>4,756</td>
<td></td>
</tr>
<tr>
<td>Idaho</td>
<td>1,687,809</td>
<td>3,951</td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td>6,946,685</td>
<td>16,342</td>
<td></td>
</tr>
<tr>
<td>Connecticut</td>
<td>3,581,504</td>
<td>8,501</td>
<td></td>
</tr>
<tr>
<td>Maryland</td>
<td>6,003,435</td>
<td>14,350</td>
<td></td>
</tr>
<tr>
<td>North Carolina</td>
<td>10,155,624</td>
<td>24,713</td>
<td></td>
</tr>
<tr>
<td>Hawaii</td>
<td>1,422,029</td>
<td>3,467</td>
<td></td>
</tr>
</tbody>
</table>
Hospital service areas (HSAs) are local health care markets for hospital care. An HSA is a collection of ZIP codes whose residents receive most of their hospitalizations from the hospitals in that area. HSAs are defined by assigning ZIP codes to the hospital area where the greatest proportion of their Medicare residents were hospitalized. Minor adjustments are made to ensure geographic contiguity. Most HSAs contain only one hospital. The process results in 3,436 HSAs.

Hospital referral regions (HRRs) represent regional health care markets for tertiary medical care. Each HRR contains at least one hospital that performs major cardiovascular procedures and neurosurgery. HRRs are defined by assigning HSAs to the region where the greatest proportion of major cardiovascular procedures were performed, with minor modifications to achieve geographic contiguity, a minimum population size of 120,000, and a high localization index. The process results in 306 hospital referral regions.
AHA Bed Capacity Maps

People per Hospital Bed (Including Adult ICU), by HRR

Bed Type: All Hospital Beds (including Adult ICU)
Age Group: All
Population in Poverty: 5.6%
Population Uninsured: 31.7%
Show Individual Facilities: No
AHA COVID-19 Bed Occupancy Projection Tool

Select bed type, projection scenario, projected date, and percentage of beds committed for non-COVID care.

Using IHME COVID-19 case projections and assuming 60% of all adult ICU beds are occupied by non-COVID patients, it is projected that on 5/20/2020, 47,706 (61%) out of 78,848 adult ICU beds in the U.S. will be occupied.
AHA COVID-19 Bed Occupancy Projection Tool

Selections on bed type, scenario and occupancy are reflected in the curve below.
A Walk Run-through of Two COVID-19 Models
Disclaimers

This presentation is an illustration of the use of two models, not about the theory behind the models.

The models cited in this presentation are not necessarily a representative sample of existing COVID-19 models.

I am a statistician, not an epidemiologist.
The COVID-19 Pandemic
There are so (too?) many COVID-19 models

- There is even an “ensemble model” that combines predictions from different models by using averages
- Currently, includes predictions for only the cumulative number of deaths at the national and state levels

National Forecast (as of May 12)
Over 100K Deaths by June 1st
Actual Deaths as of May 16: 87,315

Sources:
- https://reichlab.io/covid19-forecast-hub/
Which model(s) to use?

A model's predictions:
- Are simply educated guesses, not snapshots of the future
- Are only as good as the assumptions they are based on
- Are only as good as the input data
- Tend to be the less reliable (have greater uncertainty) the further out they are into the future

All models are wrong, but some are useful
George E. P. Box (1919-2013)
Which models are useful? 
Some considerations

- Goals (Output):
  - What do you want to predict?
  - Number of cases, deaths, resource use (e.g., beds, ventilators)
  - At which level?
  - Country, state, hospital referral region (HRR), county, specific hospital(s)

- Personal preference:
  - Simplicity
  - Input parameters
  - Ability to change scenarios

- Model:
  - What factors does it take into account?
  - Is it evolving/learning over time?
AHA Compendium of COVID-19 Models

- Focuses on nine (external) case mapping and projection tools that predict and compare resource demands to capacity
- These tools are not necessarily better than other models but are useful for planning hospital resources
The AHA Compendium of Models: A Summary

<table>
<thead>
<tr>
<th>Case Projection And Capacity Planning Models</th>
<th>Model Type</th>
<th>Estimation level</th>
<th>C.I.</th>
<th>Social Distancing</th>
<th>Mobility</th>
<th>Output table</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. UW-IHME — COVID-19 Forecasting Tool</td>
<td>Hybrid*</td>
<td>State</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Harvard University — Regional Hospital Capacity Calculator</td>
<td>Formula-based**</td>
<td>HRR</td>
<td>N/A</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Qventus — Localized COVID-19 Model and Scenario Planner</td>
<td>SEIR</td>
<td>HRR; System; Hospital</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Penn Medicine — CHIME:COVID-19 Hospital Impact Model for Epidemics</td>
<td>SIR</td>
<td>State; System; Hospital</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Rush University — Hospital Resource Calculator for COVID-19</td>
<td>SEIR</td>
<td>Hospital</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Health Catalyst — Capacity Planning Tool</td>
<td>SIR</td>
<td>County, Hospital</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>7. Cleveland Clinic — Hospital Impact Modeling</td>
<td>SEIR</td>
<td>Hospital</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>8. Stanford Medicine — COVID-19 ICU and Floor Projections</td>
<td>SEIR</td>
<td>Hospital</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>9. RAND Corporation — Critical Care Surge Response Tools</td>
<td>Formula-based**</td>
<td>Hospital</td>
<td>N/A</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* A combination of disease transmission model and statistical (curve-fitting) models
** Outputs are calculated using formulas instead of mechanistic/statistical models.
Two Illustrative Models

IHME Model

- By the Institute of Health Metrics and Evaluation (IHME) at U of Washington
- Dubbed as the “White House model”
- Has been widely cited, and also criticized because it didn’t model epidemiological factors such as disease transmission and incubation period
- Has since been modified to address these criticisms

Qventus Model

- Developed by Qventus (https://qventus.com) – provides a platform that “incorporates artificial intelligence, behavioral science, and data science to deliver a close-loop system for automating patient flow”
## Two Illustrative Models

<table>
<thead>
<tr>
<th>IHME Model</th>
<th>Qventus Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>o State level</td>
<td>o Hospital(s) level</td>
</tr>
<tr>
<td>o Simple to use</td>
<td>o Needs more user input</td>
</tr>
</tbody>
</table>
IHME Model
Only requires selecting the country or state from a drop-down menu for country or state

**Country or state level:**

- Percent change in mobility as a function of when social distancing was implemented and/or lifted
- Daily infection and testing
- Daily deaths
- Cumulative deaths
- Daily resource use: all beds, ICU beds, ventilators
IHME Model Output 1: Illinois Predicted Change in Mobility*

- Mobility decreases with social distancing
- A 55% drop in mobility on Apr 1st
- A 10% increase in mobility following easing of stay-at-home restrictions

*As of May 16, 2020
Source: https://covid19.healthdata.org/united-states-of-america/illinois
IHME Model Output 2:
Illinois Predicted Daily Infections and Testing*

Graph shows

- Predicted infections:
  - Are much higher than the confirmed infections up to May 10
  - Have wide confidence intervals (shaded region)
  - Ex.: Predicted infections on June 1st is between 623 and 23,325!

- Daily tests:
  - Predicted to go up to 25K by mid-June

*As of May 16
Source: https://covid19.healthdata.org/united-states-of-america/illinois
IHME Model Output 3:
Illinois Predicted Resource Demand*

Output #5:
- Total beds:
  - Predicted demand is below bed capacity (~15K) throughout the whole period
- ICU beds:
  - Predicted demand will not exceed total ICU bed capacity (~1.1K beds)

*As of May 16
Source: https://covid19.healthdata.org/united-states-of-america/illinois

Total bed capacity = 14,552

ICU bed capacity = 1,131

All beds needed (projected)

ICU beds needed (projected)

Invasive ventilators needed (projected)
Qventus Model
Qventus Model

Inputs

- Select hospital
- Enter:

**PANDEMIC RESPONSE & SOCIAL DISTANCING**
**MARKET**
**HOSPITAL ASSUMPTIONS**
**COVID-19 ASSUMPTIONS**

Outputs

**Hospital(s) or HRR level:**
- Total new COVID-19 admits in the next 7 days (Med-Surg, ICU, ICU+Ventilator)
- Days remaining until capacity is reached (Med-Surg, ICU, ICU+Ventilator)
- Total deaths over the next 45 days
- Daily resource use: Med-Surg, ICU, ventilator:
  - Daily PPE and PPE nursing shifts
Qventus Model: Selecting Hospital

- Select hospital from the drop-down menu:
  - Edward Hospital in Naperville, IL
  - HRR #133: Hinsdale, IL

- Model pre-populates the HRR parameters:
  - Number of cases: 3,247
  - Population size: 517,862
  - Case growth rate: 2.92% per day

Source: https://covid19.qventus.com/modeling/hospitals
Enter:

a. Social distancing dates
b. PCR tests per day
c. Mask effectiveness

Note: Based on Illinois data (not data specific to HRR)

Sources:
Illinois Department of Public Health
https://www.dph.illinois.gov/covid19/covid19-statistics
Illinois Policy Organization
Qventus Model: Testing Input
Edward Hospital, HRR 133

Source for PCR testing data
Illinois Department of Public Health
https://www.dph.illinois.gov/covid19/covid19-statistics

Note: Based on Illinois data (not data specific to HRR)
Calculating Mask Effectiveness

Starting May 1, Illinois residents were ordered to wear masks when in public.

**Mask Effectiveness =**

(% of the population wearing masks) X

(% reduction in the likelihood of an infected person infecting others because of the mask)

= 50% X 80%

= 40%

Qventus Model: Market Inputs
Edward Hospital, HRR 133

Enter:

a. HRR known cases
b. HRR population
c. Market share (%) = \( \frac{\text{Hospital bed capacity}}{\text{HRR bed capacity}} \)

Note: Pre-populated for the selected HRR
Qventus Model: Hospital Inputs
Edward Hospital, HRR 133

Enter: Hospital assumptions for Med-Surg, adult ICU, Vents*

a. Beds available
b. Additional surge capacity (optional)
c. Non-COVID occupancy
d. Current COVID patients (optional)

Note: Pre-populated for the selected hospital using data from Definitive Healthcare

<table>
<thead>
<tr>
<th>Bed Capacity and Current Patients</th>
<th>Med-Surg</th>
<th>Adult ICU</th>
<th>Vents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beds Available</td>
<td>273</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Add'l Surge Capacity</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Non-COVID Occ %</td>
<td>81.6</td>
<td>89.6</td>
<td>60</td>
</tr>
<tr>
<td>Current COVID Patients</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Qventus Model: COVID-19 Inputs
Edward Hospital, HRR 133

Enter: Level of Care and LOS*

- a. Non-critical care (%)
- b. Critical care (%)
- c. Critical care with vents (%)
- d. Daily new infection growth rate
- e. Percent of infections being reported
- f. Asymptomatic rate

Doubling Time = \frac{\ln(2)}{\ln(1 + \text{growth rate})} = \frac{\ln(2)}{\ln(1.02493)} = 28.1

*Note: Pre-populated based on local age demographics, state reports, HCUP, recent literature, etc.
Edward’s daily Med-Surg bed demand are predicted to decrease within the next 45 days (from 27 beds on 5/17 to 5 beds on 7/1).

The demand throughout the period is below the 50 beds available for COVID-19 patients at Edward Hospital.
Edward’s daily ICU bed demand are predicted to decrease within the next 45 days (from 10 beds on 5/17 to 2 beds on 7/1).

But with only 3 ICU beds available for non-COVID patients, Edward Hospital is predicted to be short of ICU beds from 5/17 up to 6/24.
Concluding Thoughts
Some models are useful but…

• Be clear about your goals
• Simplicity is convenient, but context matters
• Models, data and assumptions are changing over time
• Predictions (whether presented as such or not) are not merely points. They are intervals.
• Be humble. Nobody really knows what is going to happen!
Thank you!

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American Hospital Association

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Questions?