Projecting COVID-19 Hospitalizations
for Regions 2, 3, and 4 of the Kentucky Regional Hospital Preparedness Program (HPP) Coalition
during the Implementation of the State’s “Targeted Measures”

Projection Period:
14 November 2020 – 15 January 2021

<table>
<thead>
<tr>
<th>HPP Region</th>
<th>Population (Estimated 2019)</th>
<th>Number of Counties</th>
<th>Largest County</th>
<th>Largest City</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>374,030</td>
<td>11</td>
<td>Daviess</td>
<td>Owensboro</td>
</tr>
<tr>
<td>3</td>
<td>1,286,637</td>
<td>15</td>
<td>Jefferson</td>
<td>Louisville</td>
</tr>
<tr>
<td>4</td>
<td>308,919</td>
<td>10</td>
<td>Warren</td>
<td>Bowling Green</td>
</tr>
</tbody>
</table>
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Draft Preparation Date: November 30, 2020
The State of Kentucky’s Targeted Measures (link)

20 November 2020 to 13 December 2020:

- **Gyms, fitness centers, pools, other indoor recreation facilities:** “33% capacity limit; group classes, team practices and competitions prohibited; masks must be worn while exercising”
- **Venues, event spaces and theaters:** “Each room will be limited to 25 people. This applies to indoor weddings and funerals”
- **Private Social Gatherings:** “Up to eight people from a maximum of two households”
- **Professional services:** “Office-based businesses limited to 33% of employees; all employees who are able to work from home must do so; all businesses that can close to the public must do so”
- **Restaurant and bars:** “No indoor food or beverage consumption; carryout and delivery encouraged; socially distance outdoor seating”

20 November 2020 to 4 January 2021:

- “All public and private schools (K-12) to cease in-person instruction”:
  - **Elementary schools:** “Elementary schools may reopen for in-person instruction Dec. 7”
  - **Middle and high schools:** “will remain in remote or virtual instruction until at least Jan. 4, 2021.”
Takeaways:

- In the absence of the targeted measures (or if there is no compliance with the restrictions), the number of active hospitalizations is expected to be:

  - 494 in Region 2
  - 1,092 in Region 3
  - 210 in Region 4
  - by mid-December 2020

  - 870 in Region 2
  - 1,690 in Region 3
  - 256 in Region 4
  - by mid-January 2021.

The total numbers of inpatient beds in the regions are:

  - 838 in Region 2
  - 3,942 in Region 3
  - 823 in Region 4

- High compliance with the targeted measures (if it reduces transmission rate by 75%) prevents approximately the following numbers of excess hospitalizations:

  - 439 in Region 2
  - 690 in Region 3
  - 117 in Region 4
  - by mid-December 2020

  - 763 in Region 2
  - 1,583 in Region 3
  - 226 in Region 4
  - by mid-January 2021.

- Mid-range compliance with the targeted measures (if it reduces transmission rate by 50%) prevents approximately the following numbers of excess hospitalizations:

  - 371 in Region 2
  - 574 in Region 3
  - 141 in Region 4
  - by mid-December 2020

  - 661 in Region 2
  - 1,363 in Region 3
  - 191 in Region 4
  - by mid-January 2021.

- Even low compliance with the targeted measures (if it reduces transmission rate by 25%) prevents approximately the following numbers of excess hospitalizations:

  - 238 in Region 2
  - 355 in Region 3
  - 87 in Region 4
  - by mid-December 2020

  - 459 in Region 2
  - 933 in Region 3
  - 123 in Region 4
  - by mid-January 2021.

- Mid-range and high compliance with the new restrictions is projected to prevent excess hospitalizations and will allow the regions’ hospitals to operate elective surgeries at normal capacity.
Kentucky Regional Hospital Preparedness Program (HPP) Coalition

HPP Region 3 Counties:
Bullitt, Breckinridge, Grayson, Hardin, Henry, Jefferson, Larue, Marion, Meade, Nelson, Oldham, Shelby, Spencer, Trimble, Washington

HPP Region 4 Counties:
Allen, Barren, Butler, Edmonson, Hart, Logan, Metcalfe, Monroe, Simpson, Warren

Source: https://kyepltc.org/hospital-preparedness/coalitions/
Total Covid-19 Cases and Deaths in Kentucky HPP Regions 2–4

Note: Authors calculations using the New York Times Data (link)
Confirmed Active Covid-19 Hospitalizations for Kentucky HPP Regions 2–4 Based on the Latest Hospitalization Report (Numbers Are Corrected for Reporting Delay)

Notes: Authors’ calculations using the data from the Kentucky Health Information Exchange (KHIE).
A Conceptual Framework for Modeling Covid-19 Pandemic in HPP Regions 2-4:
A Susceptible-Exposed-Infectious-Recovered (SEIR) Model
# Transmission and Clinical Parameters Used in the SEIR Model

<table>
<thead>
<tr>
<th>Parameters Extracted from the Literature:</th>
<th>Region 2</th>
<th>Region 3</th>
<th>Region 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propotion of Infections That Are Asymptomatic\textsuperscript{1,4}</td>
<td>43%</td>
<td>30%</td>
<td>50%</td>
</tr>
<tr>
<td>Incubation Period (Days)\textsuperscript{3-8}</td>
<td>3.5</td>
<td>2.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Pre-Symptomatic Period (Days)\textsuperscript{9-11}</td>
<td>1.5</td>
<td>1.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Infectious Period for Asymptomatic Infections (Days)\textsuperscript{12,13}</td>
<td>7.0</td>
<td>4.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Parameters Extracted from the KHIE and Jefferson County Person-Level Data:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infectious Period for Mildly Symptomatic Infections (Days)\textsuperscript{14-16}</td>
<td>15.0</td>
<td>8.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Infectious Period for Severely Symptomatic Infections (Days)</td>
<td>5.0</td>
<td>2.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Proportion of Symptomatic Infections That Required Hospitalization\textsuperscript{17,18}</td>
<td>11.5%</td>
<td>6.5%</td>
<td>16.5%</td>
</tr>
<tr>
<td>Duration of Hospital Stay of Those WhoRecovered from the Infection (Days)</td>
<td>6.0</td>
<td>4.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Duration of Hospital Stay of Those Who Died of the Infection (Days)</td>
<td>9.0</td>
<td>5.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Fatality Rate Among Hospitalizations</td>
<td>12.2%</td>
<td>7.2%</td>
<td>17.2%</td>
</tr>
</tbody>
</table>

**Notes:** For each parameter of the SEIR model, a range of values from the lower bound to the upper bound were used in simulations. The parameters in the first section of the table were extracted from the literature. The parameters of the second section are calculated by the authors using two separate person-level data sources: (1) Kentucky Health Information Exchange (KHIE) COVID-19 hospitalization data, collected and compiled at the Kentucky Cabinet for Health and Family Services (CHFS); (2) Jefferson County COVID-19 Case and Fatality Data, collected and compiled at the Louisville Metro Department of Public Health and Wellness (LMPHW). The information on infectious periods is not available in the KHIE data and is extracted from Jefferson County data and used for all regions. A lower bound is the 25\textsuperscript{th} quantile of the distribution of the parameter value in the related subsample, and an upper bound is the 75\textsuperscript{th} quantile. The exceptions are percentages (“proportion of symptomatic infections that require hospitalization” and “fatality rate among hospitalizations”) and the upper bound of the number of days of “infectious period for mildly symptomatic infections.” The 75\textsuperscript{th} quantile of the latter parameter in Jefferson County data is 53 days, significantly different from what is reported in the literature; therefore, the upper bound was selected such that it has the same distance from the median as the lower bound does. For percentages, 5% above and below was selected as upper and lower bounds, respectively.
The Fit of the SEIR Model to the Observed Active Hospitalization Data in Kentucky HPP Regions 2–4: March 15 to November 13, 2020 (dots are the observed data. The highlighted path us the median of 300 simulations.)
The Timeline of the Targeted Measures and Modelled Interventions

Start of the Targeted Measures:
Restrictions on Bars, Restaurants, Private Gatherings, Gyms, Venues, Prof Services, and Schools

In-Person Instruction in Elementary Schools May Begin

Non-School Restrictions Expire

In-Person Instruction in Middle and High Schools May Begin

Modeled Interventions:

Intervention 1: Implementation of All Targeted Measures

Intervention 2: Only School Restrictions

Intervention 3: All Targeted Measures Expire

Note: Detailed information on the restrictions is available at Kentucky.gov.
Projection Scenarios

Given the components of the targeted measures, the following projection scenarios were considered:

*The ↓ sign indicates a decrease.*

<table>
<thead>
<tr>
<th>#</th>
<th>Scenarios</th>
<th>Intervention Number</th>
<th>Interventions Description</th>
<th>Intervention Start Date</th>
<th>Intervention End Date</th>
<th>Assumed Percentage Change in Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Continuing the Status Quo</td>
<td>None</td>
<td>Absence of the Targeted Measures</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Low Compliance with the Restrictions</td>
<td>1</td>
<td>Implementation of All Targeted Measures</td>
<td>20-Nov</td>
<td>13-Dec</td>
<td>25% ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Only School Restrictions</td>
<td>14-Dec</td>
<td>4-Jan</td>
<td>3% ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>All Targeted Measures Expire</td>
<td>5-Jan</td>
<td>15-Jan</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Mid-Range Compliance with the Restrictions</td>
<td>1</td>
<td>Implementation of All Targeted Measures</td>
<td>20-Nov</td>
<td>13-Dec</td>
<td>50% ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Only School Restrictions</td>
<td>14-Dec</td>
<td>4-Jan</td>
<td>3% ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>All Targeted Measures Expire</td>
<td>5-Jan</td>
<td>15-Jan</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>High Compliance with the Restrictions</td>
<td>1</td>
<td>Implementation of All Targeted Measures</td>
<td>20-Nov</td>
<td>13-Dec</td>
<td>75% ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Only School Restrictions</td>
<td>14-Dec</td>
<td>4-Jan</td>
<td>3% ↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>All Targeted Measures Expire</td>
<td>5-Jan</td>
<td>15-Jan</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes: (1) The SEIR model’s transmission parameter is the multiplication of the probability of transmission per-contact and the per capita contact rate between the susceptible and the infectious. The latter component carries the effect of a non-pharmaceutical intervention if it influences personal and social protection measures. (2) The new school restrictions are expected to affect about 20% of Jefferson County’s student population because the rest attended public schools that applied distance learning from July 2020. Since 6-18 years old constitute 15.8% of Jefferson County’s population, if the restriction decreases these students’ contact rate by 95%, then it is expected that the overall contact rate in the County decreases by 3% (=20%×15.8%×95%) with respect to the pre-November 20 period. This assumption were applied to all three regions. (3) The presumed percentage decreases in transmission during full implementation of the targeted measures may resemble mask-wearing effectiveness and its take-up in reducing the transmission. High mask-wearing may decrease the reduce the risk of infection by 85%, but low mask-wearing rates will reduce its effectiveness proportionally.
Status Quo’s Projections for 14 Nov 2020–15 Jan 2021 (Assumption: no change in contact rate)
Scenario 1’s Projections for 14 Nov 2020–15 Jan 2021 (Assumption: low compliance, contact rate 25%↓)

Region 2

Region 3

Region 4

Implementation of All Targeted Measures: Nov 20, 2020

Only School Restrictions: Dec. 13, 2020
Scenario 2’s Projections for 14 Nov 2020–15 Jan 2021 (Assumption: mid-range compliance, contact rate 50%↓)

Region 2

Region 3

Region 4

Implementation of All Targeted Measures: Nov 20, 2020

Only School Restrictions: Dec. 13, 2020
Scenario 3’s Projections for 14 Nov 2020–15 Jan 2021 (Assumption: high compliance, contact rate 75%↓)
Summary of Projection Results

Active Hospitalization in Region 2 under Different Scenarios (Medians of 300 simulations)
Active Hospitalization in Region 3 under Different Scenarios (Medians of 300 simulations)
Active Hospitalization in Region 4 under Different Scenarios (Medians of 300 simulations)
This report investigated the simulated effect of the implementation of a set of targeted measures by the State of Kentucky to contain the recent sharp increase in COVID-19 cases and active hospitalizations on COVID-19 transmission.

Three scenarios of compliance with the targeted measures were considered: low, mid-range, and high. The scenarios were assumed to decrease the transmission of the coronavirus by 25%, 50%, 75% in Kentucky HPP Regions 2–4. For these scenarios, the projections for active hospitalizations were made until mid-January 2021. These projections were based on medians of 300 simulations.

The status quo scenario (absence of the targeted measures) estimates that by mid-January 2021 active hospitalizations will increase to approximately:
- 870 in Region 2
- 1,690 in Region 3
- 256 in Region 4

Scenario 1 (low compliance with targeted measures) estimates that by mid-January 2021 active hospitalizations will increase to approximately:
- 411 in Region 2
- 757 in Region 3
- 133 in Region 4

Scenario 2 (mid-range compliance with targeted measures) estimates that by mid-January 2021 active hospitalizations will increase to approximately:
- 209 in Region 2
- 327 in Region 3
- 65 in Region 4

Scenario 3 (high compliance with targeted measures) estimates that by mid-January 2021 active hospitalizations will increase to approximately:
- 107 in Region 2
- 107 in Region 3
- 30 in Region 4
• Given the total number of inpatient beds in the regions,
  - 838 in Region 2
  - 3,942 in Region 3
  - 823 in Region 4,

  even mid-range compliance with the measures will allow the regions’ hospitals to operate elective surgeries at normal capacity.
References for the Parameters of the SEIR Model


