UTK COVID-19 CALCULATOR
CAPABILITY AND DEVELOPMENT INFORMATION

The calculator provides a user-friendly interface to project number of cases and hospitalization needs based on confirmed number of cases and known hospital resources. Its predictive capabilities are based on dynamics inferred directly from the observed number of confirmed cases.

For the calculator, projected cases are based on an average of daily growth rates in your county/region. As additional data on cases are included, projections will adjust accordingly. For the calculator, projected hospitalizations are based on a 20% average hospitalization rate, with ICU beds based on the average percentage of critical cases, or 14% of hospitalizations. These figures are based on information provided by the World Health Organization on COVID-19.[1] Data on hospital bed availability was compiled from Definitive Healthcare.[2] These are estimates only. Please contact your local health department, or hospital system for more accurate and up-to-date information.

Much like the weather, the closer the projection is in time to today's date, the more likely it is to be accurate. The further out in time, the less accurate the projections.

This calculator was developed by Dr. Katie A. Cahill and Dr. Deborah Penchoff at the University of Tennessee, Knoxville in conjunction with the Coronavirus-19 Outbreak Response Experts (CORE-19).[3]

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[1] https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200306-sitrep-46-covid-19.pdf?sfvrsn=96b04adf_2
[2] https://www.definitivehc.com/
[3] http://core19.utk.edu/

PROJECTED INFORMATION AND LIMITING PARAMETERS

The projected information includes:

- Number of cases
- Estimate of staffed hospital beds needed
- Estimate of ICU needs

The limiting parameters entered by the user include:

- Current date
- Projection date
- Confirmed number of cases

DEFINITIONS AND FORMULAS

- **Areas**

  The calculator currently has capability to evaluate predictions per county and per defined health regions. The platform is built to allow for new regions/zones to be incorporated very quickly.

  Counties: Anderson, Bedford, Benton, Bledsoe, Blount, Bradley, Campbell, Cannon, Carroll, Carter, Cheatham, Chester, Claiborne, Clay, Cocke, Coffee, Crockett, Cumberland, Davidson, Decatur, DeKalb, Dickson, Dyer, Fayette, Fentress, Franklin, Gibson, Giles, Grainger, Greene, Grundy, Hamblen, Hamilton, Hancock, Hardeman, Hardin, Hawkins, Haywood, Henderson, Henry, Hickman, Houston, Humphreys, Jackson, Jefferson, Johnson, Knox, Lake, Lauderdale, Lawrence, Lewis, Lincoln ,Loudon, Macon, Madison, Marion, Marshall, Maury, McMinn, McNairy, Meigs, Monroe, Montgomery, Moore, Morgan, Obion, Overton, Perry, Pickett, Polk, Putnam, Rhea, Roane, Robertson, Rutherford, Scott, Sequatchie, Sevier, Shelby, Smith, Stewart, Sullivan, Sumner, Tipton, Trousdale, Unicoi, Union, Van Buren, Warren, Washington, Wayne, Weakley, White, Williamson, and Wilson.

  Health regions: East, Mid-Cumberland, Northeast, Northwest, Shelby, South Central, Southeast, Southwest, Upper Cumberland.

- **Daily rate of increase**

  The daily rate of increase is the variation at which the number of cases changed from the previous day.

  It is calculated as:

$$Daily\ rate\ of\ increase = \\ = \frac{number\ of\ cases\ today\ - number\ of\ cases\ yesterday}{number\ of\ cases\ yesterday}$$

  Percentage daily rate of increase is calculated as the $daily\ rate\ of\ increase$ x 100.

- **Average daily rate of case increase**

  The average daily rate of case increase is calculated as the median of daily rate increases over the time period selected.

  Mathematically, it is defined as:

$$Median\ (daily\ rate\ of\ increase) = \\ = \frac{1}{2}\left(\left(daily\ rate\ of\ increase\left\lfloor\frac{each\ daily\ rate\ of\ increase + 1}{2}\right\rfloor\right)\right. \\ \left. + \left(daily\ rate\ of\ increase\left\lceil\frac{each\ daily\ rate\ of\ increase + 1}{2}\right\rceil\right)\right)$$

  Note that $\boldsymbol{daily\ rate\ of\ increase}$ is an ordered array of values containing each daily rate of increase in the sample (i.e. the components in the array are defined as $\boldsymbol{each\ daily\ rate\ of\ increase}$.)

- **Average doubling-time for cases**

  The doubling rate of cases indicate how long it will take for the number of cases to double.

  It is calculated as:

$$Average\ doubling\ time\ for\ cases = \frac{100}{average\ daily\ rate\ of\ case\ increase}$$

  If utilizing the percentage of daily rate of increase, one must divide by 100.

- **Estimated cases**

  The estimated cases are calculated by applying the average daily rate of case increase to the number of cases confirmed the day prior to the requested date.

  Mathematically, it is expressed as:

$$Estimated\ cases\ for\ day\ 2 = (estimated\ cases\ for\ day\ 1)\ x\ (average\ daily\ rate\ of\ case\ increase)$$

Notice that the cases reported by the state during weekends are often much lower than the total, with most overall weekend confirmed cases reported on Mondays.

The methods utilized for predictive capabilities in this calculator will be adjusted every one to two weeks to account for variation in parameters needed to accurately reflect the observed cases. Changes may include adjusting the period for the calculated rate of increase, include functions and necessary fittings and/or functions with dynamic parametrization, etc.

Since the calculator currently bases its predictions on observed phenomena, adjustment such as those stemming from Stay-at-Home measures are embedded into the projection.

- **Estimated hospitalizations**

  The estimated hospitalizations are estimated as 20% of the projected number of cases (based on information provided by the World Health Organization on COVID-19).[1]

  Some regions have calculator which allow for variable hospitalization percentages. If your calculator does not have this capability, your hospitalization estimate is calculated as:

$$Estimated\ hospitalizations = 20\%\ (estimated\ cases)$$

- **Estimated ICU needed**

  Estimated ICU needs are estimated as 14% of the estimated hospitalization (based on information provided by the World Health Organization on COVID-19).[1]

  Similarly to the estimated hospitalization, some regions have calculators which allow for variable percentages. If your calculator does not have this capability, your ICU needs are calculated as:

$$Estimated\ ICU\ needs = 14\%\ (estimated\ hospitalizations)$$

- **Estimated total number of beds in your area**

  The estimated total number of beds in your area is taken from available data from Definitive Healthcare.[2]

  Please, make sure you verify the number of available staffed hospital beds in your county/region from your local health department.

[1] https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200306-sitrep-46-covid-19.pdf?sfvrsn=96b04adf_2

[2] https://www.definitivehc.com/

- **Estimated total number of ICU beds in your area**

  The estimated total number of ICU beds in your area is taken from available data from Definitive Healthcare.[2]

  Please, make sure you verify the number of available ICU beds in your county/region from your local health department.

INTERFACE

Functionality steps and protocol described in this section utilize an example based on April 1 for Knox County.

The user is prompted to follow the following steps:

1. Enter county or region name (cell C5)
2. Enter today's date (cell D10)
3. Enter projection date (cell C11)
4. Enter number of confirmed cases in county/region up to yesterday (cells C22 to C113)

The calculator then provides the average daily rate of case increase, the average doubling-time for cases, the estimated number of cases, the estimated hospitalization, and compares against estimated number of beds in the county/region (as shown in the figure below).

AVERAGE DAILY RATE OF CASE INCREASE		22.1%
AVERAGE DOUBLING-TIME FOR CASES		4.5 days
TODAY'S DATE		4/1/2020
ESTIMATED CASES BY	4/2/2020	98
ESTIMATED HOSPITALIZATIONS BY	4/2/2020	20
ESTIMATED ICU NEEDED BY	4/2/2020	3
ESTIMATED TOTAL NUMBER OF BEDS IN YOUR COUNTY		1,650
ESTIMATED TOTAL NUMBER OF ICU BEDS IN YOUR COUNTY		147

In this example, today's date was April 1, and the requested projection was for April 2.

The calculator then gives the following message.

At the current rate of increase, there could be **98** cases in your county by **4/2/2020** It is likely that **20** will need hospitalization, with **3** likely having ICU needs.

Your county seems to have enough beds for patients who will need hospitalization. Please, verify the staffed hospital beds in your county are not in use. Please, verify availability of ICU resources.

The calculator predicted there would be 98 confirmed cases in Knox County by April 2, with needs for 20 staffed hospital beds, from which 3 are ICU units. Given that it was estimated that Knox County has 1,650 staffed hospital beds, and 147 ICU units, the calculator indicates that there seems to be enough hospital beds, but one must check how many beds are in use.

The calculator currently does not compare against available beds, but this feature can be added if data on availability of hospital beds are provided to the calculator developers.

Just for comparison, the calculator predicted 98 cases for April 2. Knox county observed 92 confirmed cases on April 2.

PERFORMANCE

The calculator bases predictions on available confirmed cases. The first confirmed case in Knox County was on March 12. Therefore, between April 1 and April 7 the calculator for Knox County has had only approximately 3 weeks of available data, with the first 10 days reporting only between 1 and 4 cases. A larger sample of cases in Knoxville will help the calculator's accuracy. Notice that the largest differences between predicted and confirmed cases occur during weekends. It seems that cases are underreported on weekends (Fri-Sun) with higher increases on Mondays.

Outside of weekends, the calculator predicted estimated number of cases within 13% of the number of confirmed cases. For example, the table below shows predicted number of confirmed cases for the following day between April 1 and April 7.

Predicted on	Predicted for	Cases		Cases Difference	
		Predicted	Confirmed	Number	Percentage
Wed, 1-Apr	Thu, 2-Apr	98	92	6	7%
Thu, 2-Apr	Fri, 3-Apr	111	98	13	13%
Fri, 3-Apr	Sat, 4-Apr	130	99	31	31%
Sat, 4-Apr	Sun, 5-Apr	137	115	22	19%
Sun, 5-Apr	Mon, 6-Apr	138	119	19	16%
Mon, 6-Apr	Tue, 7-Apr	160	143	17	12%
Tue, 7-Apr	Wed, 8-Apr	166	148	18	12%

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