Photo provided courtesy of CDC: Alissa Eckert, MS; Dan Higgins, MAMS

COVID19SURGE

Software to Estimate the Impact of COVID-19 Pandemic on Hospital Surge Capacity

COVID19Surge.v1 Beta Test Version

This manual accompanies the software tool COVID19Surge, which is an adaptation of the previously published FluSurge 2.0 and FluSurge Special Edition (at: https://www.cdc.gov/flu/pandemic-resources/tools/flusurge.htm and https://www.cdc.gov/h1n1flu/tools/flusurge/)

Acknowledgements

Disclaimers

The numbers generated through COVID19Surge are not to be considered predictions of what *will* actually occur during a coronavirus pandemic. Rather, they are illustrations designed to aid the planning and preparation of a response to a surge in demand for hospital-based resources due to the COVID-19 pandemic.

The findings and conclusions in this manual and the accompanying software (COVID19Surge) are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention (CDC)

System Requirements

COVID19Surge uses the Windows* operating system (Microsoft Windows 2010 or higher) and Excel (Microsoft Office 2013 or higher). Full functionality of CoVID19Surge only is supported in the desktop version of Microsoft Office for Windows PCs. Some functionality may not be available in Microsoft Office for Macs or in the browser version of Office 365.

NOTE: Upon opening COVID19Surge, users *must* click the button at the top of the document to enable macros.

Technical note: Readers are advised not to change the cell reference style from the standard, default A1 style to the R1C1 style as this will cause conflicts with the programming.

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Introduction

The current COVID-19 pandemic is resulting in an increased number of hospitalizations across the United States. It is anticipated that demand for hospital services may exceed the capacity to provide those services. To aid in planning the allocation of scarce resources, COVID19Surge helps hospital administrators estimate the impact of the COVID-19 pandemic on your hospital. The tool has been designed to estimate the surge in demand for hospital services based on the extent to which community mitigation strategies such as increased social distancing, shelter-in-place recommendations and community lockdowns are implemented.

Based on the community population and number of cases to date, the type of social distancing measures being taken in the community and duration of such efforts; and estimates of hospital resources (non-ICU [Intensive Care Unit] hospital beds, ICU beds, and mechanical ventilators) provided by the user for a specific hospital or group of hospitals, COVID19Surge estimates the number of hospitalizations, ICU admissions and patients requiring mechanical ventilation due to the COVID-19 pandemic. This tool compares the potential numbers of persons hospitalized, persons requiring ICU care, persons requiring ventilator support during a pandemic with existing hospital capacity.

Background

As of April 14, 2020, approximately 580,000 COVID-19 cases have been reported in the United with more than 22,000 deaths. (Source: https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html). It has been estimated that an additional 35,000 to 62,000 ventilators (almost double the current supply in use), with trained staff to use them, may be needed to adequately address the COVID-19 pandemic. (Koonin, 2020)

To manage the anticipated large surge in demand for hospital-based services, and to efficiently allocate scarce hospital resources, the COVID19Surge tool can help hospital administrators better estimate the likely increases in the number of hospital admissions, persons requiring ICU care, and the number of persons requiring ventilator support, with several different social distancing scenarios with varying degrees of intensity/stringency.

Brief Introduction to the tool: COVID19Surge

COVID19Surge generates estimates of cases over time (the epidemiological curve) using a simple mathematical model (details provided in the Appendix) in which people who are susceptible to disease are infected by an already infectious person. After a period of time in which the newly infected person (case) is not infectious, he or she begins to shed virus in sufficient amounts that they are now infectious to other persons.

With COVID-19, a case can shed virus and infect others before showing any overt symptoms (pre-symptomatic), as well as after symptoms appear. It is also possible that an infected individual can shed virus to the extent of being a risk of infecting others, but show no overt symptoms (asymptomatic) The entire period, pre-symptomatic and

symptomatic, and those that remain asymptomatic, during which the case can infect other people is termed the "contagious period," also known as the infectious period.

After the infectious period, cases enter a convalescent period, in which they may have symptoms, but are no longer shedding the virus. For cases who are hospitalized, we assume that they are no longer infectious due to isolation and infection control measures and the convalescent period is the length of hospitalization. In reality, some hospital personnel are, unfortunately, infected from exposure to COVID-19 patients. For simplicity, we have assumed that the numbers of health care personnel so infected represent a very small percentage of total cases. For non-hospitalized patients, we assume a convalescent period of 5 days (Imperial College). Cases eventually either recover and stop shedding virus and infecting others, or in the worst-case scenario, die. COVID19Surge assumes that once infected and recovered, a person is no longer susceptible to re-infection (at least for the duration of the time considered in the model). The average number of persons infected by an infectious person during the infectious period is between 2.0 and 2.6. See Table 1 (Appendix) for the list of input variables, the values used, and the sources for such values. A full table of model assumptions can be found in Table 1.

COVID19Surge produces a base case illustration of the surge in hospital admissions assuming no effective intervention to stop or slow transmission has been enacted. A user can then select up to 3 community intervention strategies to determine the potential reduction in cases and duration of the epidemic. With these user-defined illustrative scenarios (base case, no intervention + 3 intervention scenarios), the user then enters estimates of hospital resources (e.g., unoccupied beds, unoccupied ICU beds and mechanical ventilators available for COVID-19 patients). The user also enters their estimates of the average per-patient duration of hospitalization, ICU occupancy and time on a mechanical ventilator.

It is important to note that, while these illustrated strategies may reduce peak demand for hospital resources at any given time, it does not necessarily mean there will be fewer COVID-19 cases overall.

Overview of how to use the COVID19Surge Tool

To use the tool, the user will need to provide an estimate of the population of the hospital catchment area or local jurisdiction and the number of cases to date, and the available hospital resources (non-ICU beds, ICU beds, and mechanical ventilators). These data requirements are described below under the heading "Data Input."

Results will be shown for the number of non-ICU beds, ICU beds and ventilators (for two different rates of disease transmission) if no social distancing efforts are in place (the base case) and for three community intervention strategies that may be in place in the local area, labeled as follows:

    1) Intervention 1 (low intensity);
    2) Intervention 2 (medium intensity), and;
    3) Intervention 3 (high intensity).

NOTES:

1) **To obtain more complete descriptions of various community-level interventions, users should consult CDC's Community Mitigation Framework webpage (at:** https://www.cdc.gov/coronavirus/2019-ncov/downloads/community-mitigation-strategy.pdf **).**
2) **A user can change at will, in COVID19Surge, the labels of the community-level interventions.**

Example definitions of community interventions

Intervention 1: A low intensity social distancing strategy that could include for example, voluntary "shelter-in-place" for high-risk groups, bans on gatherings with more than 50 people, public advocacy around "social distancing" and enhanced hygiene, possible school closures, travel advisories, and passive monitoring of those with symptoms. These are often in place in areas with limited ongoing community transmission.

Intervention 2: A medium intensity social distancing strategy that could include community-wide "shelter-in-place" recommendations, shutdown of non-essential businesses, school closures, bans on gatherings with more than 10 people, passive monitoring of those with symptoms, public advocacy around social distancing and enhanced hygiene. Possibly closed borders or restricted travel.

Intervention 3: A high intensity social distancing strategy in which everyone is considered at imminent risk of being infected or is already infected. This strategy could include for example, forced community-wide home quarantine, full shutdown of all businesses, closed borders, active monitoring.

Source: Intervention descriptions and associated rates of onward transmission adapted from: Imperial College.

Output
Based on these inputs, COVID19Surge estimates numbers of persons hospitalized, bed capacity needed, ICU capacity needed, and ventilator usage over the course of the pandemic.

Load, start, and navigation instructions

Open the COVID19Surge spreadsheet and click the box at the top of the document that says, "Enable Macros," or "Enable Content" (depending on version of Excel being used). After enabling macros, click the "Start" button on the cover page to start navigating the tool. If you encounter any issues, contact HEMU@cdc.gov with a subject line [COVID19Surge tool inquiry].

General navigation instructions: Users will click buttons to navigate through the tool. To return to the cover page from anywhere within the tool, click the "Close" button located in worksheets' lower right corner.

Yellow buttons throughout the tool contain definitions or explanations.

Data input

COVID19Surge contains four work sheets: Part A. Hospital Resources; Part B. Hospital Stays; Part C. COVID-19 Outbreak Details; and Part D. Epidemiological Parameters (Optional/Advanced) in which users may enter data. Data entry cells are white and clearly identified on worksheets with a purple callout box.

NOTES:

1. All user-entered data are saved by using the "Save & Exit" button when exiting COVID19Surge tool. To change any value, simply type over them.

2. All default values and sources used in the tool can be found by clicking

    Access Technical Worksheets (ADVANCED)

    on the Results (Main) pages and then clicking the link to "Default Values".

3. Worksheets that contain default values have buttons to "Reset inputs to default values."

Part A. Hospital Resources

On the "Hospital Resources" page, the user will find information related to population, supply of unoccupied non-ICU beds, unoccupied ICU beds, and ventilators.

In the COVID19Surge tool, non-ICU hospital beds are defined as general medical and surgical beds that are staffed and immediately available for routine care of admitted COVID-19 patients. This may be different from the total number of licensed beds and do not include beds that are only used for a portion of a patient stay, such as outpatient or emergency room beds. ICU beds are staffed beds in the intensive care unit that are available for COVID-19 patients.

Step 1. Enter the population of your hospital catchment area or local jurisdiction:

Enter the population of the hospital catchment area or local jurisdiction in the appropriate cell. This is the population of the area you want COVID19Surge to use to estimate results. A suggested value is the population of the hospital's catchment area; however, users may choose to use the local population or any other relevant population. The default population size for illustration purposes is 1,000,000 persons.

NOTE: State and metropolitan statistical area population estimates can be obtained from the U.S. Census Bureau (www.census.gov) or from state and local vital statistics offices. If the area of interest is outside the United States, contact the regional or national census office for population estimates.

Step 2. Enter basic hospital resources:

In the section labeled "Hospital Resources," the user will enter the hospital(s)' total number of licensed and staffed non-ICU beds that are UNOCCUPIED. If COVID19SURGE is being used to make estimates for the local or state jurisdiction, enter these numbers for the relevant area.

Similarly, the user will enter the hospital(s) or jurisdiction's total number of licensed and staffed ICU-beds that are UNOCCUPIED.

In the appropriate cell, the user will enter the hospital(s) or jurisdiction's total number of available ventilators. The default values provided in COVID19SURGE are the number of staffed non-ICU beds, ICU beds and mechanical ventilators for community hospitals in the United Sates and are taken from the American Hospital Association.

NOTE: The values that you or previous users entered will automatically appear. To change these previously entered values, simply type over them. All data entered in the spreadsheet are saved automatically when exiting the tool.

Click on the "Part B. Hospital Stays" button on the worksheet's right side to move to the next section.

Part B. Hospital Stays for COVID-19 Patients

The "Hospital Stays" page contains information about COVID-19 cases in terms of the proportion, on average, that 1) are admitted to hospital (non-ICU), 2) require ICU care, and 3) need a ventilator in the ICU. COVID19Surge assumes patients fall into one category (e.g., non-ICU vs. ICU) and do not transition from one category to another. Cells on this page are prepopulated with default values taken from Imperial College (see table immediately below). Users may choose to modify the default values by entering new data in the cell.

Default values for hospital stays

Hospital stay type	Average length of stay
Non-ICU	8 days
ICU, no ventilator	10 days
ICU, requiring ventilator	16 days

Source: CDC COVID-19 preliminary data

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If the user chooses to change the default values:
In the section about non-ICU patients, enter the average proportion of COVID-19 cases that will be admitted and the average length of stay (in days) of those patients.

In the section about ICU patients, enter the average proportion of admitted COVID-19 cases who will require ICU care, along with the average duration (in days) in the ICU for patients that DO NOT NEED a ventilator.

In the section about ventilator use, input the average proportion of COVID-19 cases in ICU that will need ventilators, the average duration (in days) in the ICU for patients who require a ventilator, and the average number of "downtime" days per ventilator.

Step 1:	Enter information about non-ICU COVID-19 patients	
	Average % of COVID-19 cases who will be admitted for hospital care	5.50%
	Average length of non-ICU hospital stay	8 days

Step 2:	Enter information about ICU COVID-19 patients	
	Average % of admitted COVID-19 cases who will require ICU care	20.00%
	Average duration in ICU (if no ventilator)	10 days

Step 3:	Enter information about ventilator use	
	Average % of COVID-19 cases in ICU that will need ventilators	70.00%
	Average duration in ICU (if ventilator required)	16 days
	Average downtime per ventilator (i.e., decontamination / relocation)	1 days
	Average days in use per ventilator	17 days

Source for Default Values: COVID-19 Preliminary Estimates (CDC)

Click on the "Part C: Outbreak Details" button on the worksheet's right side to move to the next section.

The user has the option to calculate age-weighted population values. Clicking the button to do so, will take the user to Part E. Age-Weightings. For more information about this (optional/advanced) page in the tool, go to page 14 of the manual.

OPTIONAL (ADVANCED): Calculate Age-Weighted Values

If you are using data specific to your population of interest, no further age adjustment will be necessary. If you wish to age-adjust the default values to your population structure, click "Calculate Age-weighted Values". You will need to know the age-specific proportions of the population and age-specific risks for the parameters of interest.

Calculate Age-Weighted Values

Part C. Community Outbreak Details

The "Community Outbreak Details" page contains information about COVID-19 case counts (specific to the user-determined date to start analysis and relevant population) and the effectiveness of interventions to mitigate the spread of the virus. Users may choose to modify default values by entering new data in the cell. When unsure about these data, local public health can provide information.

If the user chooses to change the default values:
In Step 1, the section on case counts, the user enters the date, either today's or a date the user chooses to mark the start of the analysis.

In Step 2, enter the number of COVID-19 cases in the hospital catchment area or jurisdiction in the **14 days before the analysis start date**. Then, enter the TOTAL number of cases within the hospital catchment area or jurisdiction up to the date the analysis starts.

Step 1:	Enter today's date (or date for start of analysis, if different)	
	Date analysis starts	4/6/2020

Step 2:	Enter information about case counts in your jurisdiction*	
	Cases in the 14 days before analysis starts	120
	Total Cases to date analysis starts	250

Users may wish to consult with local or state public health officials to get these numbers

The next section about the effectiveness of community interventions contains a table with information to compare no intervention with effectiveness of three intervention scenarios: "Intervention 1 (low intensity)," "Intervention 2 (medium intensity)," and "Intervention 3 (high intensity)."

In Step 3, the user may enter values in table cells to change the date intervention began/begins and the duration of intervention (in days). NOTE: The earliest date that interventions start MUST match Step 1: Date analysis start.

Users are encouraged to use the tool to explore the potential impact of different durations of intervention and to discuss with policy makers the possible implications of different intervention duration scenarios.

The default values of percent reduction in new infections per case (i.e., intervention effectiveness) were adapted from htt://www.covidactnow.org and based on estimates from Imperial College. We assumed that a successful social distancing would result in 29% reduction in new infections per each infectious case, more stringent shelter-in-place measures would reduce new infection by 50%, and a community lockdown would reduce the number of new infections per case by 88%. The user can enter a user-defined value if the intervention is assumed to be more or less effective than the assumed default value.

After populating the cells, click on the button below the heading "View your results."

Step 3: **Enter estimates about the effectiveness of community-level interventions**

	No Intervention	Intervention 1: Low Intensity	Intervention 2: Medium Intensity	Intervention 3: High Intensity
Date Intervention Began/Begins*	4/13/2020	4/13/2020	4/13/2020	4/13/2020
Duration of Intervention (days)†	365	365	365	365
Effectiveness of interventions: % decrease in # of new infections per case	0.00%	29.20%	50.00%	87.50%

Source: Calculated based from: Imperial College paper

*Earliest date that interventions start MUST match Step 1: Date analysis starts

†Intervention duration should be discussed between user and policy makers. Users are encouraged to explore the potential impact of differe

Step 4: **View your results**

Click to View Results

OPTIONAL (ADVANCED): Epidemiologic Parameters

By clicking on the "Optional (Advanced): Epidemiologic Parameters" button, users will navigate to a page to enter alternate epidemiologic parameters.

OPTIONAL (ADVANCED): Epidemiologic Parameters

We recommend using the default epi parameters, However, if you are comfortable with changing the parameters and understand the impact on assumptions, please click this button:

Change epi parameters

Part D. Epidemiological Parameters (Optional/Advanced)

The Epidemiological parameters page contains information about disease stages and spread/transmission. The page is prepopulated with default values (see Table 1 in the Appendix). Default values were selected based on peer-reviewed studies (where available), expert opinion, and pre-print manuscripts. Users who are interested in entering alternative data inputs may do so. Similar to previous pages in the tool, data in white cells can be modified. Users can review how their parameter inputs altered the number of the daily number of infections from the graph provided on the right of Part D in the spreadsheet tool.

Initial cases; Click the "Initial Case" button to see how the model distributes the user-defined initial number of cases during the past 14 days (these initial cases are entered by the user in Part C: COVID-19 Outbreak Details). Users can choose either the exponential distribution (assuming an exponential growth of the daily number of cases) or the uniform distribution (assuming the same number of daily cases were observed during the past 14 days). It is recommended to use the default value of "exponential distribution," but users may choose to select "uniform distribution." Note that this selection of how initial cases are distributed only applies to those initial, user-entered cases. After selecting how you want initial cases distributed over the past 14 days, click "OK" to move back to the Epidemiological Parameters page.

Once data input is complete, click "Return to Outbreak Details."

- Infected (Not Contagious) Period: This is the time period in which a case is infected but is not yet infectious. The default value for the "infected, (not contagious)" is set to 3 days (Ma et al.). The user may alter this value as needed. For example, Ma et al. (Ma et al.) estimate an upper limit of 4 days.

- Contagious Period: This is the period of time during which an infected person sheds virus and is capable of infecting others. The default value is set to 5 days (Peak et al.) and includes both pre-symptomatic and symptomatic transmission.

- Convalescent Period: This period applies to non-hospitalized cases only. It refers to the later stage of illness when the patient is in the process of recovery and no longer transmitting the disease. The default value is 5 days (Imperial College). For hospitalized patients, the convalescent period is equal to the duration of the hospital stay.

- Total duration of infection/illness: For non-hospitalized cases, this is assumed to be equivalent to the sum of infected (not contagious), contagious, and convalescent period. Total duration of infection/illness may differ for hospitalized cases depending on their average length of stay.

- Time from infectiousness to hospitalization: This is the time period between an infected person shedding virus and hospitalization. The default value is set to 6 days (Ma et al.). This input cannot be changed by, and is not visible to, the user.

- New infections per case: This is the average (expected) number of new cases produced by a single infectious person in a completely susceptible population (formally referred to as the "basic reproduction number"). Previous research has found this number to be in a range of 2.0-3.0 (UK COVID Task Force) for COVID-19 (i.e., a single infected person can infect two to three additional cases). Users can choose a lower and upper estimate of new infections per case. The default values for lower and higher rates of transmission are 2.0 and 2.6, respectively (Imperial College).

Step 1: **Enter information about disease stages**

Infected (Not Contagious) Period	3	days
Contagious Period	5	days
Convalescent Period (non-hospitalized)*	5	days
Total Duration of Infection/Illness	13	days

Step 2: **Enter information about how quickly the disease spreads**

New Infections per Case (low estimate)	2.00	persons
New Infections per Case (high estimate)	2.60	persons

NOTE: The epidemiological parameters the user enters in steps 1 – 2 will affect the high and low estimates of new infections per case due to intervention.

Utilized Reductions in New Infections per Case due to Intervention

	No Intervention	Intervention 1: Low Intensity	Intervention 2: Medium Intensity	Intervention 3: High Intensity
Low Estimate	2.00	1.42	1.00	0.25
High Estimate	2.60	1.84	1.30	0.33

Part E. Age-Weightings (Optional/Advanced)

This page is to be used to adjust the US national default values by age for a specific population.

Step 1: Enter demographic information for your jurisdiction

% of Population aged 0-4 years	5.94%
% of Population aged 5-17 years	18.85%
% of Population aged 18-49 years	39.61%
% of Population aged 50-64 years	18.97%
% of Population aged 65+ years	16.63%
Total:	100.00% *(must equal 100%)*

Step 2: Enter age-specific risk for parameter of interest for each age group

Probability (0-4 years)	
Probability (5-17 years)	
Probability (18-49 years)	
Probability (50-64 years)	
Probability (65+ years)	

Step 3: Your age-weighted parameter value is   0.0000

Demographic information:
The default values for the age breakdown of the U.S population were taken from: https://www.populationpyramid.net/united-states-of-america/2020/ and represent the proportion of the population in each age group for the United States as a whole. Users may choose to replace these proportions with data that are more relevant to their specific population of interest. Population age breakdowns at the state level can be found at: The Kaiser Family Foundation. State and local data may also be available from state vital statistics agencies. Users may also wish to consider altering, as data relevant for their jurisdiction become available, the age-weighting to reflect risk of hospitalization, ICU admittance and need for mechanical ventilation adjusted for factors such as race/ethnicity and underlying serious medical conditions.

Age-adjusting parameters of interest:

The default values on the page "Part B. Hospital Stays" have been age-weighted for the US population for the proportions of patients admitted to the ICU and ICU patients using ventilators. The default values for duration of stay are the average duration of hospital stay for each patient category and is taken from Imperial College. To use a different age population breakdown, please enter the relevant information into the boxes "under "Demographic Information".

Users can also enter age-specific information for parameters such as the hospitalization rate by age, or the duration of hospital stay. For example, if the user has data that indicate that the duration of an ICU stay is:

Ages 0-17: 5 days
Ages 18-64: 10 days
Ages 65+: 21 days

that information can be entered in the appropriate boxes to get an age-weighted duration of ICU stay in this way:

Ages 0-4: 5 days
Ages 5-17: 5 days
Ages 18-49: 10 days
Ages 50-64: 10 days
Ages 65+: 21 days

This produces an age-weighted duration of ICU stay of 10.58 days This information can then be entered in the "Duration of ICU Stay - no ventilators" box on the "Part B. Hospital Stays" page. Numbers entered into this page will be rounded to the closest whole day.

The process will need to be repeated for each parameter that users wish to adjust for age.

Results

Main Summary

The Main Summary & Navigation page contains three side-by-side graphs that illustrate differences in bed occupancy and ventilator use for no intervention and three social distancing scenarios. By using the "Transmission" dropdown box at the top of the page, the user can set a lower (R0 = 2.0) or higher (R0 = 2.6) rate of transmission to see how the estimates of bed occupancy and ventilator use change. The red-dotted line of the graphs represents the user set capacity for non-ICU beds, ICU beds, and ventilators, respectively from "Part A: Hospital Resources."

From this page, by clicking the button above the graphs, the user may go to the next level of results (demand summaries) for each outcome of interest: non-ICU

Demand Summaries

Demand summary pages present four graphs, one for each of the intervention scenarios showing estimated demand for hospital resources (beds, ICU beds, ventilators), based on higher and lower estimates of disease transmission. These estimates of demand are then compared to hospital capacity as entered by the user in "Part A. Hospital Resources."

The Demand Summaries results pages also contain tabular information based on higher and lower estimates of transmission for:

- Total Admissions
- Peak Daily Occupancy
- Days over Capacity
- % patients given a bed

For more detailed results about each intervention scenario, the user may click the buttons for "More Details."

Detailed Results

The Detailed Results pages contain a graph illustrating ICU demand based on higher and lower estimates of transmission compared to hospital capacity as determined by the user in "Part A. Hospital Resources."

The Detailed Results pages also contain tabular information based on higher and lower estimates of transmission for:

- Total ICU Admissions
- Peak ICU Admissions
- ICU Occupancy

Printing

In order to print your results on a single page, you must change the printing page setup to Landscape format. To do so,
1). Click File and then choose Page Setup.
2). In the Orientation section, change Portrait to Landscape.
3). Click OK.

CONTACT

For additional help or feedback, please email your comments or questions to or Martin I Meltzer M.S., Ph.D. (MMeltzer@cdc.gov) or contact the Health Economics and Modeling Unit at hemu@cdc.gov.

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Appendix

Table 1. Assumptions used in COVID19Surge

Metric	Default Value (Range)	Source
Infected but not yet infectious period (days)	2.5 (Upper: 3.95)	Ma et al.
Contagious period	4.8	Peak et al.
Convalescent Period	5	Imperial College
Time from infectious to hospitalization (days)	6	Ma et al.
New infections per case (R_0)	2.4 (2.0 – 2.6)	Imperial College
	2.2 (1.4 – 3.9)	Li et al.
Percent reduction due to Intervention 1 (low intensity)	29.2%	Covid Act Now; Imperial College
Percent reduction due to Intervention 2 (medium intensity)	50.0%	Covid Act Now; Imperial College
Percent reduction due to Intervention 3 (high intensity)	87.5%	Covid Act Now; Imperial College
Proportion of all COVID-19 cases that are hospitalized	5.5%	Preliminary COVID-19 estimates
Proportion of all COVID-19 cases that die (case fatality rate)	1.4% (0.9 – 2.1)	Wu et al.
Age-adjusted proportion of hospitalized COVID-19 cases that are admitted to the ICU	20%	Preliminary COVID-19 estimates
Age-adjusted proportion of COVID-19 ICU cases on mechanical ventilator	65%	Preliminary COVID-19 estimates
Average length of hospital stay (days) for COVID-19-related illness, no ICU	8	Imperial College
Average length of hospital stay (days) for COVID-19-related illness, ICU, no ventilator	10	Imperial College
Average length of hospital stay (days) for COVID-19-related illness, ICU, ventilator	16	Imperial College

Model overview:

COVID19Surge is a spreadsheet-based model that allows a user to estimate the number of COVID-19 cases within a given geographical area that will need hospitalization, both within and outside of the intensive care unit (ICU), and those that will need mechanical ventilation. The model allows the user to estimate the impact of commonly used social distancing measures on the peak number of cases needing hospitalization and on when that peak demand will occur.

Type of model:

COVID19Surge is a compartmental model (SIICR) that tracks people through five disease states:

- Susceptible (not yet infected with COVID-19);
- Infected but not yet capable of infecting others;
- Infectious and able to transmit the disease to others
- Convalescing – no longer infectious, but still using hospital resources, and
- Recovered or dead.

We assume that all people who have not been infected are susceptible and that those who recover are immune and thus removed from the susceptible population.

Progression only: A patient can only progress forward through the model, and can never regress (e.g., can never go from incubating back to susceptible). Nor can a patient skip a state (e.g., go from incubating to recovered, skipping infectious).

Community size: The community size is entered into the model by the user. We suggest using the hospital's catchment area, however users may choose to use the local population or any other relevant population. The default population size is 1,000,000 persons.

Infected (Not Contagious) Period: This is the time period in which a case is infected but is not yet infectious. The default value for the "infected, but non-infectious period" is set to 3 days (Ma et al.). The user may alter this value as needed. For example, Ma et al. (Ma et al.) estimate an upper limit of 3.9 days.

Contagious Period: This is the period of time during which an infected person sheds virus and is capable of infecting others. The default value is set to 5 days (Peak et al.) and includes both pre-symptomatic and symptomatic transmission.

Convalescent Period: This period applies to non-hospitalized cases only. It refers to the later stage of illness when the patient is in the process of recovery and no longer transmitting the disease. The default value is 5 days (Imperial College). For hospitalized patients, the convalescent period is equal to the duration of the hospital stay.

Total duration of infection/illness: For non-hospitalized cases, this is assumed to be equivalent to the sum of the infected (not contagious), contagious, and convalescent

periods. Total duration of infection/illness may differ for hospitalized cases depending on their average length of stay.

Time from infectiousness to hospitalization: This is the period of time in which an infected person sheds virus (i.e., is infectious) prior to hospitalization. The default value is set to 6 days (Ma et al.) and cannot be changed by the user.

New infections per case: This is the average (expected) number of new cases produced by a single infectious person in a completely susceptible population (formally referred to as the "basic reproduction number"). Previous research has found this number to range between 2.0-3.0 (i.e., a single infected person can infect two to three additional cases) (UK COVID Task Force) and between1.4 – 3.9 (Li et al.) for COVID-19. Users can choose a lower and upper estimate of new infections per case. The default values for lower and higher rates of transmission are set to 2.0 and 2.6, respectively (Imperial College).

Risk of onward transmission: The risk of onward transmission in COVID19Surge depends on the intervention strategy selected. Without intervention, the risk of onward transmission is set such that each infectious person transmits the virus to 2.4 additional people (i.e., R_0 = 2.4). Each possible intervention strategy reduces the onward transmission by a given percentage as follows:

   Social distancing: 29% reduction in cases

   Shelter-in-place: 50% reduction in cases

   Community lockdown: 88% reduction in cases

The percent decrease in the number of new infections per case are prepopulated with default values adapted from http://www.covidactnow.org and based on estimates from Imperial College.