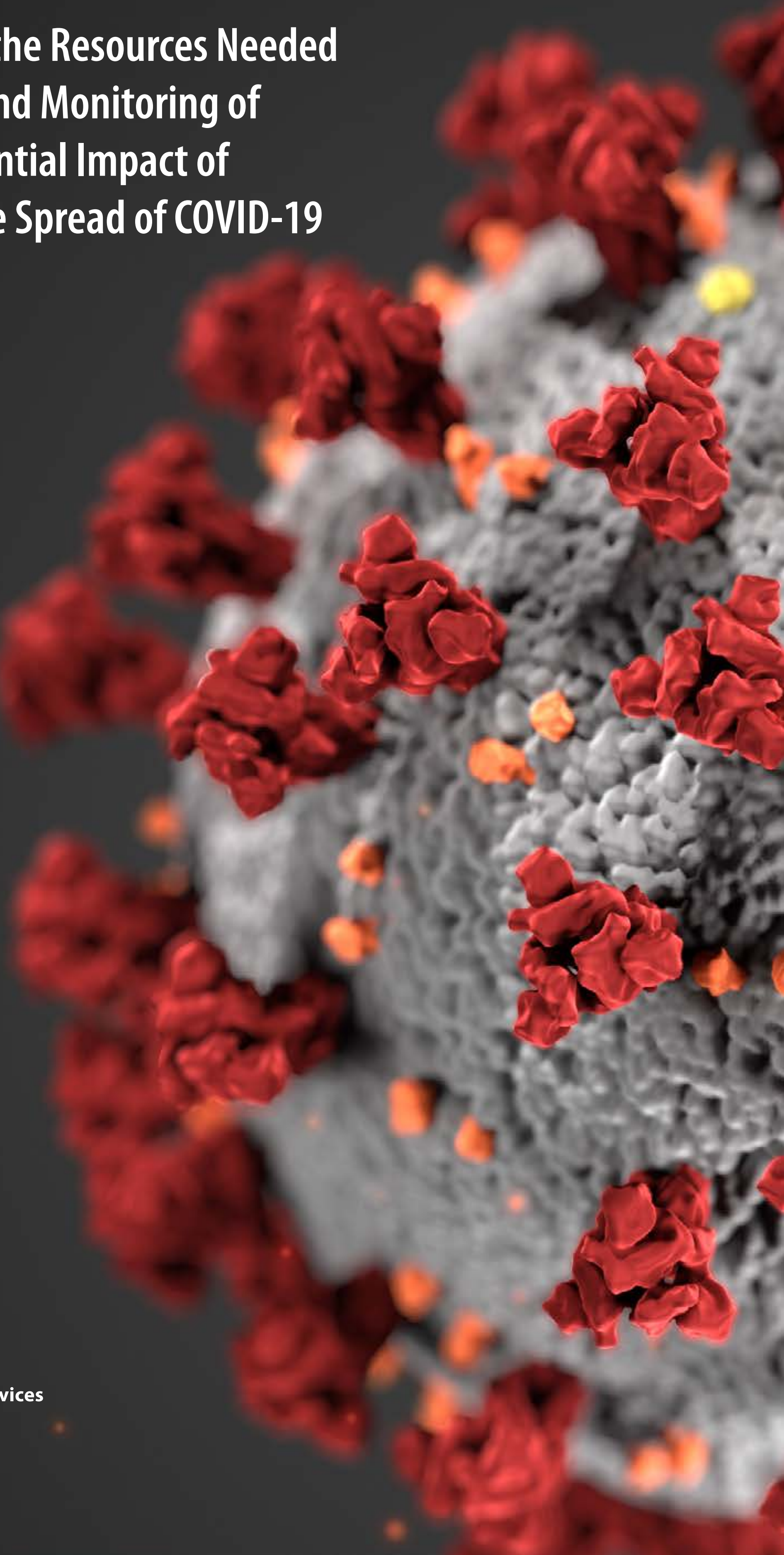
COVIDTracer

A Planning Tool to Illustrate the Resources Needed to Conduct Contact Tracing and Monitoring of COVID-19 Cases and the Potential Impact of Contact Tracing Efforts on the Spread of COVID-19



COVIDTracer v1 Beta Test Version

This manual accompanies the software tool COVIDTracer, beta version 1.0, released by CDC and available at https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/COVIDTracer.html.

For questions or technical assistance, please contact MMeltzer@cdc.gov or hemu@cdc.gov.

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

AUTHORS of COVIDTracer (alphabetical order):

Bishwa B. Adhikari, Leah S. Fischer, Bradford Greening, Seonghye Jeon, Emily B. Kahn, Gloria J. Kang, Martin I. Meltzer, Gabriel Rainisch, and Michael L. Washington. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA.

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Disclaimers and Limitations

The numbers generated through COVIDTracer are not to be considered predictions of what will actually occur during a coronavirus pandemic. Rather, they are illustrations designed to aid public health officials in planning and preparing for contact tracing of COVID-19 cases. All estimates may either over- or under-represent the true number of contact tracers needed, depending on user inputs and variables not accounted for in the model.

Limitation: Testing: COVIDTracer does not include considerations of COVID-19 testing strategies, i.e. impacts of testing strategies over time are not considered. Nor does COVIDTracer consider the personnel needed to conduct such testing. If a user has a question about testing and contact tracing, please contact the COVIDTracer team at HEMU@cdc.gov.

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

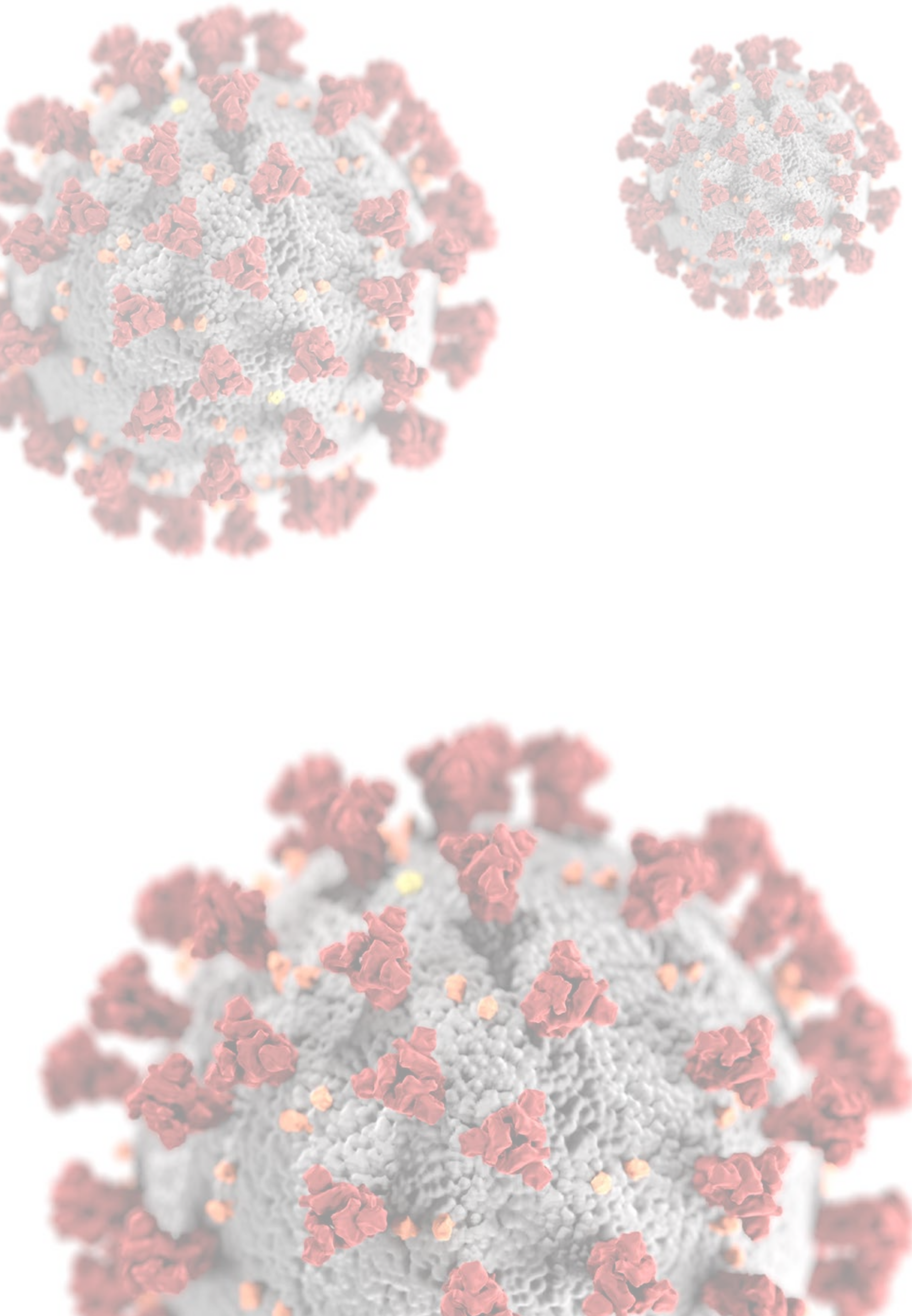
System Requirements

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

NOTE: Upon opening COVIDTracer, 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.

Contents



Background

As of June 2, 2020, more than 1.8 million cases of COVID-19 and more than 107,000 COVID-19 related deaths had been reported in the United States. Beginning in March 2020, states and local communities instituted social distancing measures to slow transmission of coronavirus infections, save lives, and reduce the burden on healthcare resources. These measures vary across localities and include stay at home orders, school and business closures, and cancellation of large events and mass gatherings. While effective, these measures have great economic and societal costs.

Contact tracing of infected patients aims to contain and control the spread of infectious disease epidemics by quickly identifying cases, identifying cases' contacts, isolating cases, and quarantining and monitoring case contacts for infections and symptom development.

Brief Introduction to the Tool: COVIDTracer

COVIDTracer allows users to explore, relative to interventions such as social distancing interventions, several contact tracing strategies using data inputs that reflect their particular jurisdiction to assess the personnel and time that will be needed to conduct contact tracing effectively. COVIDTracer also provides numerical results and graphs of the potential impact of contact tracing efforts on COVID-19's spread in comparison with social distancing interventions. This comparison aims to aid public health officials and policy makers to decide which strategy is likely to provide the most control with the available resources.

The tool compares social distancing strategies like those implemented in many localities in the first phase of COVID-19 response and three different illustrative contact tracing/monitoring strategies. It allows users to change the default values for:

- each of the 3 possible contact tracing strategies
- the potential effectiveness of each strategy
- the average number of contacts per case
- the time needed to undertake activities (e.g., interview cases to obtain list of potential contacts)

It is important to note that, while these illustrative contact tracing strategies may reduce disease transmission, using these strategies does not necessarily mean there will be fewer COVID-19 cases overall.

Geographic Locale

COVIDTracer can be used for almost any locale and public health jurisdiction, including rural communities.

Overview: How to Use COVIDTracer

NOTE: Throughout this document, we provide an illustrative scenario and accompanying discussion of how a public health planner might use this tool to think about the issues involved in weighing the balance between social distancing and contact tracing. These illustrations will appear in the shaded text boxes.

To use the tool, the user will need to provide for a particular location (e.g., state, city, county) estimates of the number of cases to date, number of cases in the last 14 days, impact of contact tracing, and contact tracing resources needed (e.g., personnel and time). These data requirements are described below under the heading "Data Input."

The Three Contact Tracing Strategies

The tool generates estimates of the number of personnel needed and the impact on case counts of COVID-19 if social distancing efforts are in place, or if they are lifted, or partially lifted, and replaced by one of three potential contact tracing strategies, labeled as follows:

Strategy 1, No Contact Tracing:

Case identification and isolation only

Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated.

Strategy 2, Contact Tracing:

Strategy 1 + contact tracing with self-monitoring and self-isolation if symptomatic

Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated. Contacts of cases are identified, asked to self-monitor for symptoms, and to self-report and isolate if they become symptomatic.

Strategy 3, Contact Tracing, Quarantine, and Monitoring:

Strategy 1 + contact tracing + quarantine and monitoring of contacts

Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated. Contacts of cases are identified, quarantined, and monitored through daily phone calls for 14 days, as selected by the jurisdiction. If contacts become symptomatic, they are re-designated as cases.

NOTE: Detailed descriptions of the three strategies can be found in the section titled "Contact Tracing Strategies."

Further, users can alter and adapt these strategies, as described in the section titled: "Part B. Impact of Contact Tracing Strategies."

COVIDTracer Output

Based on the number of contacts per case and the expected number of hours that contact tracers are expected to work per day, COVIDTracer estimates the total number of contacts identified, the number public health workers needed, and total staff hours required. It also produces illustrations of the impact on the total number of COVID-19 cases for each of the contact tracing strategies over the course of the pandemic.

Load, start, and navigation instructions

- Note that some functionality will not be available in Microsoft Office for Macs or in the browser version of Office 365. Open the COVIDTracer 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 [COVIDTracer tool inquiry].

Click buttons to navigate through the tool should be a header with two bullets below it.

- To return to the cover page from anywhere within the tool, click the "Close" button located in worksheets' upper right corner.
- Yellow buttons throughout the tool contain definitions or explanations.

Contact Tracing Strategies

Provided below are descriptions of the social distancing strategies and three potential contact tracing strategies with respective default values that are used in COVIDTracer.

NOTE: All the default values described here and entered into the model can be changed by the user.

Social distancing strategies

Description: Current social distancing interventions to "flatten the curve" (e.g., shelter-in-place orders, school closures, etc.) remain in place and unchanged.

Model used: We used a basic Susceptible, Exposed/Infected, Infectious, Recovered (SEIR) mathematical model to provide an estimate of COVID-19 cases over time, with and without social distancing interventions (see description, of model in "Model Overview").

Case identification and contact training strategies

For the default scenarios, in the Main Results, community lockdown restrictions are lifted and replaced with one of the strategies listed below. For each strategy, users can allow for a partial continuation of social distancing in conjunction with contact tracing strategies.

The following strategies are based on ideal timelines where there is little to no lag between each step in the testing and contact tracing cascade. The situation in each jurisdiction may differ from these timelines for various reasons (e.g., turn-around time for test results, time required to reach all contacts). Users are encouraged to edit the default values described below to reflect actual data for each jurisdiction to receive more accurate results.

Strategy 1: Case identification and isolation—(symptom-based strategy)

Description: Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated.

Details and Default Values

- COVID-19 cases are infectious from days 4-8 after initial exposure/infection, with an equal likelihood of transmission on each day of infectivity.
  - » Days 4–5: Cases are pre-symptomatic but shedding virus and thus are infectious.
  - » Day 6: Cases become symptomatic and are identified to public health officials, either through self-identification by the patient or identification from health care providers.
  - » Day 7: Case isolation begins, resulting in cessation of onward transmission in the community.
- 50% of all cases are identified and adhere to isolation measures.
- All default values can be changed by the user to examine the impact of different levels of success with case identification and isolation.

Strategy 2: Strategy 1 + contact tracing—(symptom-based strategy)

Description: Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated. Contacts of cases are identified and asked to self-monitor for symptoms and to self-report and isolate if they become symptomatic.

Details and Default Values

- COVID-19 cases are infectious from days 4–8 after initial exposure/infection.
  - Days 4–5: Cases are pre-symptomatic but shedding virus and thus are infectious.
  - Day 6:
    - Cases become symptomatic.
    - Cases are identified to public health as cases and isolated.
    - Between 5 and 20 contacts per case are identified and asked to self-monitor for symptoms and self-isolate if symptomatic.
    - Onward transmission ceases for cases and symptomatic contacts (i.e., secondary cases).
- 45% of all cases are identified and adhere to isolation measures.
- All default values can be changed by the user to examine the impact of different levels of success with the contact tracing strategies.

Strategy 3: Strategy 1 + contact tracing with monitoring and quarantine—(exposure-based strategy)

Description: Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated. Contacts of cases are identified, quarantined, and monitored through daily phone calls for 14 days, as selected by the jurisdiction. If contacts become symptomatic, they are re-designated as cases.

Details and Default Values

- COVID-19 cases are infectious from days 4-8 after initial exposure/infection.
  - Day 4–5:
    - Index cases are pre-symptomatic but shedding virus and thus are infectious.
    - Secondary cases are isolated through quarantine measures and thus stop spreading disease to others.
  - Day 6–8:
    - Index cases are symptomatic.
    - Index cases are identified to public health as cases and isolated.
    - Between 5 and 20 contacts per case are identified and placed into quarantine.
    - Contacts are monitored daily for symptoms.
    - Onward transmission ceases for index cases (i.e., first-generation cases).
- 40% of all cases are identified and adhere to isolation measures, 40% of contacts adhere to quarantine guidelines.
- All default values can be changed by the user to examine the impact of different levels of success with the contact tracing strategies.

Data input

COVIDTracer contains four main pages for user input:

Part A. Outbreak Details;

Part B. Impact of Contact Tracing Strategies;

Part C. Contact Tracing Resources Needed; and a fourth optional/advanced page;

Part D: Epidemiological Parameters (advanced/optional).

HOW TO ALTER INPUT VALUES: WHITE INPUT CELLS: Throughout the tool, data entry cells are in white and clearly identified on worksheets. Users can change the default values in the **white** cells to reflect the situation(s) in their jurisdictions. Users can also conduct their own "what if" scenario analyses (i.e., sensitivity analyses) by making changes to the values in the **white** cells.

NOTES ON DATA ENTRY:

1. All user-entered data are saved by using the "Save & Exit" button on the Cover page when exiting COVIDTracer tool. To change any values, simply type over them.
2. All default values and sources used in the tool can be found by clicking on the upper right corner of Results (Main) pages and then clicking the link to "Default Values."

   See Technical Worksheets

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

   Reset Inputs On This Page to Default Values

Part A. Outbreak Details (Before contact tracing)

The "Outbreak Details" page contains information and inputs for population size, COVID-19 case counts, and the effectiveness of social distancing strategies that have been implemented to date. Default values for total cases to date and cases in the past 14 days illustrate a hypothetical metropolitan area that is experiencing a large-scale outbreak but where case counts have plateaued. Users can readily modify default values by entering new data based on their local situation in the white cells.

Part A: Step 1: Users enter the jurisdiction population.

Step 1: Enter the population of your jurisdiction

Total Population	100,000	*persons*

Part A: Step 2: Users enter today's date, the TOTAL number of COVID-19 cases in the jurisdiction to date, and the number of cases reported in the **last 14 days** within the jurisdiction.

Step 2: Enter information about case counts in your jurisdiction

Today's Date	6/2/2020	
Total cases to date	1,900	*cases*
Cases in the last 14 days	590	*cases*

Note: These data inputs will only create curves for the purpose of calculating resources needs. They are not intended as, nor should be intepreted as, forecasts of future cases

Illustrative Scenario: Part A: Outbreak Details (Before contact tracing)

In coordination with local decision makers, we are public health officials examining the potential impact of lifting currently in-place social distancing measures that include business shutdowns and shelter-in-place orders. If social distancing is eased (e.g., "partial re-opening") or even totally stopped, we want to know how many people we would need to hire to do contact tracing in a way that slows transmission at least as much as social distancing. We would like to make the switch to contact tracing in two weeks. Our local health department serves a population of 100,000.

To start, in steps 1 and 2, we enter the jurisdiction's total population, today's date (June 2, 2020), the total number of COVID-19 cases to date, and the number of new cases that have been reported in the last 14 days.

Part A: Step 3: Users select whether social distancing measures have been implemented within their jurisdiction. If social distancing measures have not been implemented, users must indicate if and when such measures are expected to begin.

Users then select from five different patterns (described below) the one that best describes how the daily number of new cases have changed over the last 14 days. From this input, the tool calculates an estimated impact of social distancing measures that are currently in place (see section on Model Overview for details).

If social distancing measures **have** been implemented:

Step3: Enter estimates about the effectiveness of social distancing measures implemented through the present date

Have social distancing measures already started?	Yes	
Pattern of change in daily case counts over the last 14 days	Daily case counts have plateaued	

Drop down boxes

How to choose?

If social distancing measures **have not** been implemented (using the same drop-down boxes as in Figure above):

Step3: Enter estimates about the effectiveness of social distancing measures implemented through the present date

Have social distancing measures already started?	No	
Will social distancing measures begin prior to initiating contact tracing?	Yes	
Date social distancing measures will begin in jurisdiction	6/2/2020	
Pattern of change in daily case counts over the last 14 days	Daily case counts have plateaued	

How to choose?

Illustrative Scenario: Part A: Pattern of COVID-19 cases in past 14 days

On March 21, 2020, our governor ordered all businesses not designated as essential to shut down and asked residents to shelter-in-place, except for essential trips. To model the impact of these measures, in Step 3, we choose "yes" from the dropdown box. We are not sure how effective these measures have been at slowing transmission, but we have noticed that the number of new cases reported each day has stopped increasing.

To determine which of the five case growth patterns to choose, we compare the shape of the epidemic curve for the last 14 days (i.e., the number of new cases each day), to the illustrative curves shown in the main text below. In our jurisdiction, we continue to have roughly the same number of new cases each day. Our pattern most closely resembles the default scenario listed in the drop-down menu, labeled "Daily case counts have plateaued." We therefore selected that option from the drop-down box.

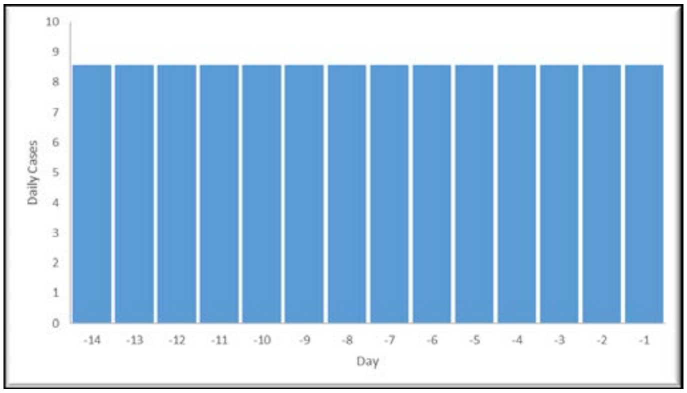
Technical description of pattern of cases over past 14 days: Choosing one of these five patterns will select an appropriate level for the number of new infections per case, or Rt. The illustrative Rt are shown in the graphs in the main text below. The user may also choose to enter their own estimate of the effectiveness social distancing measures by selecting "Manual."

Part A: Step 3: Estimated Effectiveness of Social Distancing Measures

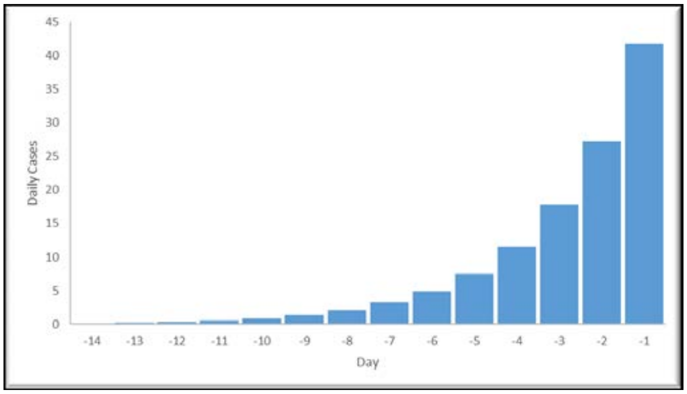
The default, the number of cases in the past 14 days entered by the user are set as remaining constant over those 14 days (i.e., a uniform case distribution). The rationale for this is that many users will be using this tool near the epidemic peak. **We recommend that most users do not change this setting.** However, if growth of cases has been changing over the last 14 days, users can use the descriptions below to select the pattern which best matches their jurisdiction. To choose the best initial case distribution, users can also compare the shape of their local epidemic curve for the last 14 days to the graphics provided below. If none of the default distributions fit the user's local transmission distribution, the tool allows users to manually enter their own estimate of the effectiveness of social distancing.

Part A: Step 3: Patterns of change in case counts over last 14 days (Options: Select one)

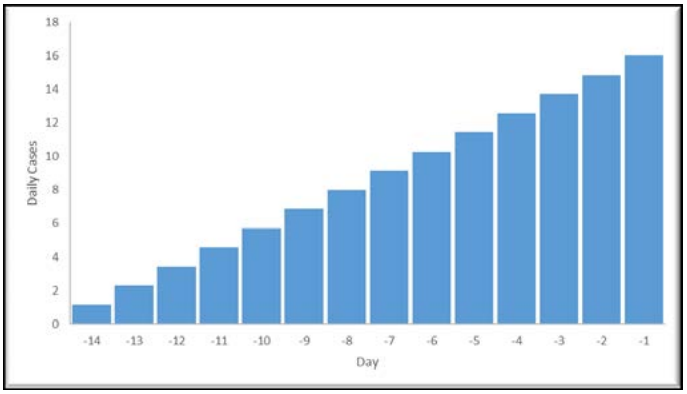
Daily case counts have plateaued:
This is the default distribution. Choose this distribution if the number of new cases has reached a plateau and is neither increasing nor decreasing each day. This is equivalent to $R_t = 1.0$.



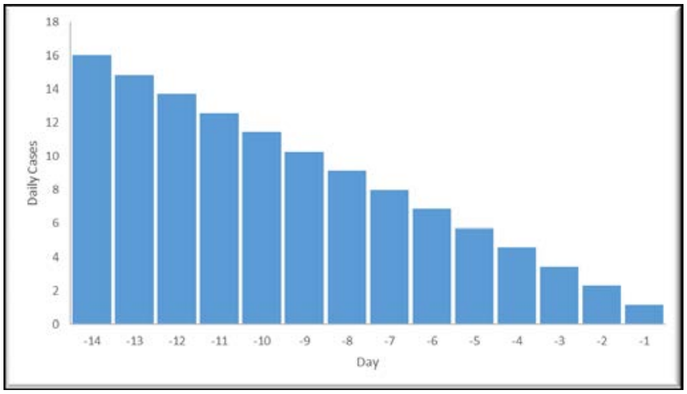
Daily case counts are increasing rapidly:
Choose this distribution if cases have been increasing at an increasing rate over the previous 14 days. This is often the case early in the growth of an epidemic, after community transmission has been established but before control measures are put into place. This is equivalent to $R_t = 1.8$.



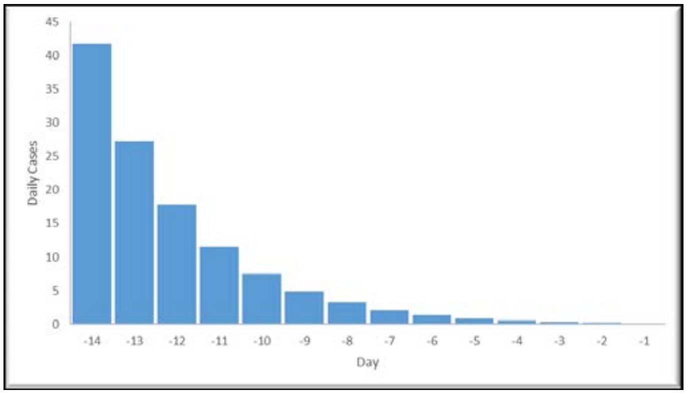
Daily case counts are increasing slowly:
Choose this distribution if cases have been increasing at the same rate over the last 14 days, (e.g., if the number of new cases each day increases by the same amount each day). This will often be the situation after the rate of case growth has slowed from exponential but is continuing to increase before the epidemic peak. This is equivalent to $R_t = 1.2$.



Daily case counts are decreasing slowly:
Choose this distribution if the number of new cases is beginning to decline at a steady rate after the epidemic peak day has occurred. This may be seen, for example, if strict adherence to social distancing measures has prevented onward transmission such that new cases are infecting fewer than one other person. This is equivalent to $R_t = 0.8$.



Daily case counts are decreasing rapidly:
Choose this distribution if the number of new cases is decreasing rapidly, usually due to effective implementation of prevention measures such as isolation, quarantine and vaccination. This is equivalent to $R_t = 0.33$.



Although we recommend using the default values set on the "Epi Parameters" worksheet, users may modify these parameters in Step 4, as follows (a more detailed explanation is provided in the section labeled "Part D: Epidemiologic Parameters"):

Step 4: **(OPTIONAL/ADVANCED) Epidemiologic Parameters**

^It is recommended that the default parameters be used, however, if the user understands the implications for results, changes can be made below.

Change Epidemiologic Parameters — Allows the user to modify the parameters that inform the modeled estimates of future cases.

NEXT STEP: ONCE FINISHED entering input values in Part A, user should click on the "Part B. Impact of Contact Tracing Strategies" button in the navigation buttons at the top of the page to move to the next section.

Part B. Impact of Contact Tracing Strategies

Part B: Step 1: The user enters the date on which contact tracing is planned to start (or, may have already started). The default option is to manually enter the date the jurisdiction will start (has started) contact tracing by selecting "Manual" in the drop-down box.

Step 1: **Enter the date on which contact tracing interventions will begin**

Choose entry method	Manual	
Days past epidemic peak		
Date contact tracing begins (no ramp-up)	6/16/2020	
Date chosen	6/16/2020	

Drop down box

Date Entry Method

If the user chooses "days past peak" from the drop-down box, enter the number of days past the epidemic peak day of cases (with social distancing in place) that the jurisdiction will start contact tracing. Note that the tool automatically generates the date contract tracing begins using data inputs from the Outbreak Details page.

Step 1: **Enter the date on which contact tracing interventions will begin**

Choose entry method	Days past Peak	
Days past epidemic peak		10
Date contact tracing begins (no ramp-up)		6/12/2020
Date chosen	6/12/2020	(Peak + 10 days)

Date Entry Method

Auto generated data

Illustrative Scenario: Part B: Choosing start date of contact tracing programs

To stimulate the economy and get people back to work, our governor has decided that the shelter-in place orders will be lifted at the beginning of June 2020, and that businesses may reopen if they adhere to social distancing guidelines. Since we have been given a date when contact tracing will need to begin, we choose the "Manual" data entry, and enter the date "June 2, 2020."

Alternative illustrative scenario:

Our governor has decided to keep social distancing practices in place until there are data to show that the number of new cases per day has begun to decrease. In this scenario, she would like to switch from social distancing to contact tracing 10 days after the estimated epidemic peak. To calculate that date, we choose "Days past peak" as the date entry method and enter "10" in the box "Days past epidemic peak."

Part B: Step 2: The user considers the values for each contact tracing strategy in the table for: 1) timing of case isolation; 2) proportion of cases traced and isolated successfully; 3) the strategy trigger, chosen from the drop down boxes as either symptom onset ("Symptoms") or identification of contacts ("Contact ID"); 4) whether the contacts are identified and listed; and 5) whether the contact follow-up occurs.

Step 2: Set up the scenarios for contact tracing strategies

Contact Tracing Strategy Input	Strategy 1	Strategy 2	Strategy 3
Number of days after infection that case is isolated	7	6	4
% of all cases successfully isolated and contacts traced and monitored	50%	45%	40%
Strategy Trigger	Symptoms	Symptoms	Contact ID
Contacts are identified and listed?	No	Yes	Yes
Contacts follow-up occurs?	No	No	Yes

**Successfully traced = the strategy worked as assumed and transmission to the next generation was prevented*

Drop down boxes

Part B: DESCRIBING THE TERM "Strategy Trigger"

In Step 2, the term "Strategy trigger" defines how a case is identified and the subsequent actions.

Strategy Trigger "Symptoms:" This means that a case is only identified when they are diagnosed with COVID-19 (either by a laboratory-based test and/ or by symptom-based diagnosis). With this trigger, if contacts are traced, they will be asked to monitor themselves for symptoms and, if they become symptomatic, report to the health authorities.

Strategy Trigger "Contact ID:" This means that when a case is identified (either by a laboratory-based test and/ or by symptom-based diagnosis), their contacts are traced and informed that they should quarantine themselves. The contacts are subsequently monitored for compliance with the isolation/ quarantine requirements. Should the contacts develop any symptoms potentially indicative of COVID-19 illness, they will be tested. That is, this strategy is more pro-active than the other strategy in terms of tracing contacts and actively reducing the risk of the contacts infecting others. This strategy will require more personnel per case compared to the other strategies described in the default scenarios.

Help in Selecting the Strategy Trigger: To aid the user in selecting between the two Strategy Triggers available, the user should select "yes" or "no" for each of the following two options:

- **Contacts are identified and listed?** For the Strategy Trigger of "Symptoms," users can select "yes"—contacts are identified—BUT contacts would only be isolated IF they become symptomatic and diagnosed as having COVID-19 (diagnosed either by a laboratory-based test and/ or by symptom-based diagnosis). A Selection of "no" would indicate that contacts are not identified (as in the default illustrative Strategy 1).
- **Contacts follow-up occurs?** If a user selects the Strategy Trigger of "Symptoms," by definition, the user should select "no." This is because the definition of the Strategy Trigger "Symptoms" EXCLUDES frequent follow-up of contacts (and requiring them to remain isolated for 14 days) (see earlier description of Strategy Trigger "Symptoms"). A user should only select "Yes" for this option IF Strategy Trigger "Contact ID" is selected.

Illustrative Scenario: Part B: Entering values to assess impact of Contact Tracing Strategies

To have the greatest impact on slowing or preventing the spread of coronavirus, as public health officials we would ideally hire enough contact tracers to identify all cases, their contacts, and then monitor their isolation status and symptoms daily, and ensure their compliance with quarantine recommendations (Strategy 3).

However, we are not sure whether our health department can, within a very short time span, hire and adequately train enough staff to identify and monitor all cases and their contacts. As an alternative, we also want to examine how many staff members would be needed if we identify all contacts, but do passive monitoring where we ask the contacts to: 1) monitor themselves for symptoms; 2) report back to a health department call line if they become symptomatic; and 3) self-isolate immediately upon developing symptoms (Strategy 2).

Finally, we want to estimate the resources that would be needed and the potential impact, if our health department only has enough contact tracing staff to do a thorough job of case identification and isolation, without tracing any contacts (Strategy 1).

In COVIDTracer, Part B (Impact of contact tracing), Step 2, we decide to accept the COVIDTracer default values for the number of days after infection that a case is isolated. (Note: this implies that, because cases shed virus and can infect others whilst the cases are pre-symptomatic, even with 100% success in identifying cases and contacts, we would continue to see transmission of disease).

With the resources we are likely to have available, we expect that we will successfully identify and isolate 45% of cases and trace their contacts under strategy 2 (i.e., the default values). However, because we expect that some contacts will refuse to quarantine in the absence of symptoms, we lower our "success rate" for strategy 3 to 40% of cases and contacts successfully identified, with follow-up active monitoring for compliance with isolation recommendations and development of any symptoms that could indicate a COVID-19 illness.

Alternative illustrative scenario(s):

Any of the parameters in Part B, Step 2 can be changed "at will." If, for example, we think that using contact tracing apps will increase our ability to monitor contacts on a daily basis, we might choose to raise the "percent of all cases successfully isolated, and contacts traced and monitored." On the other hand, if we think that contact tracing and monitoring will be difficult, or that we only have enough staff to monitor contacts with a higher risk of transmitting disease, we might choose to lower this percentage.

Note: Users will also be able to test the impact of several of these assumptions on the Sensitivity Analysis pages.

Part B: Step 2: DESCRIPTION OF STRATEGIES:

Strategy 1 (Case Identification and Isolation): Cases will be identified and thus isolated only after becoming symptomatic. We assume that it takes one (1) day to identify and isolate symptomatic cases under this strategy. Because cases can transmit disease before becoming symptomatic (2 days of pre-symptomatic transmission), there will be a minimum of 3 days of onward transmission before the case is isolated. Therefore, the cases are isolated on day 7 after their initial exposure/infection (i.e., after 3 days of pre-infectious period and 3 days of transmission). Users can change this if they think the time from identification to isolation will take more than one (1) day. The trigger for this strategy is "Symptom."

Strategy 2 (Strategy 1 + Contact Tracing): As with Strategy 1, cases will be identified and isolated only after becoming symptomatic. Contacts will be traced quickly upon case identification and asked to monitor symptoms and self-isolate, if symptomatic. Because contacts who convert to cases are identified earlier, the duration of onward transmission may be shortened. The default value of 6 days from infection to isolation may be changed by the user. The trigger for this strategy is "Symptom."

Strategy 3 (Strategy 1 + Contact Tracing and Quarantine): With contact tracing and quarantine, those contacts who adhere to quarantine restrictions will be isolated even before symptoms begin and will be less likely to transmit the disease to others. The default value of 4 days from infection to isolation was chosen to indicate that cases and contacts were isolated before they infect others; this may be changed by the user. The trigger for this strategy is "Case ID."

Part B: CHANGING THE DEFAULT CONTACT TRACING STRATEGIES

A user can change the default values that define the default contact tracing scenarios. If users do wish to make such changes, they can do so by changing one or more of the values in Step 2, as follows:

Part B: Step 2: Changing when a case is effectively isolated: For all default strategies, the default value for when cases start being capable of transmitting disease is day 4 after infection. The cases become symptomatic on day 6 (default value). Reducing the time period between infection and when cases may be effectively isolated decreases the risk of cases infecting others. The illustration (colored chart below) of the chart in COVIDTracer's Part B shows how each strategy affects the number of days during which a case can transmit disease. Users can model the impact of such a reduction in risk by changing, in Step 2, the "Number of days after infection that case is isolated."

Part B: Step 2: Illustration: Changing the timing of when a case is isolated

Day	Strategy 1	Strategy 2	Strategy 3
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	**0.20***	**0.20**	0.00
5	**0.20**	**0.20**	0.00
6	**0.20**	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00

Legend

- *Infected, not yet infectious* (days 1–3)
- *Infectious, pre-symptomatic* (days 4–5)
- *Infectious & symptomatic* (days 6–8)
- *Recovering, no longer infectious* (days 9–14)

* 0.20 represents the proportion (i.e., 20%) of total infectiousness. An infectious case is, by default values (See Appendix A: Supplemental Table 1), consider contagious for 5 days. The default values are set such that an infectious person has equal probability of infecting another person during each of those 5 days.

In COVIDTracer, 14 days is the default value for the total time from infection with COVID-19 until recovery. Without any interventions, cases are infectious from days 4–8 (days since initial infection). The light orange shading (days 4–5) shows when an infected person is pre-symptomatic (not showing any symptoms) but is shedding virus sufficient to potentially infect others. The dark orange shading (days 6–8) shows the days when cases are both symptomatic and capable of transmitting disease. The green shading represents time (days 9–14) when recovering cases are no longer infectious.

With Strategy 1, it is assumed that cases are isolated after the first day of symptoms; thus, the infectious period is shortened to 3 days (from 5 days under no intervention) and onward transmission reduced by 40%.

With Strategy 2, contacts that develop symptoms are asked to self-isolate immediately upon developing those symptoms, thus reducing the infectious by one (1) day (i.e., they are still at risk of infecting others during the 2 days of the pre-symptomatic infectious period). Risk of onward transmission, in Strategy 2, from contacts who become symptomatic is reduced by 60% (using the default values).

With Strategy 3, contacts are quarantined while they are still in the pre-infectious period, and thus transmission only occurs from asymptomatic cases. Risk of onward transmission, in Strategy 3, from contacts who become symptomatic is reduced by 100% (using the default values).

Default values for the timing and duration of infectiousness and the daily probability of transmission can be modified on Page D. Epidemiologic Parameters (Optional/Advanced).

Part B: Step 2: Changing the overall effectiveness of a strategy: The percent of all cases successfully isolated, and contacts traced and monitored is intended to be a general estimate of the overall success of that strategy. Users can readily change the estimated success of each strategy for any, and all, of the three contact tracing strategies. For example, in Strategy 3, the default value of 40% indicates that "overall, for a group of people identified as cases and the contacts of such cases, 40% are identified, monitored, and successfully isolated or quarantined and do not infect others."

Note that increased testing and timely access to testing results may increase the compliance, and consequently the overall success rate. Although the model does not explicitly estimate the impact of testing, users can implicitly account for it by changing the effectiveness of contact tracing. In addition, if users wish to examine the impact of a single strategy under different levels of effectiveness, they could also do so by changing these values. For example, if users wish to see the impact of case isolation and contact tracing (Strategy 2) with different levels of success (e.g., 45%, 50%, 75%), they would enter those values and change the Strategy Trigger to match.

Part B: Step 3: Users indicate whether partial social distancing restrictions will continue after contact-tracing is implemented; and account for the additional reduction in transmission due to continued partial social distancing restrictions.

Step 3: Account for additional effects of continued social distancing measures

Social Distancing Continues?	Strategy 1	Strategy 2	Strategy 3
Will partial social distancing restrictions continue?	No	No	No
Estimated % reduction in transmission due to continued partial social distancing			
Combined % reduction in transmission from contact tracing + continued social distancing, if applicable	13.0%	17.6%	40.0%

No data yet exist on the effectiveness of partial continuation of social distancing measures (i.e., effectiveness of partial re-opening). For partial social distancing restrictions, given that so few data are available, the default values in COVIDTracer are set to 0%.

Courtemanche et al. (2020) evaluated the impact of different types of social distancing measures during the time period when COVID-19 cases were increasing in U.S. states and jurisdictions. Based on the Courtemanche et al. study, some ranges of impact of social distancing interventions (from the period when cases were increasing) are provided as follows. The higher estimates are based on longer periods of implementation of these interventions:

- Continued shelter-in-place: 24%–39% reduction in transmission
- Continued business closures: 20%–25% reduction in transmission

Courtemanche et al. also evaluated the impact of school closures and the ban on large gatherings (500 or more people). They found no evidence that these measures influenced the growth rate of COVID-19 cases. In their study, based on data collected for U.S. states, school closures and large event bans occurred before the implementation of shelter-in-place. In many states, for relatively short periods of time, small social gatherings outside of the school setting were still allowed. A table of estimates of impact of social distancing measures, by type of measure, adapted from the Courtemanche et al., is available in Appendix B of the manual. We strongly caution that, in measuring the impact of such interventions (either while cases are increasing or decreasing), much remains unknown. For example, it is unclear when social distancing measures are eased, and communities start to re-open, if such social distancing measures will have the same impact as when cases were increasing, and the interventions were first put in place.

Part C. Contact Tracing Resources Needed

The table on this page contains information about the length of time it takes to perform activities such as case identification, contact tracing, and monitoring.

Step 1: Enter the estimated number of contacts per case

	Lower	Upper	
Contacts per case	5	20	*contacts per case*
False Alerts per case	-	-	*alerts per case*
Number of days contacts are monitored	14	14	*days*

Alert Info

Step 2: Enter the daily work hours and overhead hours

	Lower	Upper	
Daily shift length (hours)	8.00	12.00	*hours per day*
Overhead hours (e.g., prep time, supervisory time, support staff)	5%	5%	*of total hours needed*

Enter Data in White Boxes Only

Step 3: Enter the estimated time needed to interview and monitor cases and contacts

Information about Staff Groups

	Staff Group	Lower	Upper	
Initial case interviews	1	1.00	2.00	*hours per case*
Initial case interviews (false case alerts)	1	2.00	4.00	*hours per alert*
Initial contact interviews	1	0.50	1.00	*hours per contact*
Case/contact monitoring & follow-up	2	0.25	1.00	*hours per day*

[†]For each case, there are a number of associated contacts (see Step 1). The time entered here represents the daily hours per case/contact required to monitor both the cases and associated contacts. If the number of assumed contacts-per-case are notably changed (in Step 1), users are advised to concurrently alter the monitoring time.

Part C: Step 1: Users enter upper and lower values for the number of contacts per case, false alerts per case, and number of days contacts will be monitored. Note that the default value for "false alerts per case" is 0. Thus, no resources are needed for follow-up of mis-identified, non-COVID cases. Users may change this "at will" as more information about "false alerts" becomes available.

Part C: In Step 2: Users enter upper and lower estimates for the duration (in hours) of a daily shift, along with a percentage for overhead hours to cover activities need to support the contact tracing activities.

Part C: Step 3: Users enter the upper and lower values for time (in hours) required, **per case,** for each type of activity—initial case interview, interviews of "false alerts," initial contact interviews, case and contact follow-up monitoring (if done in a given contact tracing strategy).

Users also use a drop-down box to categorize staff into one of two "groups" for each activity. Staff can be categorized as either "Group 1" or "Group 2," with "Group 1" representing more experienced staff, and "Group 2" representing less experienced staff. This categorization will aid planners in determining, from the total number of staff needed, the numbers of more experienced staff that will be needed.

Part C: Step 3: Changing the default values of time per activity: The values defining the length of time it takes to perform case identification, contact tracing and monitoring activities may be affected by factors specific to the user's jurisdiction and the population being monitored. Users are encouraged to alter COVIDTracer's default values to account for activities not explicitly designated within the tool. For example, the average time needed to find and interview a contact could be changed to incorporate the need for multiple attempts to find a contact. Users may also decrease the estimated time needed for activities if they believe the use of electronic methods will reduce the burden on public health staff.

For more information about default values for contact tracing activities, see Appendix A: Supplemental Table 1.

Illustrative Scenario: Part C: Entering values to calculate personnel per case identified

At the end of May 2020, the governor lifted shelter-in place orders and allowed businesses to reopen if they adhere to social distancing guidelines. Our health department plans to move ahead with developing and implementing contact tracing and we need to estimate the resources needed to do this given our current understanding of disease transmission in our jurisdiction. We decide initially to keep all default values to estimate the maximum number of staff needed on a peak day under various contact tracing strategies.

Alternative illustrative scenario:

Any of the parameters in steps 1–3 can be changed "at will." If, for example, as businesses reopen, we think each case has twice as many contacts as set by the default, we would change the values in that field to be 10 and 40 for the lower and upper estimates. We also are thinking about using technology to interview and monitor contacts, hoping it will reduce the amount of time needed for these activities. We decided to reduce by half the default values such that lower and upper values for initial contact interviews are 0.25 and 0.50 hours, respectively.

Part D. Epidemiologic Parameters (Optional/Advanced)

The Epidemiologic Parameters in Part D contains information regarding states of disease and transmission dynamics of COVID-19. The page is prepopulated with plausible default values (see Appendix A: Supplemental Table 1). Default parameters were selected using best available data; sources include peer-reviewed studies, expert opinion, and pre-print manuscripts. Users may alter these default values by modifying the data in the white cells. Users can see in the graphs provided on the right-hand side of Part D how changes in parameter inputs alter the number of the daily cases.

Part D: Step 1. Enter information about how quickly the disease spreads without mitigation

Step 1: **Enter information about how quickly the disease spreads without mitigation**

New Infections per Case (R0)	2.00	*infections*	R0 Info?

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" or R_0. Preliminary studies of COVID-19 transmission have reported R_0 values ranging 2.0–3.0 (i.e., a single infected person will infect two to three others on average) (UK COVID Task Force, 2020). Reports from Imperial College also estimated an R_0 range of 2.0–2.6 (Ferguson et al., 2020). The default value for new infections per case is set to 2.0; however, users may enter in their own estimates for new infections per case.

Part D: Step 2. Enter information about how the disease transmission occurs over the duration of illness (without mitigation).*

Step 2: Enter information about how the disease transmission occurs over the duration of illness (without mitigation)

Day	No Mitigation	
1	0.00%	
2	0.00%	
3	0.00%	*Infected, not yet infectious*
4	**20.00%**	
5	**20.00%**	*Infectious, pre-symptomatic*
6	**20.00%**	
7	**20.00%**	
8	**20.00%**	*Infectious & symptomatic*
9	0.00%	
10	0.00%	

Disease Stage (with Color Legend) — Disease Stages?

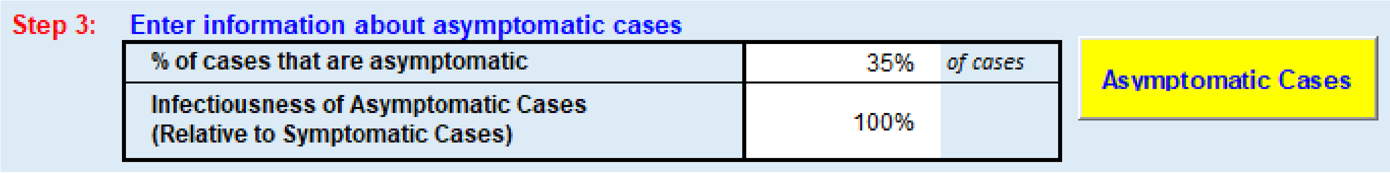
Disease Stage		
Infected, not yet infectious	3	*days*
Infectious, pre-symptomatic	2	*days*
Infectious & symptomatic	3	*days*
Recovering, no longer infectious	6	*days*
Total Duration of Infection/Illness	**14**	***days***

* Note that in this Step 2, for clarity, the per day risk of onward disease transmission, is displayed as a percentage of total risk. In Part B, these percentages are displayed as proportion (e.g. 0.20—see earlier), The values are directly equivalent.

In Part D: Step 2, the "Disease Stage" box shows the distribution of infectious days and is prepopulated with default values for the number of days in each stage. These defaults are described in Appendix Part C. Users can modify the white cells in the table, but, for simplicity, the total duration of disease is fixed at 14 days.

The table on the left is color coded to show disease stages by day and a user-determined proportion of disease transmission without mitigation. The default values in COVIDTracer are that cases are equally contagious during the infectious stage (both pre-symptomatic and symptomatic). Users may alter the percentages (summing to 100%) to reflect a different transmission scenario without mitigation. For example, a user could decide that cases are most contagious on days 5 and 6 from infection, and change the percentages to reflect that (e.g., day 4—15%, day 5—30%, day 6—30%, day 7—15%, day 8—10%).

Part D: Step 3. Enter information about asymptomatic cases



Step 3 contains information related to asymptomatic cases. In COVIDTracer, the default value is that 35% of cases are asymptomatic. The default value for infectiousness of asymptomatic cases is that asymptomatic cases are equally infectious relative to symptomatic cases (i.e., 100% similarly infectious as symptomatic cases). Users can modify either or both these inputs to test the impact of these default values.

Part D: Finished Entering Input Data: Once a user has finished entering input data in Part D, the user should click the "Return to Outbreak Details" box.

NOTE: In the Results page, users have the option to select links to pages that will allow them to explore "what-if scenarios." On these pages, the user can readily change input values, and compare the impact of such changes to the initial set fo entered values.

Results

Results: Potential Impact of Contact Tracing on COVID-19 Cases

As shown in the two Figures below, COVIDTracer provides Results for: 1) the potential impact of each strategy on the future trajectory of the estimated daily and cumulative case counts; and 2) the maximum number of staff needed to conduct contract tracing at the epidemic peak.

NOTE: The Illustrative Results shown in the two Figures below were produced using the default values in the tool (see earlier text and the Appendix for a list of inputs and default values).

Illustrative Results: Part 1: Impact of contact tracing scenarios on future cases compared to a "base case" in which social distancing measures continue without change.

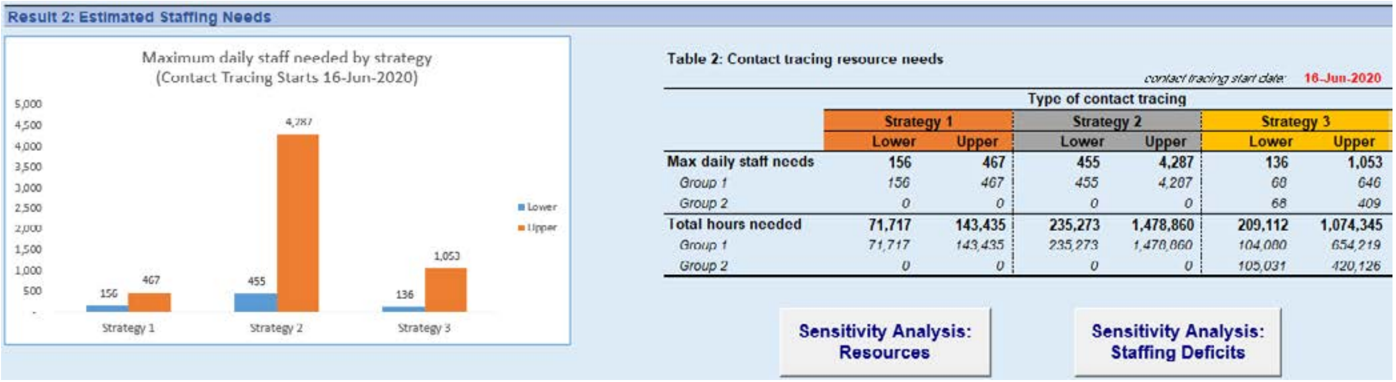


Table 2: Contact tracing resource needs

contact tracing start date: 16-Jun-2020

	Type of contact tracing					
	Strategy 1		Strategy 2		Strategy 3	
	Lower	Upper	Lower	Upper	Lower	Upper
Max daily staff needs	**156**	**467**	**455**	**4,287**	**136**	**1,053**
Group 1	*156*	*467*	*455*	*4,287*	*68*	*646*
Group 2	*0*	*0*	*0*	*0*	*68*	*409*
Total hours needed	**71,717**	**143,435**	**235,273**	**1,478,860**	**209,112**	**1,074,345**
Group 1	*71,717*	*143,435*	*235,273*	*1,478,860*	*104,080*	*654,219*
Group 2	*0*	*0*	*0*	*0*	*105,031*	*420,126*

Illustrative Results: Part 2: Estimated staffing needs for each of the three contact tracings scenarios examined.

Result 1: Potential Impact of Contact Tracing Strategies on Future Epidemic Trajectory

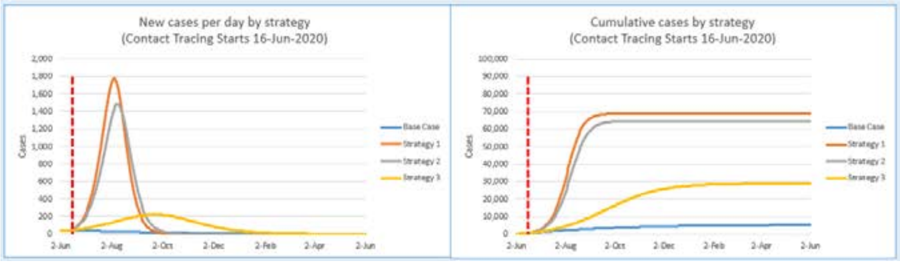


Table 1: Outbreak duration and total cases by type of intervention

contact tracing start date 16-Jun-2020

	Type of contact tracing			
	Base Case	Strategy 1	Strategy 2	Strategy 3
Duration (days)	> 365	142	155	334
Date of Peak	2-Jun	5-Aug	9-Aug	23-Sep
Cases on Peak Day	41	1,781	1,485	224
Total number of cases	5,205	68,871	64,589	28,890

Sensitivity Analysis: Cases

Understanding the Results: The **Illustrative Results,** shown in the Figures above, can be interpreted as described in the text box below.

Illustrative Scenario: Understanding the Results

For the "base case" (the blue line in Illustrative Results: Part 1), social distancing measures continue with the same intensity, and no contact tracing strategies are implemented. The vertical red dashed line shows (see Result 1, screen shot above) the day upon which the user has indicated that contact tracing will start for Strategy 1–3. In this illustrative scenario, it is assumed that social distancing measures will be lifted after contact tracing strategies are in place (strategies 1–3).

The chart line for the base case shows that, with social distancing measures continuing unchanged, the outbreak would continue at a very low level for longer than one (1) year with approximately 5,205 total cases per 100,000 population during that time.

Results for Strategy 1 (Case identification and isolation):

Using the default values and with a scenario in which all social distancing restrictions are lifted, we see that a rapid rise in the number of new cases would be expected. This is because we can only identify cases after they develop symptoms, at which point they have been transmitting disease for 3 days. In this case, since social distancing measures have been lifted, many more people are at risk of exposure.

In this illustration, while the duration of the outbreak would be shortened to 142 days (approximately 5 months), there would be an estimated 68,871 total cases during that time. The estimated peak day of the outbreak is 5 August 2020, with approximately 1,781 cases occurring that day. With strategy 1, between 156 case investigators (assuming a 12-hour workday), and 467 case investigators (assuming an 8-hour workday) would be needed at peak (note: In Strategy 1, there is no contact tracing).

Results for Strategy 2 (Strategy 1 + contact tracing):

With Strategy 2, which adds contact tracing, with provision of information about how to self-monitor for symptoms and instructions to self-isolate if contacts become symptomatic, we see that the potential number of total cases is still much higher than would be expected with continued social distancing restrictions, but less than expected with strategy 1. In this illustration, the outbreak would be expected to continue for approximately 5 months (155 days), with an estimated 64,589 cases per 100,000 population during that time. The estimated peak day of the outbreak would occur 9 August 2020, with approximately 1,485 cases occurring that day. With strategy 2, between 455 contact tracers (assuming a 12-hour workday and an average of 5 contacts per case), and 4,287 contact tracers (assuming an 8-hour workday and an average of 20 contacts per case) would be needed at peak.

As is true with Strategy 1, the number of cases rises after social distancing measures are lifted. In this case, because contacts isolate immediately upon developing symptoms, we decrease the number of days of onward transmission from 3 to 2, and fewer people are exposed.

Results for Strategy 3 (Strategy 1 + contact tracing with monitoring and quarantine):

With Strategy 3, contacts are isolated even before they are infectious without any symptoms; thus, onward transmission is effectively prevented among the fraction of contacts that isolate so that the number of new cases does not rise after social distancing is lifted.

In this illustration, the outbreak would continue for approximately one year, with an estimated 28,890 cases per 100,000 population over that time. Between 136 contact tracers and staff that conduct case and contact follow-up activities to ensure compliance with isolation requirements (assuming a 12-hour workday and an average of 5 contacts per case), and 1,053 contact tracers (assuming an 8-hour workday and an average of 20 contacts per case) would be needed at peak. This number is lower than that needed for Strategy 2, because many fewer cases occur, resulting in fewer contacts.

Sensitivity Analysis: "What If" Scenarios

Sensitivity analysis: Introduction: In COVIDTracer, on the Results page, the user can select, sequentially, up to three pages that allow users to explore how results would change when using different input values. On these three pages users can compare a selected contact tracing strategy to a "What If" scenario when varying any set of these variables: 1) contact tracing strategy parameters; 2) staffing needs, and 3) staffing shortages. The charts and graphs on these pages illustrate how estimates would change given the "What-If" scenario inputs.

User instructions are the same for each of the pages for sensitivity analysis, and we provide an example using staffing needs:

Sensitivity analysis: Example: Resources: Staffing Needs: On the Results page, users select-and-click on the Box labeled "Sensitivity Analysis: Resources."

COVIDTracer will then take the user to a page labeled "What-If Sensitivity Analysis: Staffing Needs."

Sensitivity Analysis: Staffing Needs: Step 1: Users start by selecting one of the three contact tracing strategies from the drop-down box. The choices listed in the drop-down box are the three strategies set up in "Part B. Impact of Contact Tracing Strategies" (see earlier).

Sensitivity Analysis: Staffing Needs: Step 2: The Table in Step 2 shows both the original inputs, in the shaded cells, initially selected by the user in Part C: Contact Tracing Resources Needed. In the two columns of white cells, labeled "What-If" Scenario, users enter different values for any one or all of the variables listed in the table. For instance, a user might want to see how changing the lower and upper values for number of "Contacts per Case" affects staffing needs. The Figure below shows an example in which a user has altered, for a sensitivity analysis, the values of hours per activity for each case.

Figure A: Sensitivity Analysis: Example: Altering initial values of amount of time per case for contact tracing activities

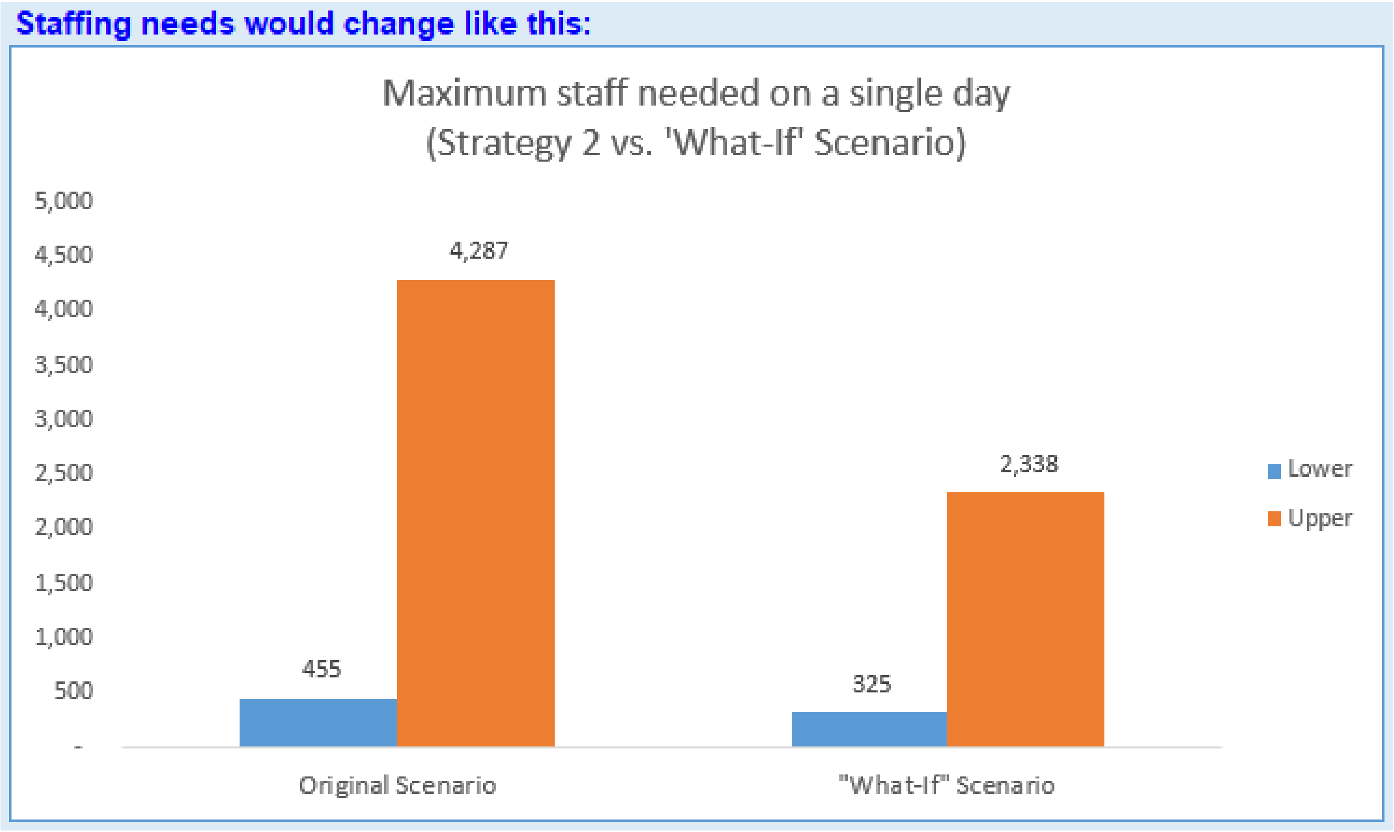
Step 1: **Choose A Contact Tracing Strategy** — Strategy 2

Step 2: **Set your "What-If" Scenario**

	Original Scenario		"What-If" Scenario	
	Lower	*Upper*	*Lower*	*Upper*
Contacts per Case	5.00	20.00	3.00	10.00
Daily shift length (hours)	8.00	12.00	8.00	12.00
Overhead hours (e.g., prep time, supervisory time, support staff)	5%	5%	5%	5%
Alerts per case	-	-	-	-
Time needed for alert screening interview (hours)	2.00	4.00	5.00	10.00
Initial case interview (hours)	1.00	2.00	1.00	2.00
Initial contact interview (hours)	0.50	1.00	0.50	1.00
Monitoring Hours for Cases + Contacts†	0.25	1.00	0.25	1.00
Number of days monitored	14.00	14.00	14.00	21.00

Sensitivity Analysis: Example: Results: Staffing Needs: The bar chart below (Figure B) illustrates the comparison between the base case, Strategy 2 in this example, and "What-If Scenario" inputs (in Figure A, above) for lower and upper estimates of the maximum number of staff needed on a single day.

Figure B: Sensitivity analysis: Example: Results from altering initial values of amount of time per case for contact tracing activities



Printing

In order to print your results on a single page, you must change the printing page setup to Landscape format. To do so,

4. Click **File** and then choose **Page Setup.**
5. In the **Orientation** section, change **Portrait** to **Landscape.**
6. 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.

References

CDC COVID-19 Modeling Team. Preliminary COVID-19 Estimates (Apr 31, 2020).

Courtemanche C, Garuccio J, Le A, Pinkston J., Yelowitz A. Strong Social Distancing Measures in the United States Reduced the COVID-19 Growth Rate. *Health Affairs.* 2020:39(7).

European Centre for Disease Prevention and Control. Resource estimation for contact tracing, quarantine and monitoring activities for COVID-19 cases in the EU/EEA. ECDC: Stockholm; 2020.

Ferguson N, Laydon D, Nedjati Gilani G, Imai N, Ainslie K, Baguelin M, Bhatia S, Boonyasiri A, Cucunuba Perez ZU, Cuomo-Dannenburg G, Dighe A. Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand. https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf

He X, Lau E, Wu P, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nature Medicine.* 2020 May 26.

Keeling MJ, Hollingsworth TD, Read JM. The efficacy of contact tracing for the containment of the 2019 novel coronavirus (COVID-19). medRxiv 2020; published online Feb 17. https://doi.org/10.1101/2020.02.14.20023036 (preprint).

Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, Ren R, Leung KS, Lau EH, Wong JY, Xing X. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. *New England Journal of Medicine.* 2020 Jan 29. https://www.nejm.org/doi/full/10.1056/NEJMoa2001316

Ma S, Zhang J, Zeng M, Yun Q, Guo W, Zheng Y, Zhao S, Wang MH, Yang Z. Epidemiological parameters of coronavirus disease 2019: a pooled analysis of publicly reported individual data of 1155 cases from seven countries. medRxiv. 2020 Jan 1. https://www.medrxiv.org/content/10.1101/2020.03.21.20040329v1

Peak C, Kahn R, Grad Y, Childs L, Li R, Lipsitch M, Buckee C. Modeling the Comparative Impact of Individual Quarantine vs. Active Monitoring of Contacts for the Mitigation of COVID-19. https://www.medrxiv.org/content/10.1101/2020.03.05.20031088v1.full.pdf

UK Government COVID Task Force. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873713/01-spi-m-o-consensus-statement-on-2019-novel-coronavirus-_covid-19_.pdf

Wearing HJ, Rohani P, Keeling MJ. Appropriate Models for the Management of Infectious Diseases. *PLOS Medicine.* 2005 Jul;2(7):e174.

Appendix

A. Default values

Supplemental Table 1. Default values used in COVIDTracer

Epi Parameters	Default Value (Range)	Source
Infected but not yet infectious period	3 days	Preliminary COVID-19 estimates*
Contagious (infectious) period	5 days	Peak et al. (2020)
New infections per case (R0)	2.0	Preliminary COVID-19 estimates*
Change in case growth over the last 14 days	R_t = 1.8 (Rapidly increasing) R_t = 1.2 (Slowly increasing) **Default R_t = 1.0 (Plateaued)** R_t = 0.8 (Slowly decreasing) R_t = 0.33 (Rapidly decreasing)	Assumed
% cases that are asymptomatic	35%	Preliminary COVID-19 estimates*
Relative infectiousness of asymptomatic cases (to symptomatic cases)	100%	Preliminary COVID-19 estimates*
Number of contacts per case**	Upper: 5 Lower: 20	Assumed

Resource Needs	Default Value	Source
Staff hours per day*	Lower: 8 hours Upper: 12 hours	Assumed
Overhead hours**†	5%	Assumed
Screening alerts**	Lower: 5 Upper: 10	Assumed
Interviewing cases**	Lower: 1 hour Upper: 2 hours	ECDC 2020
Interviewing contacts**	Lower: 0.5 hours Upper: 1 hour	Assumed
Monitoring cases and contacts**	Lower: 0.25 hours Upper: 1 hour	Assumed

* Preliminary COVID-19 estimates from unpublished CDC and ASPR/HHS assessment.
** User may change assumed values in the tool to explore how results change.
† Overhead hours includes items such as preparation time, supervisory time, and support staff time.

B. Effects of continued social distancing measures

We used the results from Courtemanche et al. (2020) to estimate the reduction in transmission under each social distancing measures. Courtemanche et al. presented their results in terms of changes in daily growth rate. COVIDTracer estimates the impact of each intervention by using percentage changes in the number infected per infectious person (The "R_t" value). To convert the estimates from Courtemanche et al. into percentage changes in R_t values, we used the relationship between the reproduction number and the observed growth rate proposed by Wearing et al. (2005). The Table below provides estimates of the impact of some social distancing interventions. The impacts are broken down by type and duration of intervention. Users of COVIDTracer may wish to refer to this table to guide their estimates of the impact of any residual social distancing type interventions that may remain after partial re-openings. Note that these estimates were made when the growth of daily cases counts was increasing. Such estimates may not apply when the growth of cases is decreasing. At this stage, we do not know of similar data for situations where the growth of cases is decreasing.

Supplemental Table 2. Impact of social distancing interventions on the reduction in transmission of COVID-19 cases

% Reduction in Transmission (R_t value)[a]

Days since start of social distancing	Shelter-in-place	Business Closures [b]
During Day 1–5	24%	20%
During Day 6–10	30%	21%
During Day 11–15	35%	27%
During Day 16+	39%	25%

Source: Adapted from Courtemanche et al. (2020) Appendix Exhibit 5: baseline values. The reduction in transmission is calculated using the equation from Wearing et al. (2005), and assuming baseline growth rate of 0.162, latent period=3 days, and infectious period=5 days.

[a] The R_t value is the number infected per infectious person.

[b] Business Closures refer to restaurants, gyms, or entertainment centers closures.

C. Model overview

COVIDTracer utilizes a compartmental model (SEIR) that tracks people through four disease states:

- Susceptible (not yet infected with COVID-19);
- Exposed/Infected but not yet capable of infecting others;
- Infectious and able to transmit the disease to others;
- 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).

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 (CDC COVID-19 Modeling Team). The user may alter this value as needed. For example, Ma et al. (2020) 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., 2020) and includes both pre-symptomatic (2 days) and symptomatic (3 days) transmission.

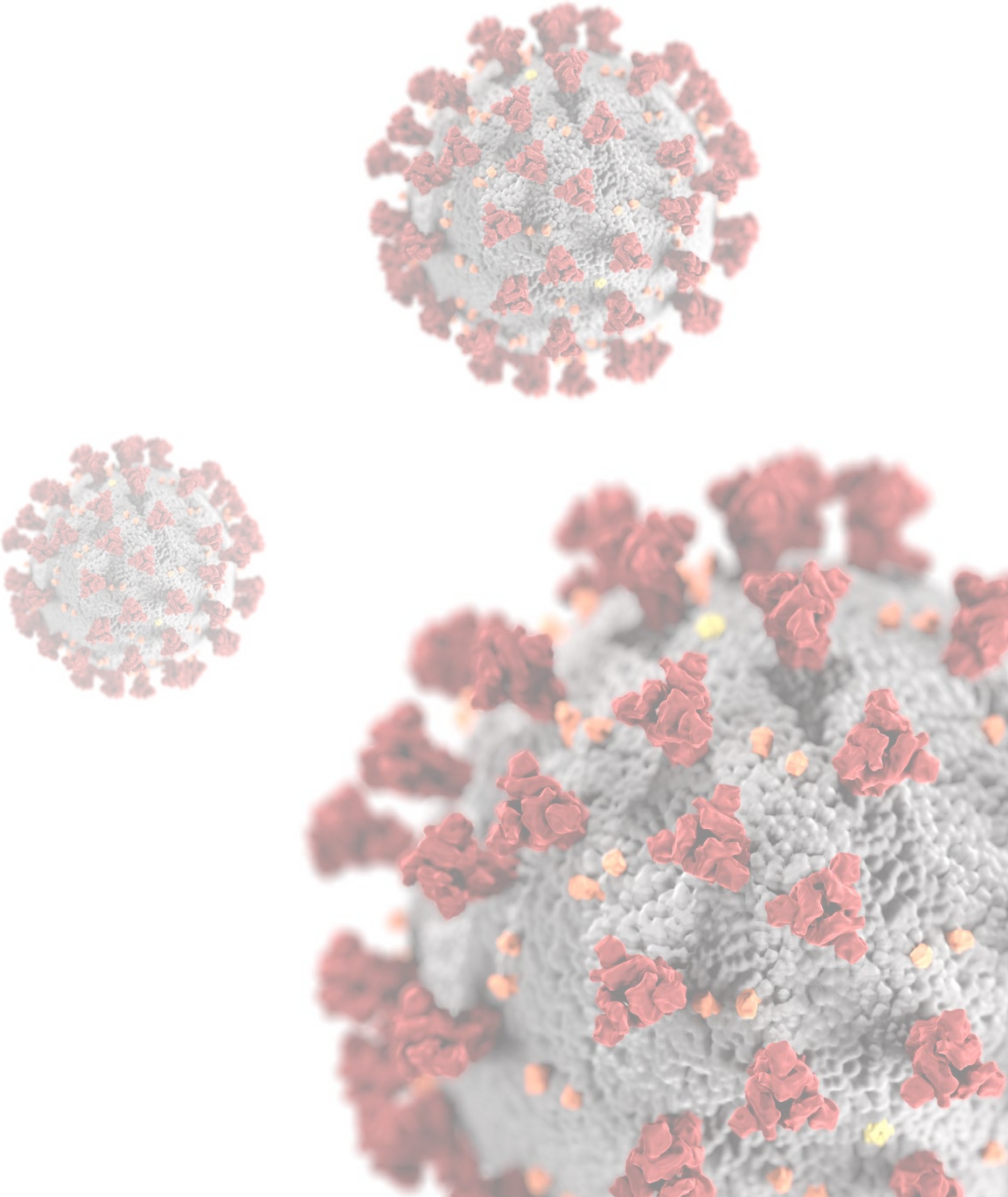
Total duration of infection/illness: Currently fixed to 14 days.

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"). Others have 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, 2020) and between 1.4–3.9 (Li et al., 2020) for COVID-19. Users can enter their own estimate for new infections per case. The default R0 value is set to 2.0 (CDC COVID-19 Modeling Team).

Effectiveness of social distancing measures: The impact of social distancing is quantified by the effective reproduction number (R_t), which is the number of cases generated by a single case in the current state of a population (as opposed to a completely susceptible population). By employing a community-wide social distancing, we assume that the average number of new cases produced by a single infectious person (R_t) decreased to a pre-set level defined under each scenario:

Case count trend in the last 14 days	Assumed R_t
Daily case counts are increasing rapidly	1.8
Daily case counts are increasing slowly	1.2
Daily case counts have plateaued	1.0
Daily case counts are decreasing slowly	0.8
Daily case counts are decreasing rapidly	0.33

Alternatively, the user can choose "Enter manually" to input their own value of estimated percentage reduction in R_0.



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