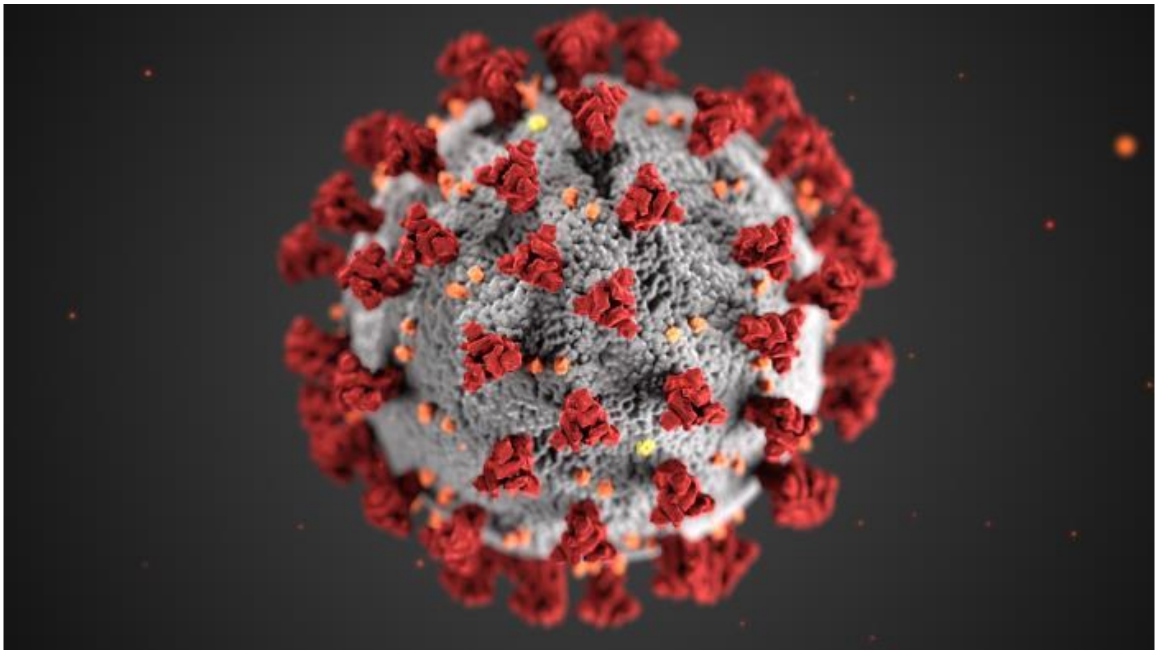

Photo provided courtesy of CDC: Alissa Eckert, MS; Dan Higgins, MAMS

COVIDTracer Advanced

A Planning Tool to Illustrate the Resources Needed to Conduct Contact Tracing and Monitoring of Coronavirus Disease 2019 (COVID-19) Cases and the Potential Impact of Community Interventions and Contact Tracing Efforts on the Spread of COVID-19

COVIDTracer Advanced v1 Beta Test Version

This manual accompanies the software tool COVIDTracer Advanced, beta version 1.0, released by CDC on 23 December 2020

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

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DATE This version: November 16, 2020

Disclaimers

COVIDTracer Advanced is not a forecasting tool and is not intended to predict what *will* occur during a coronavirus pandemic. Rather, estimates generated with COVIDTracer Advanced are illustrations designed to aid public health officials in understanding the relative planning and preparing for contact tracing of COVID-19 cases. All estimates may either over- or under-represent the real number of contact tracers needed and the degree to which estimates deviate from real values depends on user inputs as well as variables unaccounted for in the model.

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

System Requirements

COVIDTracer Advanced uses the Windows* operating system (Microsoft Windows 2010 or higher) and Excel (Microsoft Office 2013 or higher). Full functionality of COVIDTracer Advanced is only 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 COVIDTracer Advanced, 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.

*Microsoft Windows and Office are copyrighted products produced by Microsoft Corporation, WA. Use of trade names and commercial sources is for identification only and does not imply endorsement by the Centers for Disease Control and Prevention or the U.S. Department of Health and Human Services.

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Background

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.

Case investigation and contact tracing activities aim to contain and control the spread of infectious disease epidemics by quickly identifying and isolating cases, and notifying, testing, quarantining and monitoring persons exposed to COVID-19 cases (contacts).

Brief Introduction to the Tool: COVIDTracer Advanced

In April 2020, CDC introduced the COVIDTracer tool, which allows users to explore the impact of up to 3 user-defined contact tracing strategies in their own jurisdictions and to assess the personnel and time that will be needed to effectively execute the strategies. In December 2020, CDC introduced the COVIDTracer Advanced tool, which extends this capability by allowing users to distinguish impact of interventions by three age groups in terms of changes in the numbers of COVID-19 cases and hospitalizations, as well as changes in direct medical costs.

Both COVIDTracer and COVIDTracer Advanced allow the user to define and compare three different illustrative contact tracing/monitoring strategies in the context of community-level interventions with varying levels of effectiveness. Users may apply the tool to their desired setting or population by changing the default values for:

- each of 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).

Both tools also provide estimates of the staffing requirements to conduct contact tracing activities. For example, results display the time necessary to complete contact tracing activities for each case, permitting users to estimate the number of staff needed.

Both COVIDTracer and COVIDTracer Advanced produce tabular results and graphs that aim to aid public health officials and policy makers in deciding which public health intervention is likely to provide the most control with the available resources and constraints.

How is COVIDTracer Advanced different from COVIDTracer?

COVIDTracer Advanced allows users to account for age-based differences in adherence to and effectiveness of community-based interventions as well as changes in the numbers of COVID-19 cases and hospitalizations by age group. Additionally, COVIDTracer Advanced allows a user to estimate age-stratified direct medical costs associated with COVID-19 hospitalizations, and thus explore changes in direct medical costs associated with interventions.

Limitations and Assumptions

- **COVID Testing**: COVIDTracer Advanced does not include explicit considerations of COVID-19 testing strategies (such as impacts of testing strategies over time), nor does the tool consider the personnel needed to conduct such testing. Instead, calculations pertaining to the efficacy of contact tracing strategies rely on *when* a case is identified and isolated rather than *how* a case is identified. If a user has a question about testing and contact tracing, please contact the COVIDTracer team at HEMU@cdc.gov.

- **Geographic Locale:** COVIDTracer Advanced can be used for many locales and public health jurisdictions, including rural communities. However, it is not recommended for use with small populations (several hundred persons or less), as some calculations and data inputs are based on averages observed among large populations. As such, they may not represent the characteristics of small population samples.

- **Constant level of effectiveness/ impact:** Within each strategy, there is the implicit assumption that the stated level of effective reduction in transmission will remain constant over the time period of the analysis. In reality, compliance with interventions changes over time, either waning (e.g. as people become fatigued with restrictive measures) or increasing (e.g. due to improving public perceptions and support).

- **Estimates represent "average/expected outcomes":** COVIDTracer Advanced cannot identify events with a very low probability of occurrence, such as 'super-spreader' events. Estimates produced by the tool are based on (and should be interpreted as) "average" outcomes. Uncertainty surrounding such results can be explored using the Sensitivity Analyses tabs in the tool.

Overview: How to Use COVIDTracer Advanced

Load, start, and navigation instructions

Note that some functionality will not be available in Microsoft Office for Mac or in the browser version of Office 365.

- Open the COVIDTracer Advanced 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 Advanced: tool inquiry].

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' upper right corner.
- Yellow buttons throughout the tool contain definitions or explanations.

Comparison of (up to) 3 contact tracing strategies

The tool allows users to define and compare the relative impacts of a range of options for up to 3 contact tracing strategies being considered in a particular setting. Users can evaluate how changing key parameters affects estimates of future case counts as well as the number of personnel needed to conduct contact tracing.

Default (illustrative) contact tracing strategies (described briefly below) serve as examples of the types of strategies that can be analyzed with the tool or as starting points users can modify to match strategies being considered in their locale. Choosing different sets of inputs for Strategies 1, 2, and 3 allows the user to perform an assessment of the relative impact of the differences among them. Users can modify the default illustrative strategies to best fit the current situation in their jurisdiction. We provide sample explanations below to show how a set of inputs for a strategy may be interpreted in practice.

NOTE: These strategies can be readily changed by a user, and we encourage users to consider entering different strategies to best match the needs of their locale. Some strategies, such as Strategies 1 and 2 in the examples below, do not reflect CDC guidelines (https://www.cdc.gov/coronavirus/2019-ncov/php/contact-tracing/contact-tracing-plan/contact-tracing.html). These two strategies are meant to demonstrate the likely reduced impact of insufficient resources for full implementation of all contact tracing guidelines. Again, users are encouraged to explore different strategies.

Default (Illustrative) Strategy 1 (<u>Case identification and isolation only):</u>
Symptomatic cases of COVID-19 are rapidly identified within the community and effectively isolated.

This represents a "low resource" strategy, where the resources available or committed to contact tracing is much less than is required to meet CDC guidelines for effective contact tracing). It allows a user to quickly see that identifying and isolating only symptomatic cases (with no further efforts to identify or isolate those exposed to the case) would have extremely low success in reducing onward transmission, even if 100% of symptomatic cases were successfully identified and isolated (highly improbable).

Default (Illustrative) Strategy 2 (Case Identification and Isolation, and Contact Tracing):
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 their onset of symptoms and self-isolate if they become symptomatic.

This represents a "medium resource" strategy, where the resources available or committed to contract tracing is still less than is required to meet CDC contact tracing guidelines but are sufficiently greater than those used in Default Strategy 1 to further reduce onward transmission. This strategy, although not recommended by CDC guidance, could potentially be considered in areas where testing is unavailable or extremely difficult to obtain.

Default (Illustrative) Strategy 3 (Contact Tracing, Isolation, and Monitoring):
COVID-19 cases are rapidly identified within the community and effectively isolated. Contacts of cases are identified, tested, quarantined, and monitored through daily phone calls for 14 days, as selected by the jurisdiction. If contacts are identified with COVID-19 or become symptomatic, they are re-designated as cases.

This represents a strategy that aligns with current CDC guidance and should illustrate to the user the importance of being able to rapidly identify and effectively isolate both presymptomatic and asymptomatic cases.

NOTE: Detailed descriptions of these three strategies can be found in Appendix, Section C. "Detailed Description of Default Contact Tracing Strategies".

Output from COVIDTracer Advanced

Based on the number of contacts per case and the expected number of hours that contact tracers are expected to work per day, COVIDTracer Advanced 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. COVIDTracer Advanced provides additional information about age-stratified number of cases and hospitalizations, and the potential direct medical costs and Medicaid expenditures (limited to COVID-19 hospitalizations) averted for each illustrative scenario.

Data input

COVIDTracer Advanced contains seven pages for user input, including three that are optional:

Part A. Outbreak Details;
Part B. Impact of Contact Tracing Strategies;
Part C. Contact Tracing Resources Needed;
Part D: Epidemiological Parameters (Optional/Advanced);
Part E.1: Hospitalization Inputs;
Part E.2: Estimating Direct Medical Costs ((Optional/Advanced);
Part F: Estimating Aggregate Impact of Community Interventions (Optional).

OVERVIEW: 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). Users will also need to enter age-stratified case data or the population age distribution and age-stratified cost of one day of hospitalization. These data requirements are described in more detail below.

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) and strategies applied 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 Advanced 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.”

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 community-level interventions 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 where daily case counts are slowly increasing. 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.

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 1: Enter the population of your jurisdiction

Total Population	100,000	*persons*

Step 2: Enter information about case counts in your jurisdiction

Today's Date	10/9/2020	
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

Part A: Step 3: Users select whether community-level interventions (e.g., face mask orders, distance/virtual learning for K-12 schools, university closures/virtual learning, bar and restaurant closures, or moratoriums on mass gatherings) are currently implemented within their jurisdiction. If community-level interventions are not currently implemented, users must indicate if any are planned 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 community-level interventions that are currently in place (see section on Model Overview for details).

If community interventions **are being** implemented:

Step3: Enter estimates about the effectiveness of community interventions implemented through the present date

Are community interventions currently in place?	Yes	
Pattern of change in daily case counts over the last 14 days	Daily case counts are slowly increasing	

How to choose?

If community interventions **are not** being implemented (using the same drop-down boxes as in Figure above):

Step3: Enter estimates about the effectiveness of community interventions implemented through the present date

Are community interventions currently in place?	No	
Will community interventions begin before initiating contact tracing?	Yes	
Date community interventions will begin in jurisdiction	10/10/2020	
Pattern of change in daily case counts over the last 14 days	Daily case counts are slowly increasing	

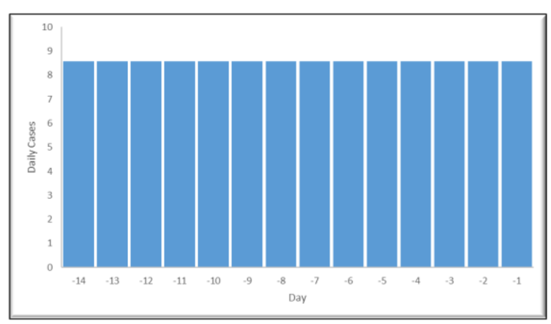
How to choose?

Part A: Step 3: Estimated Effectiveness of Community Interventions

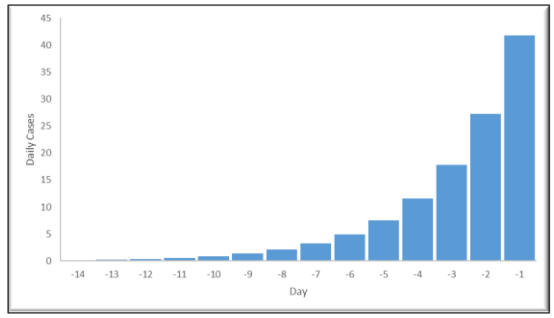
In COVIDTracer Advanced, estimating effectiveness of community interventions is connected to the number of reported cases in the last 14 days (user input in Part A, step 2). The default is “Daily case counts are slowly increasing.” However, if daily case counts have been changing rapidly, remaining constant, or decreasing over the last 14 days (see below for more detailed descriptions), users can select from these options, the pattern that best matches their jurisdiction. To choose the best initial case distribution, users can also visually compare the general shape of their local epidemic curve for the last 14 days to the graphics provided below. If none of the default distributions match the general shape of the user’s local transmission distribution, the tool allows users to manually enter their own estimate of the effectiveness of current intervention efforts.

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

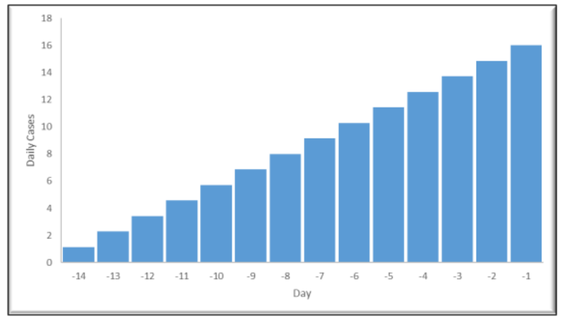
Daily case counts have plateaued: Choose this distribution if the number of new cases has reached a plateau and is neither increasing nor decreasing each day (see image at right). This is equivalent to $R_t = 1.0$ for the cases in the last 14 days.



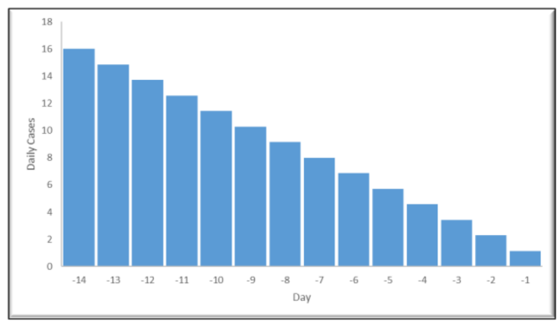
Daily case counts are rapidly increasing: Choose this distribution if cases have been increasing non-linearly over the previous 14 days (see image at right). This is often the case early in the growth of an epidemic, after community transmission is established but before control measures are put into place. This is equivalent to R_t = 1.8 for the cases in the last 14 days.



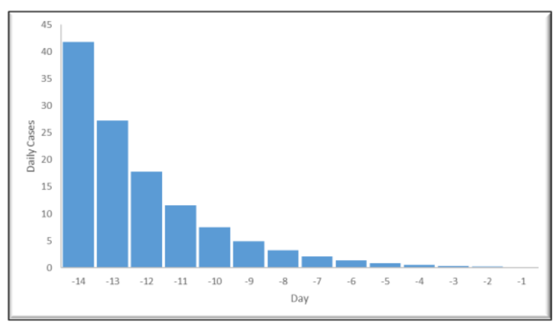
Daily case counts are slowly increasing: This is the default distribution. Choose this distribution if cases have been increasing at a steady rate (increasing linearly, see image at right) over the last 14 days. This will often be the situation after the rate of case growth has slowed from exponential but daily case counts are continuing to increase before peaking. This is equivalent to R_t = 1.2 for the cases in the last 14 days.



Daily case counts are slowly decreasing: Choose this distribution if the number of new cases has been declining at a steady rate (decreasing linearly, see image at right) 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 for the cases in the last 14 days.



Daily case counts are rapidly decreasing: Choose this distribution if the number of new cases is decreasing rapidly (decreasing non-linearly, see image at right), usually due to effective implementation of prevention measures such as isolation, quarantine and vaccination. This is equivalent to R_t = 0.33 for the cases in the last 14 days.



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).

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

Choose entry method	Manual	
Date contact tracing begins (no ramp-up)	10/24/2020	
Date chosen	10/24/2020	

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 (the event that triggers contact tracing), 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.

Note: The default strategies in the tool (see Appendix C for detailed descriptions) are provided as illustrations to allow the user to quickly see a range of potential strategy options that could be entered into the tool, and to give a starting point from which to modify these inputs to fit the individual strategies being considered in their locale. Users are encouraged to modify these default strategies as necessary to best fit the needs of their locale.

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

Drop down boxes

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

DESCRIBING THE TERM "Strategy Trigger"

In Step 2, the term "Strategy Trigger" allows the user to specify what "triggers" the contact tracing / isolation process for any single case (e.g. symptom onset). This selection is especially pertinent for strategies seeking to effectively isolate asymptomatic cases. Note that the model does not explicitly specify *how* a case is identified (i.e., does not differentiate based on identification by testing or identification by other means), but only requires this input to specify whether asymptomatic cases will be isolated under a particular strategy.

The "Strategy Trigger" input allows the user to choose one of two options as a "trigger" for initiating isolation. This affects how asymptomatic cases are handled.

Strategy Trigger Option #1 ("Symptoms"): This selection is used when the trigger for initiating isolation is the onset of clinical symptoms. Some hypothetical examples of when this option should be chosen are:

- Cases are asked/required to isolate only after the onset of clinical symptoms.
- Cases are asked to isolate after a positive test result, BUT testing is only being performed on individuals who show clinical symptoms.

In short, by choosing this trigger, the model assumes that isolation of contacts will not occur until after the onset of clinical symptoms, which will affect the ability to reduce transmission from asymptomatic cases.

Strategy Trigger Option #2 ("Contact ID"): This selection is used when the trigger for initiating isolation could occur before the onset of clinical symptoms (such as being notified of exposure to a known case). For example, contacts could be asked to quarantine based on any of the following:

- Notification of possible exposure to a known case (being "identified as a contact")
- Receiving a positive test result as part of a routine testing strategy (e.g., in a congregate setting such as a nursing home) before the onset of clinical symptoms
- Onset of clinical symptoms (as in Option #1)

This strategy is more pro-active than one using the "Symptoms" trigger, in that it greatly expands the possibility of preventing transmission from asymptomatic and pre-symptomatic cases, but likely at the cost of quarantining some individuals who do not become cases. ***Additional Strategy Details.*** The user can also adjust, on a per-strategy basis, whether certain key functions of the contact tracing process will occur or not. Selections made for either of these two inputs only affect the calculation of staff hours needed to implement the strategy but do not alter the effectiveness of contact tracing via reducing onward transmission. Because of this, the user should take care to ensure that the selections made here align logically with the chosen Strategy Trigger as follows:

- ***Contacts are identified and listed?***
    - Users selecting “Symptoms” as the Strategy Trigger: respond “yes” or “no”. A selection of “yes” indicates that staff resources (hours, entered in a later step) will be needed to complete these efforts. However, as stated above, this selection does not alter whether these contacts will be effectively isolated.
    - Users selecting “Contact ID” as their Strategy Trigger: users should select “yes”, since contacts cannot be asked to test and self-isolate unless they are identified and listed.
- ***Contact follow-up occurs?***
    - If the user has selected “no” for “Contacts are identified and listed”, they should also select “no” for this option, since if contacts are not identified and listed, there can be no follow-up.

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. 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 Advanced, 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

Timing of Case Isolation

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	**0.17**	**0.17**	0.00
5	**0.18**	**0.18**	0.00
6	**0.17**	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
Infectious, pre-symptomatic
Infectious & symptomatic
Recovering, no longer infectious

*0.17 represents the proportion (i.e., 17%) of total infectiousness. An infectious case is, by default values (See Appendix A: Supplemental Table 1), considered infectious for 11 days.

In COVIDTracer Advanced, 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 4-14 (days since initial infection). The light orange shading (days 4-5) shows when an infected person is pre-symptomatic (not showing any symptoms) but may be infectious to others. The dark orange shading (days 6-14) shows the days when cases are both symptomatic and capable of transmitting disease.

With Strategy 1, it is assumed that cases are isolated after the first day of symptoms; thus, the infectious period is shortened to 9 days (from 11 days under no intervention) and onward transmission reduced by 42%.

With Strategy 2, contacts who 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 64% (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 community-based interventions will continue after contact-tracing is implemented, and account for the additional reduction in transmission due to such continuation.

Step 3: **Account for additional effects of continued community interventions (e.g., facemask use, social distancing measures, school/business closures etc.)**

Community Interventions Continue?	Strategy 1	Strategy 2	Strategy 3
Will community-level interventions continue?	Yes	Yes	Yes
Estimated % reduction in transmission due to continued community interventions	29%	29%	29%
Combined % reduction in transmission from contact tracing + continued community interventions, if applicable	55.7%	59.8%	75.0%

Community-level interventions

For each strategy, users can alter assumptions about the estimated reduction in transmission associated with community-level interventions that may be in place in addition to contact tracing alone. A new calculator is built into the tool to allow users to develop jurisdiction-based, age-weighted estimates of such strategies' impact.

> *Description:* Community interventions are non-pharmaceutical interventions (NPIs) that are executed to "flatten the curve" (e.g., face mask orders, school closures/distance learning, university social distancing measures, bar and restaurant restrictions, moratorium on mass gatherings, etc.).

Users can either enter an overall estimate of the effectiveness of community interventions as implemented within their community, or they may wish to calculate the aggregated impact of up to five specific community intervention strategies using the Calculator Worksheet (% reduction in transmission). Users are encouraged to seek out locally appropriate estimates or consult the citations provided below. Users may also wish to enter several values for the estimated reduction in transmission to explore "what-if" scenarios. Some limited information about the impact of selected community interventions is provided below.

NOTICE: Community level interventions: Updating input values
The default inputs associated with the potential impact of community-level non-pharmaceutical interventions, such as wearing face masks and limiting gatherings, are based on available data as of mid-November 2020. The values that best describe the impact of one or more such community-level interventions may change as more data are collected and reported.

Users are therefore encouraged to consult the most recent literature available on the subject of estimated impact of such community level interventions, as well as any relevant data that are available from their jurisdictions. An example of a website that posts updates of such information is: https://www.cdc.gov/library/covid19/scienceupdates.html?Sort=Date%3A%3Adesc.

Face masks: Data on the effectiveness of face masks in preventing COVID-19 transmission have high variability depending on the type of face mask used and the adherence of the wearer to guidelines for putting on, wearing and taking off the mask. One study (Chu et al, Lancet 2020) found that cloth masks, like those worn by many people in the community setting, reduced the spread of aerosol-sized particles by ~60%, while N-95 respirators (or equivalent) like those worn in clinical settings reduced such spread by ~95%. Another study (Doung-ngern et al., EID 2020) found that wearing a mask at all times during contact was independently associated with lower risk for becoming infected with COVID-19, however, their study did not show independent association based on the type of mask used.

Social Distancing: Few data yet exist on the effectiveness of partial continuation of social distancing measures (i.e., effectiveness of partial re-opening).

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 Courtemanche et al.(2020), 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*

[1]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 values 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, <u>per case</u>, 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.

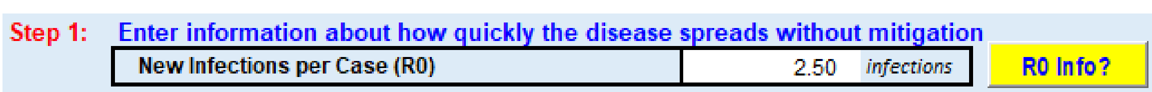
Part C: Step 3: Changing the default values of time per activity: The values defining the length of time it takes to perform case identification, contact tracing and monitoring activities may be affected by factors specific to the user’s jurisdiction and the population being monitored. Users are encouraged to alter the default values in COVIDTracer Advanced to account for activities not explicitly designated within the tool. For example, the average time needed to locate and interview a contact could be changed to incorporate the 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 needs for public health staff.

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

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 taken from the CDC COVID-19 Pandemic Planning Scenarios (https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html; see also 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



New infections per case: This is the average expected number of new cases produced by a single infectious person in a completely susceptible population in the absence of any prevention or control efforts, 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 2.5; 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		
1	0.00%	
2	0.00%	
3	0.00%	*Infected, not yet infectious*
4	11.86%	
5	23.54%	*Infectious, pre-symptomatic*
6	21.55%	
7	15.96%	
8	10.68%	
9	6.73%	
10	4.08%	
11	2.41%	
12	1.39%	
13	0.79%	
14	1.01%	*Infectious & symptomatic*
	100.00%	*(Must equal 100%)*

Enter Data in White Boxes Only

Disease Stage (with Color Legend)

Infected, not yet infectious	3	*days*
Infectious, pre-symptomatic	2	*days*
Infectious & symptomatic	9	*days*
Recovering, no longer infectious	0	*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. 0.12 – 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. Users may alter the default values (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: Enter information about asymptomatic cases

% of cases that are asymptomatic	40%	*of cases*
Infectiousness of Asymptomatic Cases (Relative to Symptomatic Cases)	75%	

Asymptomatic Cases

Step 3 contains information related to asymptomatic cases. In COVIDTracer Advanced, the default value is that 40% of cases are asymptomatic. The default value for infectiousness of asymptomatic cases is that asymptomatic cases 75% as infectious relative to 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 of entered values.

Part E.1: Hospitalization Inputs

This page contains information and tables for users to input data about COVID-19 related hospitalizations broken down by age group and if needed, to specify a jurisdiction-specific age distribution of COVID-19 cases. If the user wishes to change the age categories from their predefined values, please refer to "Part F. Estimating Aggregate Impact of Community Interventions (Optional)" for instructions.

In Part E.1, Step 1, users will set a time horizon for the analysis by using drop down menus to choose starting and ending dates. For the starting date, users may select "Model start" or specify a custom date.

Step 1: **Enter information about the time horizon**

Choose a starting date	Model start	
Choose an ending date	Model end	
Chosen date range (start, end)	10/9/2020	10/9/2021

Drop down boxes

Total Cases in Chosen Date Range			
Base Case	*Strategy 1*	*Strategy 2*	*Strategy 3*
30,069	*19,293*	*8,989*	*2,057*

If the user selects "Model start," the tool retrieves the date entered in the field for "Today's date" in Part A. Outbreak Details and that date automatically populates the field (grey cell) for the start date. When "Model start" is selected with "Model end" as the ending date, the tool automatically populates the end date to be 365 days from the starting state. When users opt to customize either or both the dates for the time horizon, the appropriate cell to populate becomes white, allowing the user to enter information in the field. The table, "Total Cases in Chosen Date Range" pulls information from the calculation pages to sum the number of new infected cases between the selected or entered start and end dates.

Step 1: **Enter information about the time horizon**

Choose a starting date	Custom date	7/31/2020
Choose an ending date	Custom date	2/6/2021
Chosen date range (start, end)	7/31/2020	2/6/2021

Total Cases in Chosen Date Range			
Base Case	*Strategy 1*	*Strategy 2*	*Strategy 3*
21,679	*13,292*	*7,217*	*2,057*

In Part E.1, Step 2, users enter information about the percent (%) risk of hospitalization by age group. Users will populate the table with percentages of hospital admissions by age group for ICU care, and ICU care with mechanical ventilation.

Step 2: Enter information about the risk of hospitalization by age group

I wish to enter data based on	Percentages

Hospitalized Cases			
Age (year)	% of All Cases Admitted for Hospital Care	% of Admitted Cases Requiring ICU Care	% of ICU Cases That Will Require Mechanical Ventilation
0 to 17	0.21	33.20	17.39
18 to 64	2.17	29.90	16.24
65+	4.12	35.00	21.10

In Step 3, users will populate the table with the percentage of the jurisdiction's COVID-19 cases that fall within each of the three age groups listed.

Step 3: Enter information about the percentage of all cases in your jurisdiction that belong to each age group

Cases by Age Group	
Age (year)	% of Total Cases
0 to 17	15.00%
18 to 64	55.00%
65+	30.00%
	100%

(must equal 100%)

Part E.2: Estimating Direct Medical Costs (Optional/Advanced)

The costing inputs page contains information needed to estimate direct medical costs associated with the three strategies, broken down by age group. In COVIDTracer Advanced, direct medical costs are limited to costs of COVID-19-related hospitalizations. We recommend users work with the default values provided in Part E.2 to estimate direct medical costs for the jurisdiction of interest.

In Part E.2, Step 1, users input information about the age distribution of the jurisdiction's Medicaid population. COVIDTracer Advanced assumes the population not covered by Medicaid is covered by other health insurance (private insurance or Medicare).

Step 1: Enter information about the proportion of patients covered by Medicaid

% of Hospitalized Patients Covered by Medicaid			
Age (year)	% Medicaid	% Other Insurance*	Total
0 to 17	18.00%	82.00%	100.00%
18 to 64	18.00%	82.00%	100.00%
65+	18.00%	82.00%	100.00%

As shown below, the tables in Part E2, Steps 2 – 3 are pre-populated with default values for treatment costs per case/day and median length of stay for hospitalized patients covered by other insurance (Table 2) and Medicaid (Table 3). The default values for hospitalization costs are taken from Premier Healthcare Database for each age stratum specified. Note, that charges are often higher than the amount actually paid by insurance companies. The initial hospital charges are adjusted using pre-set charge-to-cost ratios.

NOTE that the default cost values in Step 2 and Step 3 have already been adjusted. If a user is using unadjusted hospital charges, they can use a cost-to-charge ratio in Step 4 (see below, and Appendix D for additional information).

Another important point to note is that in COVIDTracer Advanced, patients are assigned to the highest "treatment severity" that applies to their hospitalization. Thus, for example, a patient who is admitted to the general ward for several days before being admitted to the ICU and placed on a mechanical ventilator would be put in the "ICU + ventilator" category, and the associated costs take into account all treatment severities for that hospitalization.

For more information about methods used to estimate direct medical costs and length of stay, see Appendix D: Direct medical cost calculation. Unless users have jurisdiction-specific information related to COVID-19 hospitalization costs for patients covered by private insurance and Medicaid, we recommend using the default values in COVIDTracer Advanced.

Step 2: Enter information about treatment charges per day & median length of stay (LOS) for hospitalized patients covered by OTHER INSURANCE*.

Direct Medical Charges (Hospitalized Cases using Other Insurance*)						
Age (year)	Per case ($)/day			Median Length of Stay (days)		
	Hospitalized, non-ICU	*ICU (No Ventilator)*	*ICU + Ventilator*	*Hospitalized, non-ICU*	*ICU (No Ventilator)*	*ICU + Ventilator*
0-17	$2,340.35	$3,374.66	$5,685.90	2.00	5.00	13.00
18-64	$2,117.40	$2,080.47	$3,669.90	4.00	5.00	14.00
65+	$2,061.42	$2,078.49	$3,596.81	5.00	6.00	12.00

*Note: Other insurance includes private insurance and Medicare

Step 3: Enter information about treatment charges per day & median length of stay (LOS) for hospitalized patients covered by MEDICAID.

Direct Medical Charges (Hospitalized Cases using Medicaid)						
Age (year)	Per case ($)/day			Median Length of Stay (days)		
	Hospitalized, non-ICU	*ICU (No Ventilator)*	*ICU + Ventilator*	*Hospitalized, non-ICU*	*ICU (No Ventilator)*	*ICU + Ventilator*
0-17	$2,317.91	$3,199.21	$4,494.69	2.00	4.00	10.00
18-64	$2,294.66	$2,231.62	$3,919.10	3.00	5.00	14.00
65+	$2,489.28	$2,179.42	$3,912.36	5.00	7.00	13.00

Source: Premier Healthcare Database (hospitalization charges and LOS); Note: charges are higher than costs for both "Other insurance" and Medicaid.

In Part E2, Step 4, if users are using unadjusted hospital charge data, they can adjust those charges to reflect actual costs by inputting estimated cost to charge ratios for other insurance and for Medicaid. If a user is using cost data that has already been adjusted, they should use the default cost-to-charge ratios of 1.0 (i.e., effectively no adjustment).

Step 4: Enter Cost to Charge ratio*

Cost to Charge Ratio	
Other Insurance	1.00
Medicaid	1.00

Part F: Estimating Aggregate Impact of Community Interventions (Optional)

This page contains the calculator to help the user estimate the percent reduction in transmission due to multiple community interventions to populate cell(s) in **row 28 in Part B, Step 3**. Community mitigation interventions, in addition to contact tracing (Part C of the tool), could include orders to wear face masks, a ban on large gatherings and/ or other social distancing interventions.

To use the calculator, the first step is to identify the age distribution in the user's jurisdiction of interest. From the drop-down box in Step 1, the user selects a jurisdiction, which could be the United States, a state, or the option to manually enter the name. After selecting a jurisdiction, the tool automatically populates the "Demographics" table with the three-group age stratification for a population of 100,000.

Step 1: Enter information about the age stratification in your jurisdiction or use one of the presets provided in the dropdown menu:

Choose your jurisdiction	United States

Drop down box

Demographics				
Age (year)	% Population			Pop (N)
0 to 17	23%			23,322
18 to 64	60%			60,360
65+	16%			16,318
	100%			100,000

Step 1: Enter information about the age stratification in your jurisdiction or use one of the presets provided in the dropdown menu:

Choose your jurisdiction	Texas

Drop down box

Demographics				
Age (year)	% Population			Pop (N)
0 to 17	27%			26,641
18 to 64	61%			60,607
65+	13%			12,752
	100%			100,000

Manual entry can be used if the jurisdiction of interest is, for example, a public school district. To manually enter the age distribution for a population of 100,000, the user can create new age groups and enter the relevant values for % population for the selected jurisdiction. For example, the user could choose "MANUAL ENTRY," and then enter age groups for elementary, middle and high school-aged children.

Step 1: Enter information about the age stratification in your jurisdiction or use one of the presets provided in the dropdown menu:

Choose your jurisdiction	MANUAL ENTRY

Drop down box

Demographics				
		Age (year)	Enter % Population	Pop (N)
		5-10	15%	15,000
		11-13	67%	67,000
		14-18	18%	18,000
			100%	100,000

The table in Step 2 generates, for one community intervention at a time, an estimate of effectiveness in terms of percent reduction in transmission. To derive the estimate, users will enter the percent (%) reduction in transmission associated with a particular community intervention and % adherence for each age group. The calculator computes the age-stratified net reduction (%) along with aggregate reduction in transmission for the jurisdiction population. For example, let's consider wearing masks in public spaces. We assume that wearing masks reduces transmission by 60% for all age groups (Chu et al, Lancet 2020; Doung-ngern et al, EID 2020). We assume adherence to wearing masks varies across age groups such that children are the least adherent at 20%; adults are better at wearing masks at 40% adherent; and we think seniors are the most adherent at 80%. After entering these values in the table, the calculator shows the net percent reduction for each age group and the aggregate reduction in transmission (due to mask wearing) for the jurisdiction population (26.52%).

Step 2: For a single community intervention, enter the estimated impact and adherence for each age group:

Age-Stratified Impact of a Single Community Intervention			
Age (years)	% Reduction in Transmission	% Adherence	Net Reduction (%)
0 to 17	60.00%	20.00%	12.00%
18-64	60.00%	40.00%	24.00%
65+	60.00%	80.00%	48.00%

Aggregate Reduction in Transmission (Single Community Intervention)	26.52%

In Step 3, we enter 26.52% in the table for the aggregate reduction in transmission due to mask wearing in our jurisdiction of interest. In addition to mask wearing in public spaces, large gatherings may be banned in the jurisdiction. We estimate the ban on large gatherings reduces transmission by 2% and add that to the table. Assuming the impact of community interventions are independent, the calculator sums the aggregate reduction in transmission for the two interventions of interest. The result is an age-weighted reduction in transmission of 28.52%.

The calculator estimates the percent reduction in transmission due to multiple community interventions to populate cell(s) in **row 28 in Part B, Step 3**.

Step 3: Enter the aggregate reduction in transmission for each community intervention of interest

Aggregate Impact of Community Interventions	
Intervention Name	Aggregate Reduction in Transmission (from green box above)
Masking in public spaces	26.52%
Ban on large gatherings	2.00%
<type intervention name>	0.00%
<type intervention name>	0.00%
<type intervention name>	0.00%

add in text box to

Age-Weighted (Average) Reduction in Transmission	28.52%

This assumes th

Results

COVIDTracer Advanced contains three pages of results that illustrate the 1) potential impact of contact tracing and resources needed; 2) estimated hospitalizations averted; and 3) estimated direct medical costs averted.

Note: Estimates produced by the tool should be interpreted as “on average” outcomes. Uncertainty surrounding these outputs can be explored using the Sensitivity Analyses tabs as well as other, standard methods for quantifying uncertainty (e.g. scenario analysis or univariate / multivariate sensitivity analysis).

1) Potential Impact of Contact Tracing on COVID-19 Cases

As shown in the two Figures below, COVIDTracer Advanced 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.

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

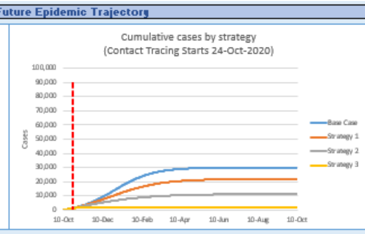


Table 1: Outbreak duration and total cases by type of intervention

contact tracing start date: ########

	Type of contact tracing			
	Base Case	Strategy 1	Strategy 2	Strategy 3
Duration (days)	289	325	335	64
Date of Peak	29-Dec	22-Dec	23-Oct	23-Oct
Cases on Peak Day	262	161	97	97
Total number of cases	29,989	21,917	11,325	1,994

Sensitivity Analysis: Cases

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

Result 2: Estimated Staffing Needs

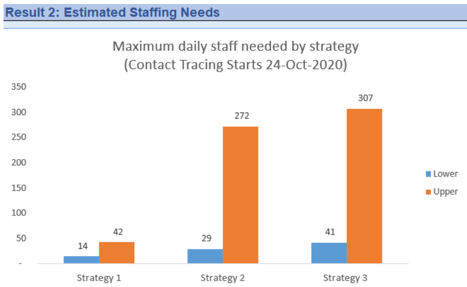


Table 2: Contact tracing resource needs

contact tracing start date: 24-Oct-2020

	Type of contact tracing					
	Strategy 1		Strategy 2		Strategy 3	
	Lower	Upper	Lower	Upper	Lower	Upper
Max daily staff needs	**14**	**42**	**29**	**272**	**41**	**307**
Group 1	*14*	*42*	*29*	*272*	*17*	*164*
Group 2	*0*	*0*	*0*	*0*	*25*	*151*
Total hours needed	**21,800**	**43,599**	**37,372**	**234,909**	**8,282**	**40,165**
Group 1	*21,800*	*43,599*	*37,372*	*234,909*	*3,079*	*19,352*
Group 2	*0*	*0*	*0*	*0*	*5,203*	*20,812*

Sensitivity Analysis: Resources

Sensitivity Analysis: Staffing Deficits

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 some social distancing measures will continue to be 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 289 days with approximately 30,000 total cases per 100,000 population during that time.

Results for Strategy 1 (Case identification and isolation):

Using the default values and assuming community interventions continue with an estimated 29% effectiveness (illustrative value only), we see that a continuing 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, the outbreak would continue for another 325 days, with an estimated 21,917 total cases during that time. The estimated peak day of the outbreak would be 22 December 2020, with approximately 161 cases occurring that day. With strategy 1 and continued community interventions with an overall 29% effectiveness, between 14 case investigators (assuming a 12-hour workday), and 42 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 less than expected with strategy 1. In this illustration, the outbreak would be expected to continue at a low level for approximately 335 days, with an estimated 11,325 cases per 100,000 population during that time. The estimated peak day of the outbreak would occur 23 October 2020, with approximately 11,325 cases occurring that day. With strategy 2, between 29 contact tracers (assuming a 12-hour workday and an average of 5 contacts per case), and 272 contact tracers (assuming an 8-hour workday and an average of 20 contacts per case) would be needed at peak.

In contrast with the base case and Strategy 1, the number of cases declines after contact tracing starts. 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 falls quickly after contact tracing is implemented (CDC recommendation).

In this illustration, the outbreak would continue for another 64 days, with an estimated 1,994 cases per 100,000 population over that time. Between 41 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 307 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.

2) Estimated Hospitalizations Averted

Results on this page include two graphs and a table. One graph displays, for the base case and three contact tracing strategies, estimates of total cases (by age group) over the user-specified time horizon for the analysis. The other graph and the table illustrate, for each of the strategies relative to the base case, the estimated number of hospitalizations (non-ICU, ICU, and ICU + ventilator) averted by age group over the user-specified time horizon for the analysis.

3) Estimated Direct Medical Costs Averted

COVIDTracer Advanced produces graphs and tables that contain estimates of direct medical costs averted and Medicaid expenditures averted broken down by strategy and stratified by age group and ward type.

Sensitivity Analysis: ‘What If’ Scenarios

Sensitivity analysis: Introduction: In COVIDTracer Advanced, 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 2) staffing needs:

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

COVIDTracer Advanced 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

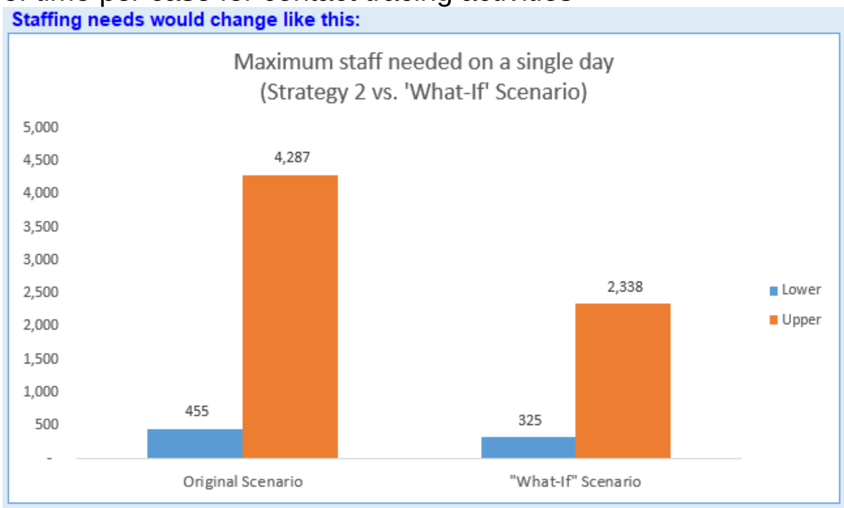
Step 1: Choose A Contact Tracing Strategy Strategy 2

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,

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

A. Default values

Supplemental Table 1. Default values used in COVIDTracer Advanced

Epi Parameters	Default Value (Range)	Source
Infected but not yet infectious period	3 days	CDC COVID-19 Pandemic Planning Scenarios *
Contagious (infectious) period	11 days	He et al. (2020)
New infections per case (R_0)	2.5	CDC COVID-19 Pandemic Planning Scenarios *
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	40%	CDC COVID-19 Pandemic Planning Scenarios *
Relative infectiousness of asymptomatic cases (to symptomatic cases)	75%	CDC COVID-19 Pandemic Planning Scenarios *
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

* CDC COVID-19 Pandemic Planning Scenarios. https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html .
**User may change assumed values in the tool to explore how results change.
† Overhead hours include items such as preparation time, supervisory time, and support staff time.

B. Effects of continued social distancing measures

NOTICE: Community level interventions: Updating input values
The default inputs associated with the potential impact of community-level non-pharmaceutical interventions, such as wearing face masks and limiting gatherings, are based on available data as of mid-November 2020. The values that best describe the impact of one or more such community-level interventions may change as more data are collected and reported.

Users are therefore encouraged to consult the most recent literature available on the subject of estimated impact of such community level interventions, as well as any relevant data that are available from their jurisdictions. An example of a website that posts updates of such information is: https://www.cdc.gov/library/covid19/scienceupdates.html?Sort=Date%3A%3Adesc.

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 Advanced 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 Advanced 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. Detailed Description of Default Contact Tracing Strategies.

The primary focus of the tool is to allow the user to define and compare the relative impacts of a range of options for contact tracing strategies that may be under consideration by decisionmakers in a particular setting. The tool allows the user to see in real-time how changing key parameters can affect estimates of future case counts as well as the number of personnel needed to conduct contact tracing.

The default strategies in the tool (described in detail below) are provided as illustrations to allow the user to quickly see a range of potential strategy options that could be entered into the tool, and give a starting point from which to modify these inputs to fit the individual strategies being considered in their locale.
Users can readily alter and adapt these strategies, as described in the section titled: “Part B. Impact of Contact Tracing Strategies.” This allows the user to flexibly enter a range of scenarios to best match what is being considered for implementation in their locale.

<u>Case identification and contact training strategies</u>

The following contact tracing strategies are based on assumed 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: Cases of COVID-19 are rapidly identified within the community and effectively isolated. Contacts of cases are not identified or asked to isolate.

This represents a “low resource” strategy that allows a user to quickly see that identifying and isolating only symptomatic cases (with no further efforts to identify or isolate those exposed to the case) would have extremely low success in reducing onward transmission, even if 100% of symptomatic cases were successfully identified and isolated (highly improbable).

Details and Default Values

- COVID-19 cases are infectious from days 4-14 after initial exposure/infection, see description of default infectivity distribution.
  - 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.

- Contacts are <u>not</u> listed and identified.
- Contacts are <u>not</u> followed up with.
- 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.

This represents a “medium resource” strategy that both improves upon Strategy 1 in terms of reducing onward transmission, but also requires additional resources. This strategy, although not recommended by CDC guidance, could potentially be considered in areas where testing is unavailable or extremely difficult to obtain.

Details and Default Values

- COVID-19 cases are infectious from days 4-14 after initial exposure/infection, see description of default infectivity distribution.
  - 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.
- Contacts <u>are</u> listed and identified.
- Contacts are <u>not</u> followed up with.
- 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, tested, quarantined, and monitored through daily phone calls for 14 days, as selected by the jurisdiction. If contacts have positive test or become symptomatic, they are re-designated as cases.

This represents a strategy that is in line with current CDC guidance and should illustrate to the user the importance of being able to rapidly identify and effectively isolate both symptomatic and asymptomatic cases.

Details and Default Values

- COVID-19 cases are infectious from days 4-14 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 6-14:
        - 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.
- Contacts <u>are</u> listed and identified.
- Contacts <u>are</u> followed up with.
- All default values can be changed by the user to examine the impact of different levels of success with the contact tracing strategies.

D. Model overview

COVIDTracer Advanced 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 11 days (He et al.,

2020) and includes both pre-symptomatic (2 days) and symptomatic (9 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 R_0 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.

E. Direct medical cost calculation

Cost analysis: Hospitals provide an initial set of charges for services and material used in treating a patient. Both Medicare/ Medicaid and commercial insurance companies obtain discounts on those charges. For example, for FY2020, Centers for Medicare and Medicaid Services (CMS) reimbursed urban-based hospitals using a nation-wide cost to charge ratio of approximately 0.293. That is, for every $1 charged Medicare/ Medicaid typically paid an average of approximately $0.29 (Table 8c at: https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/FY2020-IPPS-Final-Rule-Home-Page-Items/FY2020-IPPS-Final-Rule-Tables). Commercial health insurance firms typically negotiate their own discounts for services provided. These discounts can vary greatly by locale, insurance company and type of coverage that the patient bought.

We used Premier Healthcare Database, which is U.S. hospital-based database that contains healthcare utilization and financial data from patients hospitalized in approximately 700 hospitals. We created a dataset consisting of a cohort of patients treated for COVID-19 in hospital settings in the year 2020. We included patients covered by Medicaid and Non-Medicaid (including self-pay). We divided the cohort of patients in 3 different age groups and followed them through different paths of treatments to

estimate the healthcare costs ($) and length of hospital stays (days). We estimated the costs for patients treated in general wards, patients treated in intensive care units (ICU) without the use of mechanical ventilators and patients treated in ICU with the use of mechanical ventilators. 2019 Cost-to-charge ratios (CCR) were used to adjust charges that had not already been adjusted. For those patients whose records were not already adjusted (i.e., their records only included pre-adjusted charges), we adjusted those charges by using a cost-to-charge ratio of 0.30, obtained from the data in the Premier database. A summary of the healthcare costs and length of stay extracted from the Premier database are presented in Supplemental Tables 3 and 4.
NOTE: Supplemental Tables 3 and 4 contain hospital costs.

Supplemental Table 3: Summary of COVID-related hospital costs ($) and LOS (days) among different age group and treatment settings (Non-Medicaid)

	Cost($)/case/day			LOS (day) /case		
Age group	General ward	ICU (No ventilator)	ICU+ Ventilator	General ward	ICU (No ventilator)	ICU + Ventilator
0-17	$2,340.35	$3,374.66	$5,685.90	2.00	5.00	13.00
18-64	$2,117.40	$2,080.47	$3,669.90	4.00	5.00	14.00
65+	$2,061.42	$2,078.49	$3,596.81	5.00	6.00	12.00

Source: Premier Health Care Database, Premier, Inc.13034 Ballantyne Corporate Place Charlotte, NC 28277.

Supplemental Table 4: Summary of COVID-related hospital costs ($) and LOS (days) among different age group and treatment settings (Medicaid)

	Cost($)/case/day			LOS (day) /case		
Age group	General ward	ICU (No ventilator)	ICU+ Ventilator	General ward	ICU (No ventilator)	ICU + Ventilator
0-17	$2,317.91	$3,199.21	$4,494.69	2.00	4.00	10.00
18-64	$2,294.66	$2,231.62	$3,919.10	3.00	5.00	14.00
65+	$2,489.28	$2,179.42	$3,912.36	5.00	7.00	13.00

Source: Premier Health Care Database, Premier, Inc.13034 Ballantyne Corporate Place Charlotte, NC 28277.

To compare the estimates from Premier healthcare database, and to illustrate the potential impact of adjusting hospital charges to allow for actual insurance company reimbursements we used IBM® MarketScan® Treatment Pathways, an online tool that allowed us to access and analyze IBM MarketScan Research Databases. Since there are not yet COVID-19 related healthcare data in this database, we analyzed the costs of a cohort of influenza patients (diagnosed using ICD-10 codes) who were hospitalized. The healthcare reimbursements (payments made by insurance companies, including CMS, and not hospital charges) are summarized in supplemental Tables 5 and 6.

Supplemental Table 5: Summary of influenza-related insurance payments ($) and LOS (days) among different age group and treatment settings (Non-Medicaid Commercial insurance)

	Payment($)/case/day			LOS /case (day)		
Age group	General ward	ICU (No ventilator)	ICU+ Ventilator	General ward	ICU (No ventilator)	ICU + Ventilator
0-17	$3,905.37	$4,668.07	$6,419.15	2	4	7
18-64	$3,918.24	$4,187.98	$4,646.86	3	4	11
65+	$2,588.37	$2,429.63	$2,420.18	5	5	11

Source: IBM® Treatment Pathways MarketScan database, 2015-2020

Supplemental Table 6: Summary of influenza-related insurance payments ($) and LOS (days) among different age group and treatment settings (Medicaid)

	Payment($)/case/day			LOS /case (day)		
Age group	General ward	ICU (No ventilator)	ICU+ Ventilator	General ward	ICU (No ventilator)	ICU + Ventilator
0-17	$1,248.23	$1,372.24	$1,445.75	2	5	11
18-64	$1,535.53	$1,584.81	$1,537.95	3	3	9
65+	$1,463.83	$1,340.88	$1,834.85	4	6	5

Source: IBM® Treatment Pathways Medicaid database, 2009-2019

F. Frequently asked situations: worked examples

Example #1: Special sub-populations: Illustrating the potential impact of interventions to control the spread of COVID among sub-populations.

Intended audience: Administrators of institutions such as schools, universities and nursing homes, where the administrator and their staff are charged with the task of reducing the risk of COVID-19 transmission among those either attending the institution (e.g., staff and pupils)

Perspective of intended audience: The first, and main priority, of the intended audience is to ensure the health and wellbeing of the sub-population directly associated with their institutions (e.g., students who attend classes, residents of nursing homes).

Worked Example:
Situation: A college campus, with a total of "on-site" staff and students of approximately 30,000 persons, has experienced in the past 14 days, 350 persons testing positive for, and/ or being diagnosed with, COVID-19.

The college administrators want-and-need to get this campus-based outbreak under control - as rapidly as possible, whilst keeping the campus "open," and having as many in-person classes as feasible.

Assessing options: Assume an administrator of a college campus who wishes to examine the potential impact of 3 different combinations of interventions, as given in

Table 1. [Note: Beyond the input values and scenario described in the Steps given in this example, for simplicity all other COVIDTracer Advanced input values are kept at default. Users can, of course, change the other default values as they wish]

Table 1: Three scenarios of potential interventions with assumed levels of effectiveness

	Mask wearing			Class Size	Contact tracing			
Scenario name	Efficacy of mask wearing	Assumed mask wearing compliance	Overall effectiveness of mask wearing	Assumed impact cut class size	Days after infection isolation of case	% cases successfully isolated + contacts traced & monitored	Effectiveness contact tracing	TOTAL assumed reduction in transmission
Mask #1 + Contact Tracing	60%	20%	12%		7	50%	20%	32%
Mask #2 + limit class size + Contact tracing	60%	20%	12%	6%	7	50%	20%	40%
Mask #3 + limit class size + Contact tracing	60%	40%	24%	12%	7	50%	20%	56%

Steps in using COVIDTracer Advanced to estimate the potential impact of interventions:

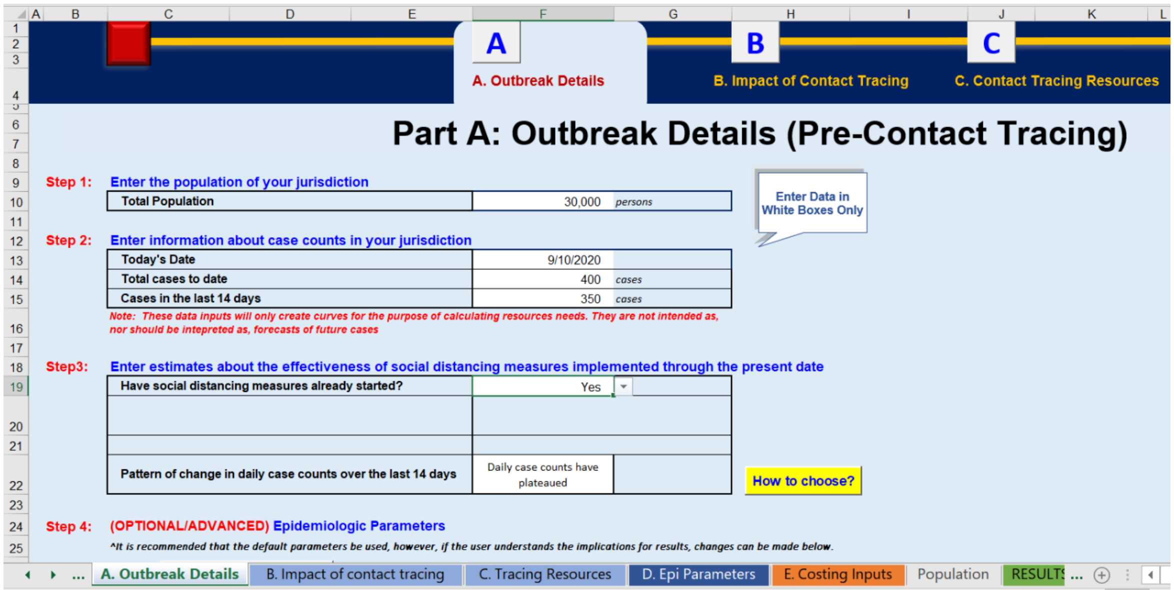
Step 1: Defining the size of the sub-population: In Part A, Step 1, enter the total sub-population that will covered by the potential interventions. This total should include students (if dealing with an educational institution), patients/ residents, staff, support staff, part time staff and volunteers – essentially, anybody who will physically come into the institution. Those who will totally virtually interact with the institution (i.e., never physically visit the institution) can be omitted from the estimate of the total population.

Step 2: Enter the number of cases that has been reported among the sub-population – both cumulative total to date, and those recorded in past 14 days.
Step 2: NOTE #1: Do not worry about where such cases were infected, even if it is likely that some were infected outside of the institution.
Step 2: NOTE #2: at a minimum, the total cumulative total cases-to-date should equal the number of cases recorded in past 14 days.

Step 3: Enter the following 2 pieces of information:
a) Already started social distancing/ intervention measures (of any type) have already been initiated among the sub-population/ in the institution. Do not consider any measures that are currently under-way among the general population.
b) Case increasing/ plateauing/ decreasing among the sub-population ONLY.

Step 3: NOTE #1: If user is unsure about the current rate-of-growth of cases among the sub-population, start by assuming “plateau” (constant number of cases over time, no perceptible change). Then, the user, after obtaining some initial Results, should consider going back and evaluating the impact on Results if that assumption is changed (e.g., go from “cases are plateauing” to “cases are slowly increasing.” The goal is to assess the impact of the initial assumption regarding current rate of growth of cases).

Figure 1: PART A: Entering population size, reported cases, and growth of cases within sub-population.



Step 4: User defines scenarios for contact tracing (Step 2 on Part B of COVIDTracer Advanced): The user defines the potential effectiveness of interventions as given in Table 1. The manual contains a detailed explanation of how to set scenarios for contact tracing strategies (Step 2 in Part B). In this example, to allow ease-of-comparison between various scenarios of additional (to contact tracing) interventions, the effectiveness of contact tracing has been set equal across all three contact tracing strategies (Table 1, Figure 2).

Step 5: User defines scenarios for additional interventions (Step 3 on Part B): In this example, we assume a user to be an administrator for a college campus, who wishes to examine the 3 scenarios given in Table 1 of this worked example, entered into COVIDTracer Advanced, Part B, as shown in Figure 2.

Figure 2: PART B: Impact in sub-population of contact tracing and other interventions*

Date contact tracing begins (no ramp-up)	9/14/2020
Date chosen	9/14/2020

Step 2: Set up the scenarios for contact tracing strategies

Contact Tracing Strategy Input	Mask #1	Mask #2 + limited class size	Mask #3 + limited class size
Number of days after infection that case is isolated	7	7	7
% of all cases successfully isolated and contacts traced and monitored	50%	50%	50%
Strategy Trigger	Contact ID	Contact ID	Contact ID
Contacts are identified and listed?	Yes	Yes	Yes
Contacts follow-up occurs?	Yes	Yes	Yes

Enter Data in White Boxes Only

Impact of timing of case isolation?

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

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

Social Distancing Continues?	Mask #1	Mask #2 + limited class size	Mask #3 + limited class size
Will partial social distancing restrictions continue?	Yes	Yes	Yes
Estimated % reduction in transmission due to continued partial social distancing	12%	20%	36%
Combined % reduction in transmission from contact tracing + continued social distancing, if applicable	32.0%	40.0%	56.0%

B. Impact of contact tracing | C. Tracing Resources | D. Epi Parameters | E. Costing Inputs | Population | RESULTS | RESULTS_Costs

* The scenarios and values indicting potential impact are given in Table 1

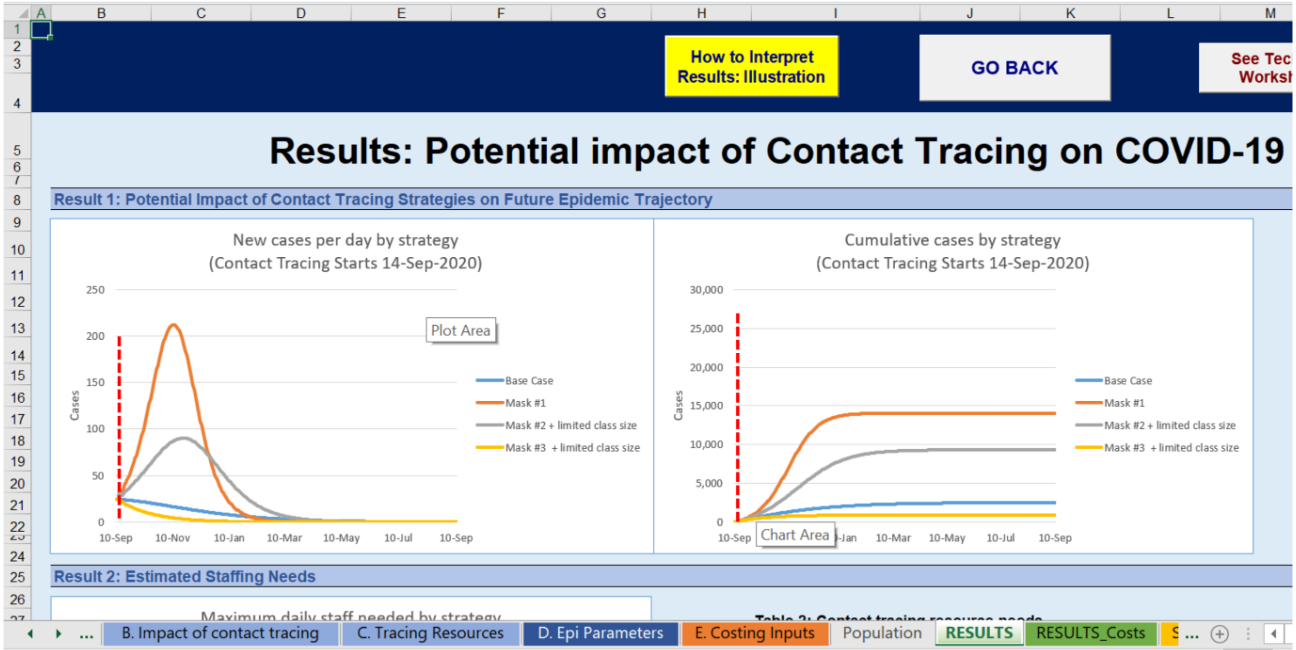
Step 6: Evaluating the Results: Figure 3 shows the Results produced using the scenarios and input values described in Steps 1 -5 of this worked example.

What do the Results "show?" The Results show that:
i) Scenarios labeled "Mask #1" and Mask #2" (see Table 1) will result, when compared to current, baseline, in an INCREASE in cases.

ii) Scenario labeled "Mask #3" has fewer cases (but NOT zero cases) than even the baseline. In this scenario, cases will decline to zero in late December 2020 (figure 3).

iii) The baseline is calculated using the assumptions set in Steps 1-3 for this example, (Figure 1), assuming 350 cases in past 14 days and trend in cases-per=day described (by the user) as "plateauing." Eventually, in late March 2021, cases-per-day will decline to zero (Figure 3).

Figure 3: Results Impact in sub-population of contact tracing and other interventions*



* The scenarios and values indicting potential impact are given in Table 1

Step 7: Policy implications: From the perspective of college administrators who need to get the campus-based outbreak under control, potentially using the interventions listed in Table 1, the policy implications are:

i) Scenarios labeled "Mask #1" and "Mask #2" are likely to be entirely untenable. The overall levels of effectiveness (combined – Table 1, Figure 2) are insufficient to rapidly bring the outbreak under control.

ii) The "baseline" scenario, in which cases are currently "plateaued' and then gradually decrease, takes too long to bring about an end of the outbreak.

iii) Scenario labeled "Mask 3" produces the smallest number of cases and in the shortest time – though cases are still likely to occur through the end of December.

Step 8: Consider feasibility: Although scenario labeled "Mask #3" may appear to be the "best option" for the college administrators to pursue, they will need to consider the feasibility of such a scenario. They need to consider how likely it will be, on a large college campus, that there will be 40% compliance of effective mask wearing. And, how likely is it that limiting class size will reduce transmission by the assumed value of 12% (Table 1, Figure 2)?

That is, in order to achieve the level of mask wearing compliance and reduction in transmission form limiting class sizes, the college administrators may need to consider additional measures, such as limiting the number of persons on campus (and college affiliated buildings and areas, such as dorms and fraternities).
Note also that there is no consideration in COVIDTracer Advanced of who will do the contact tracing. Typically, public health agencies conduct such but during this pandemic, many public health agencies do not have the capacity to conduct all the contact tracing

needed Thus, it may be problematic to ensure that even 50% of cases and their contacts are identified and effectively isolated as defined in Table 1 and Figure 2.

Step 9: Considering caveats and limitations: Any mathematical model of disease transmission is inevitably a simplification of “real life.” Thus, the user of COVIDTracer Advanced has to remember the limitations of using such a tool. These limitations include:

i) Constant level of effectiveness/ impact: Within each scenario, there is the implicit assumption that the stated level of effective reduction in transmission will remain constant over the time examined (e.g., essentially the Fall 2020 semester). People can become fatigued with these rather restrictive interventions, and the demonstrate reduced compliance-over-time.

ii) There is no allowance for “potential super-spreader” events: Even with college mandated restrictions regarding size-of-gatherings, there may still be large gatherings of college-affiliated persons for some specific event.

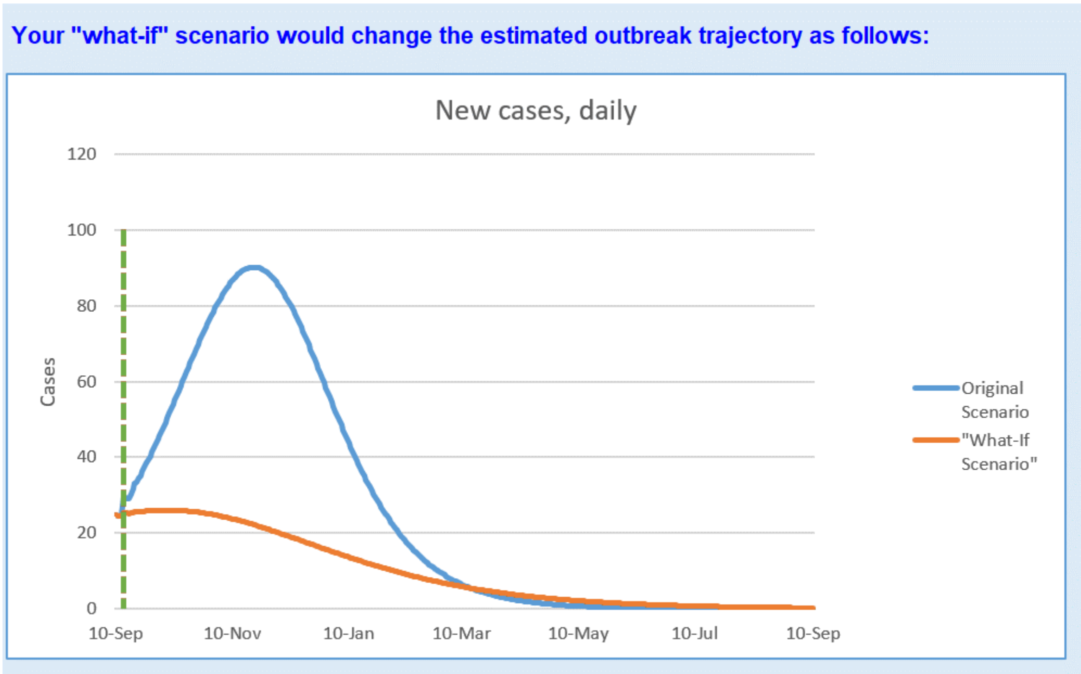
Step 10: Sensitivity analyses: An essential step: There is unlikely to be a “simple and easy fix” for the issues raised in Steps 8 and 9. The user will therefore likely find it useful to explore the impact of altering some of the input values – conducting sensitivity analyses.

COVIDTracer Advanced contains some built-in sensitivity analyses tools (in the Results page), and the manual describes how to use those tools.

For example, Figure 4, produced by using one of the sensitivity tools in the Results page, illustrates the impact of simultaneously assuming:
i) Earlier “Days after infection isolation of case”, from the 7 days given in Table 1 to an assumed 5 days (Figure 4).
ii) Reduction in successfully isolating cases by Day 5, from 50% to 35%.

From Figure 4, for the scenario labeled “Mask #2” (Table 1, Figure 2) the user can see that, even if “successful” isolation of cases and their contact drops to 35%, BUT identification of cases and contacting and start of isolation of contacts of cases starts earlier on Day 5 – then there will be notably fewer cases than is estimated to occur with the original set of assumptions (as in Table 1)

Figure 4: Sensitivity analysis: **Scenario “Mask #2”*:** Impact on cases-per-day due to changes in when cases are identified and degree of success in effectively isolating cases and their contacts.



* See Table 1 and Figure 2 for details defining scenario “Mask #2.”

G. COVIDTracer Advanced Draft Report Template

Overview of report template
This template is a suggested method of presenting a brief report of the estimates of potential impact of community level interventions calculated using COVIDTracer Advanced. The user can remove, add or otherwise alter this template as needed.

Contents of draft report

1) Objective

2) Summary of results

3) Results: Figures and tables (in order of appearance in report)
    - Figure 1: Total cases, by age group and strategy
    - Figure 2: Hospitalizations averted relative to base case, by age group and ward type
    - Table 1: Total hospitalizations averted, by strategy and age group
    - Figure 3: Direct medical costs averted relative to base case, by age group and ward type
    - Table 2: Direct medical costs averted relative to base case, by age group and ward type
    - Figure 4: Medicaid expenditures averted relative to base case, by age group and ward type
    - Table 3: Medicaid expenditures averted relative to base case, by age group and ward type

4) Methods

5) Appendices
    A. Description of scenarios with assumptions
    B. Epidemiologic parameters, and default values

Disclaimers. The numbers contained in this report should be treated as illustrations of what *could* happen (with unknown probability of actual occurrence). The numbers in this report, therefore, are intended solely as a guide to help public health officials and policymakers plan and prepare.

The findings and conclusions in this report and the accompanying appendices and spreadsheets are those of the author and do not necessarily represent the views of [Jurisdiction X].

This report is considered to represent technical help to the Department of Public Health, Government of Locale Y. It is not considered a publication of any form, nor has it been officially cleared by the author's agency. The mention of any specific, commercially available product is merely to inform the reader of methods used to produce the results presented. Such mention of specific products does not constitute any endorsement.

DRAFT Report Template
Potential impact of public health interventions designed to reduce and slow transmission for COVID-19 in [jurisdiction X]

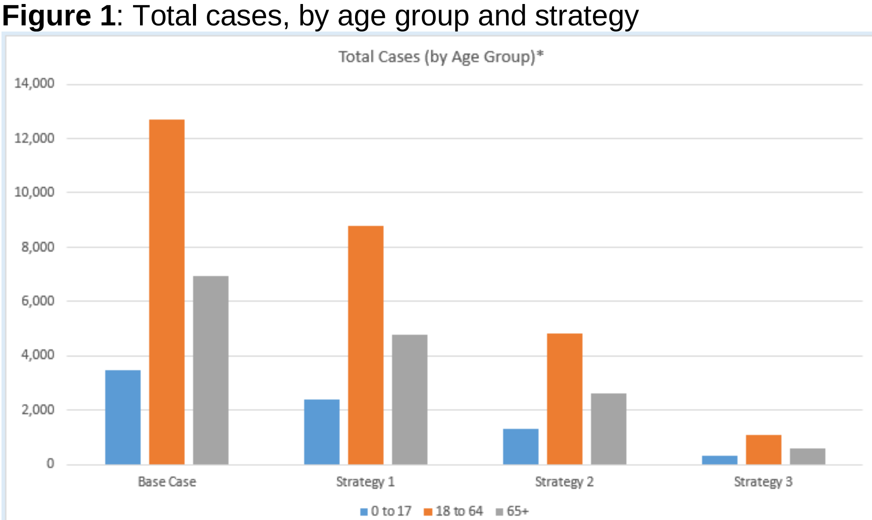
Objective
To illustrate using jurisdiction-specific data, the potential impact of community level interventions (e.g., contact tracing and mask wearing), disaggregated into age groups, designed to mitigate transmission of COVID-19 in [Jurisdiction X]. Illustrations of impact compare a base case to three alternative community-level, public health intervention strategies in terms of estimated total cases, potential number of hospitalizations averted, potential direct medical costs averted, and Medicaid expenditures averted.

Summary of Results (Example bullet points based on COVIDTracer Advanced default values)

- Compared to current social distancing practices (base case), all three strategies that employ some level of community-based interventions reduce COVID-19 transmission across all age groups, with Strategy 3 having the largest estimated impact (Figure 1).
- Compared to the base case, all three strategies that employ some level of community-based interventions result in reduced ICU and non-ICU hospitalizations, most notably among adult populations. An estimated total 350 non-ICU hospitalizations and 137 ICU (non-ventilator) hospitalizations are averted under Strategy 3 (Figure 2 and Table 1).
- Total direct medical costs averted (all age groups and ward types) relative to the base case range from an estimated $1.5 million under Strategy 1 to an estimated $4.6 million under Strategy 3. Across all strategies, estimated costs averted are largest for adults 65+ years of age; and under Strategy 3, total direct medical costs averted for this age group are an estimated $2.5 million (Figure 3 and Table 2).

Results: Figures and tables (user copy-pastes appropriate figures from COVIDTracer Advanced)

Figure 1: Total cases, by age group and strategy



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Tables and graphs (user copy-pastes appropriate figures from COVIDTracer Advanced)

Figure 2: Hospitalizations averted relative to base case, by age group and ward type

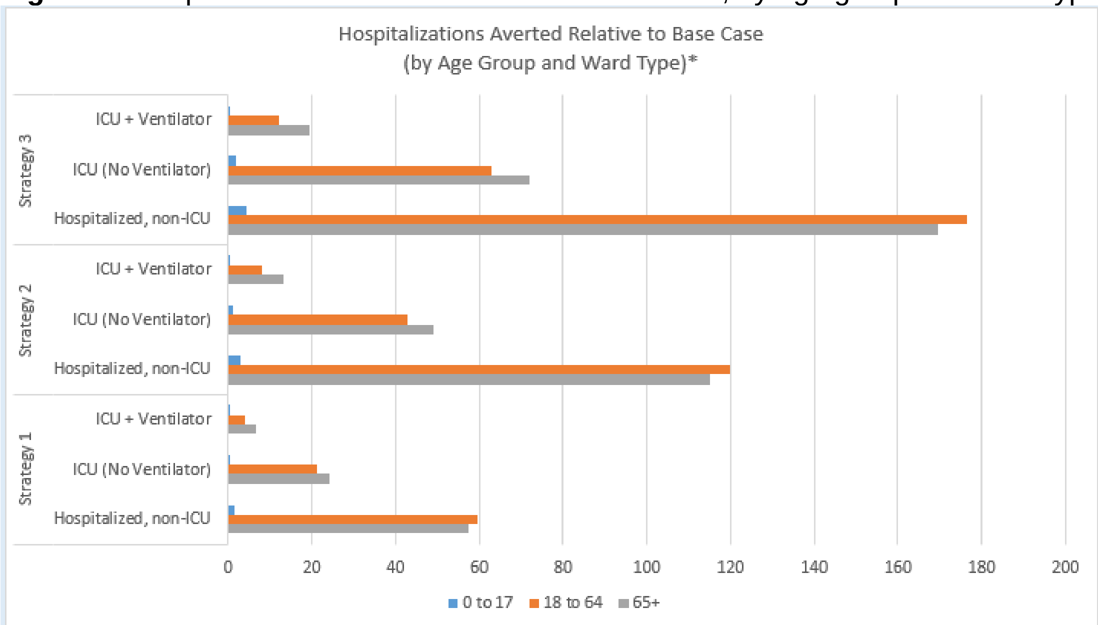

Table 1. Total hospitalizations averted, by age group and ward type

Total Hospitalizations Averted												
	Strategy 1				Strategy 2				Strategy 3			
Age (year)	Non-ICU	ICU	ICU + Ventilator	Total	Non-ICU	ICU	ICU + Ventilator	Total	Non-ICU	ICU	ICU + Ventilator	Total
0 to 17	1	1	0	2	3	1	0	4	4	2	0	6
18 to 64	60	21	4	85	120	43	8	171	176	63	12	252
65+	57	24	7	88	115	49	13	177	170	72	19	261
Total	118	46	11	175	238	93	22	352	350	137	32	519

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Figure 3: Direct medical costs averted relative to base case, by age group and ward type

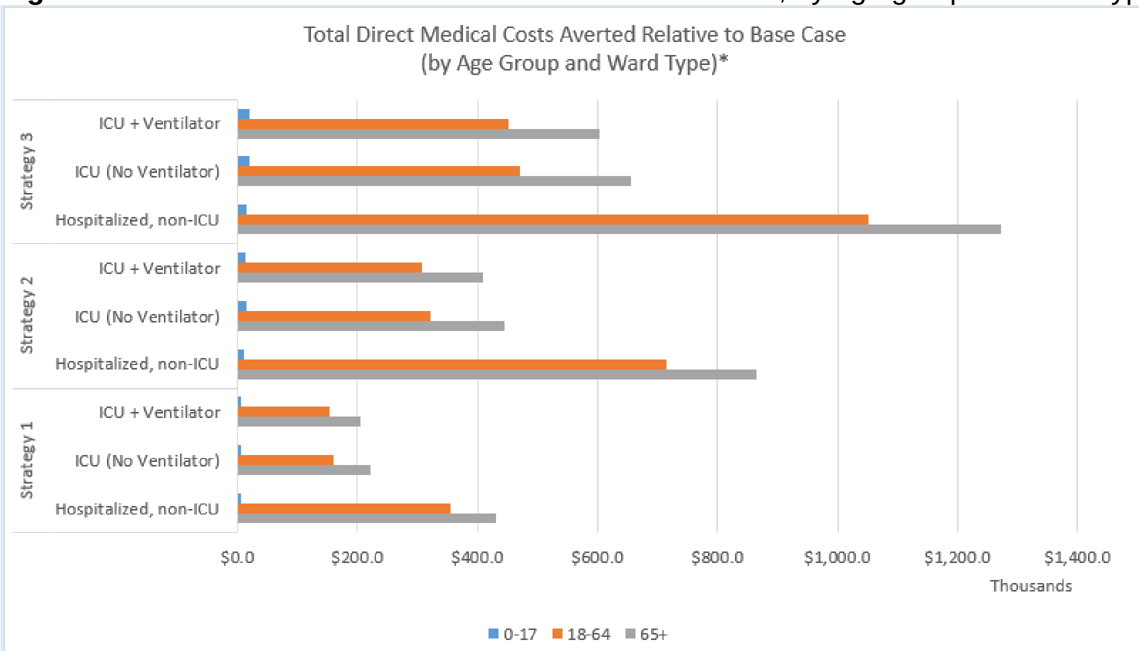

Table 2. Total direct medical costs averted relative to base case, by age group and ward type

Total Direct Medical Costs Averted Relative to Base Case												
	Strategy 1				Strategy 2				Strategy 3			
Age (year)	Hospitalized, non-ICU	ICU (No Ventilator)	ICU + Ventilator	Total	Hospitalized, non-ICU	ICU (No Ventilator)	ICU + Ventilator	Total	Hospitalized, non-ICU	ICU (No Ventilator)	ICU + Ventilator	Total
0 to 17	$4,903	$7,117	$6,480	$18,501	$9,854	$14,304	$13,024	$37,182	$14,523	$21,080	$19,193	$54,795
18 to 64	$355,276	$159,316	$152,463	$667,055	$714,019	$320,188	$306,414	$1,340,621	$1,052,254	$471,862	$451,563	$1,975,679
65+	$429,786	$221,210	$203,993	$854,989	$863,767	$444,579	$409,978	$1,718,324	$1,272,937	$655,179	$604,186	$2,532,301
	$789,965	$387,644	$362,936	$1,540,545	$1,587,641	$779,071	$729,415	$3,096,127	$2,339,713	$1,148,120	$1,074,942	$4,562,775

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Figure 4: Medicaid expenditures averted relative to base case, by age group and ward type

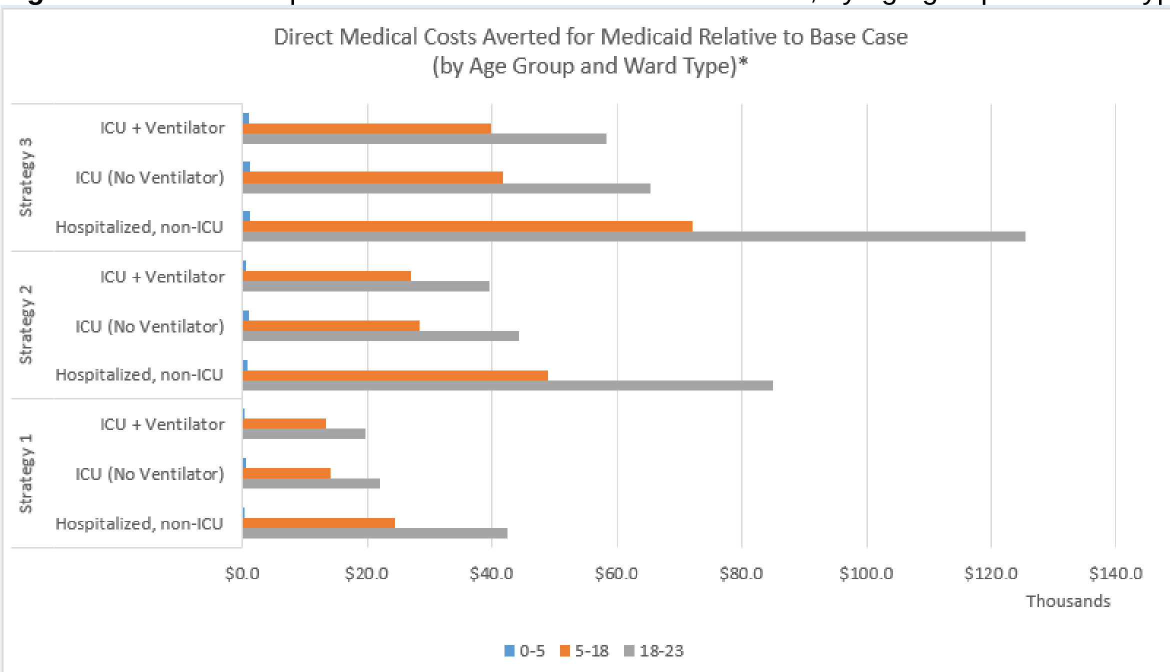

Table 3. Total Medicaid costs averted relative to base case, by age group and ward type

Total Medicaid Expenditures Averted Relative to Base Case												
	Strategy 1				Strategy 2				Strategy 3			
Age (year)	Hospitalized, non-ICU	ICU (No Ventilator)	ICU + Ventilator	Total	Hospitalized, non-ICU	ICU (No Ventilator)	ICU + Ventilator	Total	Hospitalized, non-ICU	ICU (No Ventilator)	ICU + Ventilator	Total
0 to 17	$404	$457	$338	$1,199	$811	$919	$680	$2,410	$1,195	$1,355	$1,002	$3,551
18 to 64	$24,355	$14,104	$13,443	$51,902	$48,947	$28,346	$27,017	$104,310	$72,134	$41,773	$39,815	$153,722
65+	$42,362	$22,060	$19,668	$84,089	$85,137	$44,335	$39,527	$169,000	$125,467	$65,337	$58,251	$249,056
	$67,120	$36,621	$33,449	$137,190	$134,896	$73,600	$67,224	$275,720	$198,796	$108,465	$99,068	$406,329

DRAFT Report Template
Potential impact of public health interventions designed to reduce and slow transmission for COVID-19 in [jurisdiction X]

Methods: Used the COVIDTracer Advanced tool to produce estimates of total COVID-19 cases, hospitalizations averted, direct medical costs averted, and Medicaid expenditures averted during the period [user specifies time horizon].

Data sources used to obtain estimates: (user lists data sources or default values used for each of the input tabs listed below)

Part A. Outbreak Details**;**
Part B. Impact of Contact Tracing Strategies;
Part C. Contact Tracing Resources Needed;
Part D: Epidemiological Parameters (advanced/optional);
Part E.1: Hospitalization Inputs; and
Part E.2: Direct Medical Costs (i.e., costs of COVID-19 related hospitalizations).

Appendices

A. Description of scenarios with assumptions

Base case: Current social distancing interventions to “flatten the curve.”

Scenario 1: Estimate the impact of the current mandates around wearing face masks combined with current contact tracing efforts.

Assumptions:

- Minimal social distancing efforts are in place, along with a mandate that masks be worn at all times by staff in restaurants and bars. The baseline R_0 is 2.0, (i.e., without any mitigation efforts each case will produce, on average 2.0 new cases).
- Case are identified and isolated on average, on the 5th day after symptom onset (i.e., on the 10th day after infection).
- The face mask and social distancing mandates currently in place reduce transmission by 15%.

Scenario 2: Estimate the impact of expanded use of face mask wearing (e.g., masks required in all indoor public spaces) and social distancing such that onward transmission is reduced by 25%, combined with improvement in contact tracing performance such that the time between symptom onset and case isolation is reduced from 5 days to 2 days.

Assumptions (some changed from situation 1):

- Social distancing efforts increase such that face masks are required to be worn by staff in all indoor businesses, reducing onward transmission by 25% due to these measures.
- Cases are identified and contact tracing begins, on average, on the 2nd days after symptom onset.

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- 50% of contacts are followed up with and adhere to public health recommendations to self-monitor for symptoms and self-isolate when they arise. 50% of cases comply with isolation such that onward transmission is reduced by 20%.
- The combined reduction in transmission due to additional social distancing measures and improved contact tracing is 45%.

Scenario 3: Estimate the impact of expanded use of face mask wearing (e.g., universal mandate to wear face masks in public) such that onward transmission is reduced by 40%, combined with improvement in contact tracing performance such that the time between symptom onset and case isolation is reduced from 5 days to 2 days.

Assumptions (some changed from situations 1 & 2):

- Some social distancing efforts (e.g., reduced social mobility, face mask use) are in place such that onward transmission is reduced by 40% due to these measures.
- 50% of contacts are followed up with and adhere to public health recommendations to self-monitor for symptoms and self-isolate when they arise. 50% of cases comply with isolation such that onward transmission is reduced by 20%.
- The combined reduction in transmission due to additional social distancing measures and improved contact tracing is 60%.

DRAFT Report Template
Potential impact of public health interventions designed to reduce and slow transmission for COVID-19 in [jurisdiction X]

B. Epidemiologic parameters, and default values

Table 1. Default values used in COVIDTracer Advanced

Epi Parameters	Default Value (Range)	Source
Infected but not yet infectious period	3 days	CDC COVID-19 Pandemic Planning Scenarios*
Contagious (infectious) period	11 days	He et al. (2020)
New infections per case (R_0)	2.5	CDC COVID-19 Pandemic Planning Scenarios*
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	40%	CDC COVID-19 Pandemic Planning Scenarios*
Relative infectiousness of asymptomatic cases (to symptomatic cases)	75%	CDC COVID-19 Pandemic Planning Scenarios*
Number of contacts per case**	Upper: 5 Lower: 20	Assumed

* CDC COVID-19 Pandemic Planning Scenarios. https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html .

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