COVID-19

RESOLVE TO SAVE LIVES Vital Strategies

APRIL 2021

Measures to Improve COVID-19 Response

END-TO-END QUALITY IMPROVEMENT OF COVID-19 TESTING, CASE INVESTIGATION AND CONTACT TRACING

DISCLAIMER

This guidance was developed in April 2021 to increase awareness of the need for timely and complete contact tracing to reduce COVID-19 transmission, largely driven by the short incubation period. As new variants emerge, often with increased transmissibility and shortened incubation periods, timely and complete case investigation and contact tracing become challenging or infeasible to implement for the general population.

The timeliness and completeness targets presented here must be adapted based on the epidemiology of the present variant or disease. When widespread transmission is occurring or resources are limited, the objective of performing case investigation and contact tracing must change to address logistical constraints and minimize the public health impacts of COVID-19. Health authorities and organizations may consider reserving case investigation and contact tracing only for certain high-risk congregate settings such as correctional facilities, shelters, and health facilities. Looking forward, this guidance and the bottlenecks approach it presents may be of assistance in responding to emerging variants or implementing quality improvement measures for future epidemic-prone diseases.

For the US setting, several public health organizations have issued a joint statement with an updated position on contact tracing, available here.

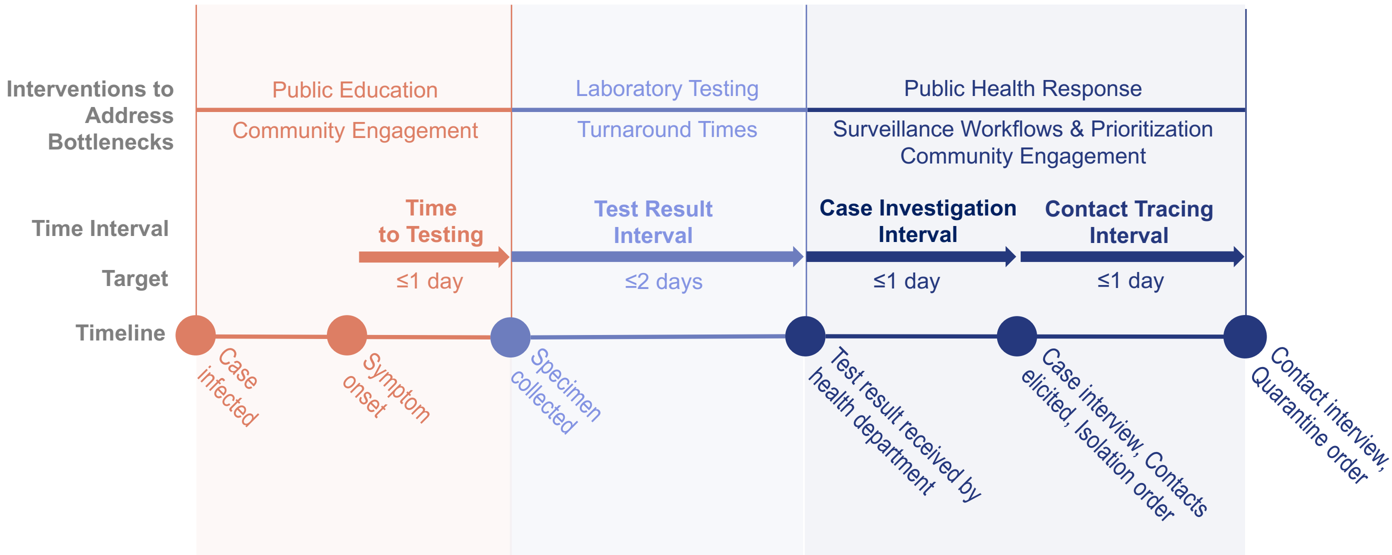
Visit PreventEpidemics.org for more.
Prevent Epidemics is a project of Resolve to Save Lives, an initiative of Vital Strategies.

Contents

Executive Summary

The COVID-19 pandemic poses severe challenges to the health ministries, regional authorities and local health departments responsible for controlling disease. This framework focuses on improving key response activities including testing, case investigation and contact tracing. In this updated second version, we have also integrated vaccines as an important tool in COVID-19 control. Other crucial components of a more effective COVID-19 response include prevention efforts such as mask use, handwashing and physical distancing.

Effective case investigation and contact tracing require a series of actions to be completed in a timely and comprehensive fashion by community members, health care providers and public health staff — from an initial case seeking testing to their contacts being identified and quarantined. If any step in this chain of events is delayed or incomplete, it will impact the entire system. Identifying bottlenecks and gaps in this chain of events is part of a systems approach in which public health actors use data to inform targeted interventions. **Case investigation and contact tracing can only reduce COVID-19 transmission when timeliness and completeness criteria are met.**



This document outlines targets for key completeness measures and time intervals between activities, based on mathematical models of case investigation and contact tracing, to effectively reduce COVID-19 transmission. Applying widely accepted methods of health care quality improvement, we provide a step- by-step framework for teams to use in analyzing and improving their systems of epidemic control.

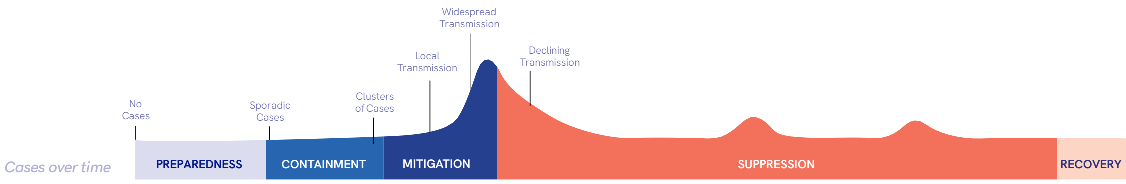
THIS DOCUMENT:

1. Defines **key metrics** (completeness and timeliness indicators) to track testing, case investigation and contact tracing efforts,
2. Outlines a process (the **bottlenecks approach**) that can be used to identify gaps, delays, and areas for improvement,
3. Describes specific **interventions** that can be taken to address the gaps and delays identified.

Using this Document in a Surge or During Vaccination

Response to the COVID-19 pandemic must change as the course of the pandemic changes. As cases surge, it becomes close to impossible to reach every case and trace every one of their contacts. During surge times, it is critical to use case investigation and contact tracing (CI/CT) to identify outbreaks with the highest risk of spreading disease and stop them through effective risk communication and community engagement. It must be impressed upon the public to both observe the "3 W's" — wear a mask, wash your hands and watch your distance — and to take responsibility for isolating when they are sick or test positive, informing the close contacts they may have exposed, and working with public health authorities to identify potential super-spreader events.

The introduction of COVID-19 vaccines is another critical juncture in the pandemic response that will introduce new opportunities to adapt and refocus CI/CT programs. During rollout of COVID-19 vaccines, CI/CT staff may be reallocated to support vaccination activities. When capacity is not sufficient to reach all COVID-19 cases, similar to during a surge, CI/CT can be focused on priority populations, such as communities with low vaccination coverage. Once vaccine is widely available, declining transmission will present health departments with an opportunity to reach every case and trace all contacts. In this setting, CI/CT is crucial to control outbreaks and hotspots, and to identify emerging threats, such as viral variants that may cause change in transmission and severity. In addition, information from CI/CT will identify communities at high risk for on-going transmission, which can inform tailored community engagement efforts and vaccination campaigns to boost coverage in these communities and control COVID-19. Because vulnerable communities have suffered a disproportionate burden of COVID-19 disease and are less likely to have sufficient vaccination coverage, prioritizing CI/CT to control transmission in hotspots may also contribute to reducing disparities.



	PREPAREDNESS	CONTAINMENT	MITIGATION	SUPPRESSION	RECOVERY
Case Investigation	Investigate all cases			Investigate all cases	
			Prioritize cases for investigation		
Contact Tracing	Trace contacts to reduce transmission			Trace contacts to reduce transmission	
	Lookback contact tracing to identify high yield events			Lookback contact tracing to identify high yield events	
			Prioritize contacts for notification		
Key Messages	Get tested as early as possible after symptoms; get tested if exposed				
	3Ws: Wear a Mask, Wash your Hands, Watch your Distance				
	Get vaccinated as soon as you are eligible				
			Public health capacity is being exceeded		
			Self-reporting, self-isolation, and home care of cases		
			Self-notification of contacts		

Above is a graphic of Resolve to Save Lives' "Adaptive Response" framework, updated to zoom in on the role of case investigation and contact tracing. There are no specific numerical thresholds for suspending contact tracing activities. Instead, public health authorities should use the timeliness and completeness indicators to identify the point at which their CI/CT programs can no longer keep up with the growth in cases. **The**

Bottlenecks Approach provides public health authorities a capacity based (rather than incidence-based) approach to determining thresholds.

Our recommendations for adapting CI/CT to different phases of the epidemic are shown in the table below:

When cases are low: Use a quality improvement framework to improve case investigation and contact tracing to suppress transmission.

When cases are increasing and capacity is stretched: Prioritize cases for investigation and emphasize look-back contact tracing.

When cases exceed public health capacity: Shift efforts to communication with affected communities, promote the 3 W's, and provide the public with tools for self-recognition, reporting and notification of contacts.

Transmission Setting	Capacity Setting	Objective	Priorities	Additional priorities, if vaccines are available
1. Sporadic cases, clusters of cases, declining transmission	Ability to implement timely and complete CI/CT	**Suppress** reproduction number	**1.** Use CI/CT at scale to suppress transmission (reduce reproduction number); use timeliness and completeness to improve systems quality **2.** Increase testing in areas where clusters or outbreaks are identified	**1.** Use information about unvaccinated cases and contacts to inform targeted vaccination and community engagement[1] **2.** Offer vaccination to people exposed to COVID-19 to protect them during future exposures[2]

Transmission Setting	Capacity Setting	Objective	Priorities	Additional priorities, if vaccines are available
2. Increasing local transmission	Reduction in timeliness and completeness of CI/CT at scale	**Maximize public health yield** of case investigation and contact tracing; prepare for widespread transmission scenario	**1.** Shift strategies to focus on identifying super-spreading events and "high yield" settings to inform policy and public health response **2.** Prioritize order of case investigations to maximize public health yield, focusing on recent cases and cases likely to have larger numbers of contacts **3.** Prioritize notification of contacts to maximize public health yield, focusing on household contacts, those in high-risk settings and those with exposure to vulnerable populations **4.** Prepare for widespread transmission by training contact tracers to perform other key public health activities and communicating to the public that case volume might surpass the ability of public health authorities to effectively test and trace	**1.** Offer vaccination to people exposed to COVID-19 to protect them during future exposures[2] **2.** Prioritize order of case investigations and contact notification: a. To identify emerging changes to local epidemiology, focus on cases among people who are vaccinated, have a history of prior SARS-CoV-2 infection or infection with a variant of concern, and their contacts. b. To maximize public health yield, focus on cases and contacts from communities with low vaccination coverage (more likely to have unvaccinated contacts) **3.** Prepare to maintain testing and vaccination clinics during widespread transmission, including where clusters are identified, and communicate any changes in CI/CT protocol to the public

Transmission Setting	Capacity Setting	Objective	Priorities	Additional priorities, if vaccines are available
3. Widespread transmission	Inability to implement timely and complete CI/CT, even with prioritization	**Mitigate** the impacts of COVID-19 on health outcomes, health care settings, and public health resources	**1.** Focus on timely and consistent communication and engagement with the public to implement the 3 W's **2.** Communicate to the public that not all cases will be investigated, people with symptoms should get tested early, and those with symptoms or with a positive test result should initiate self-isolation and self-notification of contacts **3.** Communicate home care guidance widely, including specific indications for seeking medical care **4.** Deploy digital tools: a. SMS or email notification of test results with information on follow up, self-isolation, home care, and when to seek medical attention b. Self-reporting form for cases with positive rapid or confirmatory test, depending on local guidelines c. Contact notification system that can be used by confirmed cases to notify their own contacts d. Smartphone applications for anonymous exposure notification **5.** Consider reassigning contact tracing staff to other understaffed activities within their skillset	**1.** Offer vaccination to people exposed to COVID-19 to protect them during future exposures2 **2.** In public messaging, address expectations that people who have been vaccinated:[2] a. Continue to avoid large gatherings and wear a mask and physically distance in public settings b. Seek testing if experiencing COVID-19 symptoms and self-isolate if positive c. May not need to quarantine after exposure **3.** If self-reporting form implemented, ensure vaccination status is captured

1. Most relevant in settings with increasing or widespread vaccine availability.
2. If the contact belongs to a group eligible for COVID-19 vaccination. Contacts should not seek vaccination until the quarantine period has ended to avoid exposing others to SARS-CoV-2. COVID-19 vaccines are unlikely to be effective as post-exposure prophylaxis to prevent COVID-19 because of the short (4-5 day) incubation period of SARS-CoV-2.

This document provides specific guidance on how to implement many of the above priorities, including:

- Using data to inform quality improvement efforts (see page 6)
- Prioritizing cases for investigation and contacts for notification (see page 12)
- Communicating to the public the need for self-isolation and contact notification (see page 13)

Background

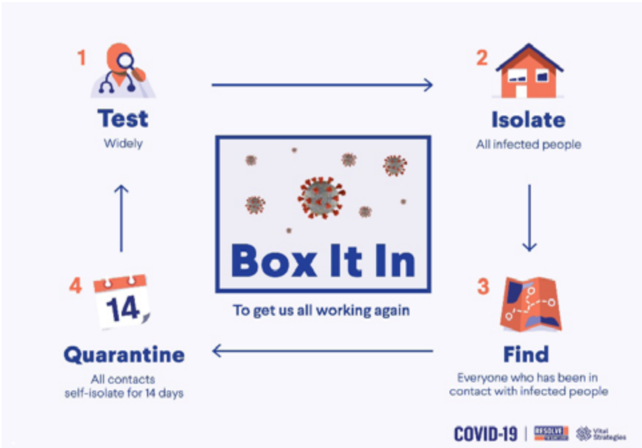


Figure 1. The Box-It-In Strategy

Controlling the COVID-19 epidemic requires ending transmission of the virus. The fundamentals to reducing transmission are described by Resolve to Save Lives' Box-It-In strategy (Figure 1): identifying as many cases as possible; isolating those cases; and identifying, quarantining and testing their close contacts. This pathway involves multiple actors—patients, laboratories, health care providers, public health departments and local communities. These efforts are particularly challenging because of the rapid timeframe in which COVID-19 is acquired and transmitted from one person to another—frequently before the first infected person even knows they are sick. If case and contact identification are not complete, or if they are too slow, transmission will continue and the virus will not be contained. Asymptomatic individuals are often identified through screening tests or as contacts of known cases; once a person is known to be positive for SARS-CoV-2, the virus that causes COVID-19, the same measures should be implemented.

The three main challenges to effective COVID-19 response are **speed, scale and completeness** (see modeling research reviewed in Annex 1)

Speed: COVID-19 moves very quickly from person to person; the average time from onset of symptoms in a case to the onset of symptoms in a contact (serial interval or generation time) is just five to six days. The speed of testing, case investigation and contact elicitation and tracing play a major role in the containment and control of the virus, specifically community-level transmission. Kretzschmar et al. (2020) found that **contact tracing will only be effective if the time from case symptom onset to receiving test results is within three days, and the time from receiving test results to quarantine of contacts is less than one day.** A U.S. Centers for Disease Control and Prevention (CDC) model suggests slightly longer time steps, but still emphasizes the need to promptly identify and isolate a case and associated contacts. Currently, delays in accessing testing and turnaround time for results are the major bottleneck in many settings.

Scale and prioritization: A rapid and large increase in cases can lead to testing delays and exceed the capacity of public health workers to complete case investigations, obtain information on contacts, and conduct successful contact tracing. Completing long and detailed case investigations are a potential bottleneck to rapidly identifying and tracing contacts. The U.S. CDC model indicates that **contact tracing should be prioritized among cases that are identified and investigated within six days of reporting or of symptom onset. CI/CT capacity may also be limited during COVID-19 vaccination campaigns. After introduction of COVID-19 vaccines, priorities for CI/CT may focus on communities with low vaccination coverage and cases among those who have been vaccinated, have a history of prior infection, or infection with a SARS-CoV-2 variant of concern.**

Completeness: Case investigation and contact tracing can only reduce the rate of disease spread significantly if a substantial proportion of cases are diagnosed, a large majority of their contacts are followed up, and both cases and contacts effectively self-quarantine or self-isolate. This requires effective identification, recruitment and isolation of positive cases. Mathematical models of contact tracing assume 80% testing and tracing coverage (i.e., 80% of cases tested and investigated; 80% of their contacts traced and self-quarantined). The U.S. CDC model suggests that **reduction of spread requires >60% of cases to be followed up.** Failure to follow up can occur at multiple stages and assessing the start of isolation and quarantine and the completeness of isolation and quarantine can be challenging. Reluctance of cases to report contacts or to respond to the contact tracing outreach are significant barriers.

Quality Improvement in Case Investigation and Contact Tracing

Effective case investigation and contact tracing requires a series of actions to occur in a timely and complete fashion, from an initial case seeking testing to their contacts being identified and quarantined. Any step in this chain of events that is delayed or incomplete will impact the entire system. Identifying bottlenecks and gaps in this chain of events is part of a systems approach in which public health actors use data to inform targeted interventions.

This document provides guidance that any public health decision-maker—from Ministries of Health, to county health departments, to universities, school systems, and other non-governmental organizations—can use to measure and improve their system to box in COVID-19. This guidance has been developed based on existing quality improvement literature, focusing on cycles of continuous quality improvement, and adapted to the current pandemic.

Key Steps for Quality Improvement

1. **Train and assemble a team,** including all major players involved in testing, vaccination, case investigation and contact tracing in your jurisdiction. Consider partnering with a community advisory board or other trusted community leaders to help identify issues in the patient and contact's experience of contact tracing, and to ensure the team demographically and linguistically reflects the communities served — this engagement will help to understand root causes and identify appropriate interventions.
2. **Define and measure key quality improvement indicators.** These indicators should measure both process and outcome/impact indicators, be monitored and reported regularly, based on the cycle of quality improvement used (e.g., biweekly or monthly). *See the following section, "Indicator Framework" for more information.*
3. **Review indicators and identify performance improvement areas as a team.** If many indicators need to be improved, determine the top priorities for improvement. Bottlenecks earlier in the process or resource constraints limiting specific types of interventions can inform the quality improvement measures prioritized.
    - As a team, develop hypotheses about the underlying reasons why your process is not meeting the target for the given indicator. Community advisors on the team can be invaluable in providing hypotheses that may be otherwise overlooked.

- Collect additional data (micro-indicators) designed to show which hypothesis is correct and how improvement might be achieved.
- As a team, decide which improvement methods or package of changes you are going to try.

4. **Prototype, then scale interventions.** Monitor quality improvement data routinely (biweekly or monthly) to see whether changes have resulted in improvement. If the change worked well, make it permanent. If it worked partially, identify modifications or changes in approach to implement and reevaluate for the next cycle.
5. **Continue monitoring and sharing** indicators routinely. Share data and suggestions for improvement with the contact tracing program lead. Share best practices that improved effectiveness of contact tracing (as measured by the monitored indices) with other, similar jurisdictions or organizations.

Quality Improvement Indicator Framework

The quality improvement framework enables public health workers to assess the effectiveness of case investigation and contact tracing at community-level by using measurements of timeliness, completeness and outcome and impact measures.

Table 1 describes key metrics for the logical framework for COVID-19 response. These indicators should inform quality improvement measures (inputs) to improve both process and output indicators and result in improved outcomes and impacts. The bottleneck analysis approach (described below) helps zero in on the output and process metrics that impede the speed, scale and effectiveness of the combined system of testing, case investigation and contact tracing.

Outcome and impact indicators should be routinely monitored and included in COVID-19 dashboards; these are described elsewhere. To achieve outcome and impact targets and reduce transmission, a combination of both speed and scale is crucial, as measured jointly by timeliness and completeness indicators.

Goals of Bottleneck Analyses

Increase efficiency and capacity, reduce delays in process and improve impact of the CI/CT process by:

- Identifying priority bottlenecks in processes
- Collecting qualitative data to support bottleneck analysis and inform decisions
- Exploring possible solutions to address the bottlenecks

Inputs	Process	Outputs	Outcomes	Impact
Resources, including equipment, human resources, and finances for technical response pillars. See appendix 1 of [this resource](#)	**Timeliness measures** • Time to testing • Test result interval (turn-around time) • Case investigation interval • Contact tracing interval	**Completeness measures** • Self-isolation percentage • Case isolation percentage • Isolation completion • Contact elicitation success rate • Contact elicitation index • Contact quarantine percentage • Contact testing percentage • Quarantine completion	• Percent of all new cases interviewed for which the case reports an epidemiologic link to at least one other case (target >80%) • Percent of all new cases that occur among quarantined contacts (target >50%)	• New cases per 100,000 population (target ≤0.7 per 100,000 per day, or ≤10 per 100,000 over a 2-week period) • Effective reproduction number (Rt) (target ≤1.0)

Table 1. COVID-19 Response Indicator Framework

Process Indicators: Timeliness Metrics to Identify System Bottlenecks

THE BOTTLENECKS APPROACH

Measuring time intervals between key process milestones can help jurisdictions identify bottlenecks and inform targeted quality improvement interventions. Bottlenecks are points in the system that, when overwhelmed, result in delays or degradation in performance for all subsequent, or downstream, actions.

The bottlenecks approach provides a framework and methodology to 1) obtain and analyze data; 2) identify bottlenecks; and 3) use bottlenecks to prioritize and implement interventions. This approach encourages stakeholders from across response areas (e.g., laboratory, surveillance, data/informatics, risk communications, community engagement) to convene and jointly investigate problems and identify solutions. Involving appropriate multidisciplinary partners, including leaders or organizations who have regular contact with highly communities experiencing disparities in case numbers, can ensure that corrective measures are strategic, pragmatic and delegated to appropriate authorities.

MEASURING TIMELINESS INDICATORS TO IDENTIFY BOTTLENECKS

Indicators of timeliness (see Figure 2 and Table 2) can be used to identify bottlenecks that slow down the end-to-end process **of COVID-19 testing, case investigation and contact tracing.** Each timeliness indicator (captures the interval between two key steps in the process, from time of symptom onset of a case (for symptomatic cases) to the effective quarantine of a contact.

To reduce COVID-19 transmission, models (see Annex 1) suggest that the end-to-end time interval should be less than the serial interval (five days, approximate time from onset of symptoms in a case to the onset of symptoms in a contact). The first interval in the figure applies only to symptomatic cases, whereas the remainder of the intervals apply to both symptomatic and asymptomatic cases. If measured values exceed targets for these intervals, specific interventions to address bottlenecks can be identified and implemented.

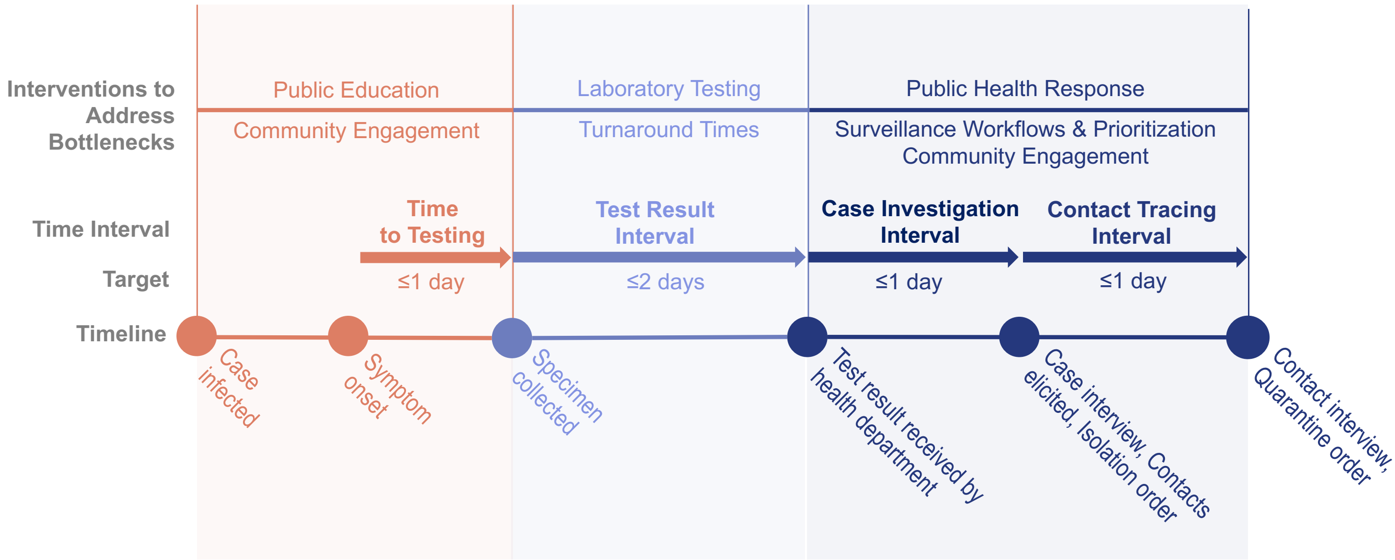


Figure 2. Schematic timeline for COVID-19 testing, case investigation and contact tracing

Indicator	Target
Time to testing interval: time from symptom onset to specimen collection, among symptomatic cases who undergo case interviews	**≤24 hours**
Test result interval: time between specimen collection and arrival of the lab test report at the local health department (laboratory turnaround time + data transmission time)	**≤48 hours**
Case investigation interval: time between a report of a new confirmed or presumed case to the local health department and interview of the case for contact elicitation	**≤24 hours**
Contact tracing interval: time between elicitation of a contact and the start of that contact's quarantine period (contact self-quarantined prior to contact tracing being scored as zero hours)	**≤24 hours**

Table 2. Suggested Timeliness Indicators

Achieving these targets may not happen right away. These targets enable officials to drive strategic progress and make strides in understanding transmission patterns (e.g., through retrospective contact tracing) and assess the effectiveness of mitigation strategies.

When bottlenecks are identified (i.e., targets are not met) for the key indicators in Table 2, it may be necessary to identify more granular steps that require remediation. For instance, the test result interval includes several steps, including the time from specimen collection to arriving at the testing laboratory (i.e., specimen transportation), laboratory testing time, and time for transmission of results from laboratories to public health staff. See Annex 2 for a more detailed version of the framework that can be used to "drill down" using micro-indicators.

Output Indicators: Completeness and the COVID Control Cascade

Just as timeliness metrics should be measured to identify and reduce bottlenecks in the end-to-end COVID-19 response process, completeness metrics should be measured to identify and reduce gaps in response coverage. COVID-19 containment can be modeled as a cascade beginning with diagnosis and ending with viral control (Figure 3). To maximize impact of testing, case investigation and contact tracing (as assessed by reduction in onward transmission), it is critical to minimize loss of patients at each step in the cascade.

Using the modeling data (Annex 1), we provide completeness targets for key steps in the cascade, including testing and investigation of cases, isolation of positive cases, completeness of isolation, and contact elicitation, tracing and quarantine (Table 3). These modeled targets are based on a strategy of suppression (i.e., reducing the basic reproduction number to <1) and are unlikely to be used during a period of widespread transmission, when capacity for case investigation and contact tracing is limited and intervention efforts focus on individual and community measures, and retrospective or lookback contact tracing to identify super-spreading events.

When transmission is sporadic or declining, including once widespread vaccination coverage is achieved, identifying key areas of "drop off" (loss to follow up) can further inform prioritization of intervention strategies to improve COVID-19 control, which are described in the next section and in detail in Annex 4.

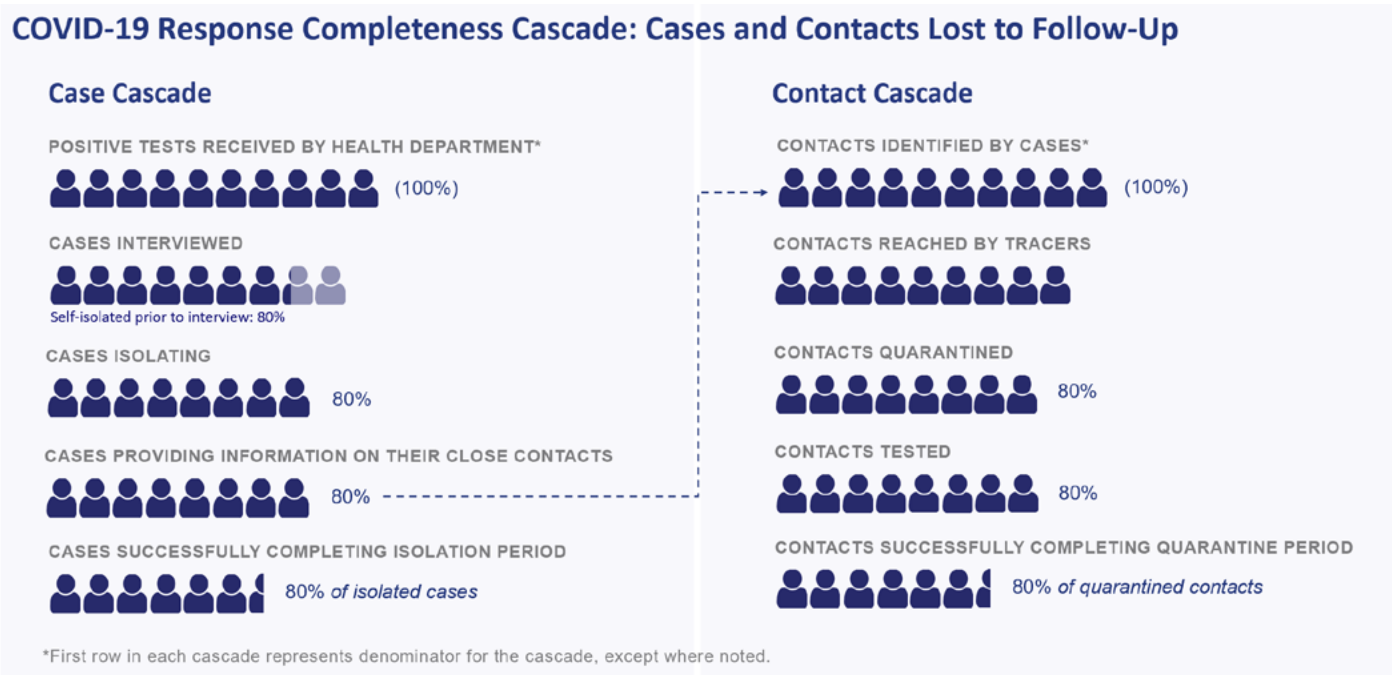


Figure 3. COVID-19 Control Cascade

Indicator	Target
Self-isolation percentage: Percentage of all confirmed cases interviewed who reported having self-isolated prior to the interview. This assesses compliance with recommendations to isolate at the time symptoms appear and not wait for a test result or a call from the health department. The jurisdiction can promote this through guidance provided at testing sites and public education.	**›80%**
Case isolation percentage: Percentage of confirmed cases reported to the health department who agree to isolate	**›80%**
Isolation completion percentage: Percentage of isolated confirmed cases who have been verified to complete their entire isolation periods	**›80%**
Contact elicitation success rate: Percentage of investigated confirmed cases reporting ≥1 contact	**›80%**
Contact elicitation index: Average number of contacts elicited per investigated confirmed case	*Varies by setting*
Contact quarantine percentage: Percentage of identified contacts who are quarantined[1]	**›80%**
Contact testing percentage: Percentage of identified contacts who receive a COVID-19 diagnostic test during their quarantine period	**›80%**
Quarantine completion: Percentage of quarantined contacts who have been verified to complete their entire quarantine periods	**›80%**

Table 3. Suggested Completeness Indicators

[1] Contacts who do not need to quarantine according to local guidance (e.g., those who are fully vaccinated) can be excluded from this calculation and those that follow in the cascade.

Packaging Intervention Strategies for Quality Improvement

Once timeliness and completeness have been measured and bottlenecks and gaps have been identified, intervention strategies can be piloted. Both speed (timeliness) and scale (completeness) are necessary to respond effectively to COVID-19. As such, a contextualized and balanced approach is required to efficiently achieve improvements toward both sets of targets.

During periods of widespread transmission, or limited capacity for CI/CT, completeness indicators are unlikely to be met; however, timeliness indicators can still inform interventions for ensuring that testing is being quickly accessed, lab results are becoming available, and cases are prioritized for investigation as described below.

Most of the intervention strategies below target improvements in timeliness, while the risk communication and community engagement strategies also address completeness. Specific, targeted interventions to address all the indicators are described in Annex 4.

REDUCE DELAYS AND HUMAN RESOURCE REQUIREMENTS DURING SURGE PERIODS BY PRIORITIZING CASES FOR INVESTIGATION AND CONTACTS FOR TRACING.

During the exponential growth phase of the epidemic, a large backlog in cases pending investigation may form, and the case investigation interval may lengthen. We recommend prioritizing cases for investigation until the incidence decreases or more case investigators can be borrowed, hired or trained. Similarly, if there are an overwhelming number of contacts to trace, **case prioritization should be conducted before contact prioritization.** If there is still an overwhelming number of contacts to trace, contacts can be prioritized until incidence decreases or human resources increase. Also consider the risk setting, if known and available based on the case investigation. Although all cases should be investigated (as per the completeness indicators and local reporting requirements), the below criteria can help with prioritizing cases to investigate when human resource capacity is limited.

Because the greatest opportunity to prevent the most transmission is among cases and contacts in the early days of infection, and frequently little information can be learned about a case until interviewed, we recommend a "last-in first-out" strategy: i.e., investigating the most recent cases reported to the health department first. Generally the **greatest opportunity to prevent transmission will be among those testing positive whose specimens were collected within the past four days** (see evidence summary in Annex 1). Within that group, prioritize those with the highest risk for transmission. The US CDC provides these high-risk criteria.

Even if no other information is available on the lab test report, it is likely that residents in congregate settings, elderly people, and those living in geographic areas identified as highly vulnerable (or with low vaccination coverage) can be recognized by their date of birth and address. Highly vulnerable geographic areas include places with low vaccination coverage, high social vulnerability, or limited testing in combination with high case rates. It may also be possible to match individuals to previous outbreak clusters and identify high risk health care personnel and first responders by matching against employment or licensure listings.

We also recommend prioritizing cases that may signal emerging changes to the virus or local epidemiology, such as infection with a variant of concern. Investigation and contact tracing these cases helps elucidate secondary attack rates, transmission settings and other epidemiological parameters to understand the public health impact of novel variants. Cases among people who are fully vaccinated or who have a history of previous infection also may signal changes in the virus and should be similarly prioritized for investigation and genetic sequencing, where available.

	Case Prioritization	Contact Prioritization
Rationale	When resources are overwhelmed, cases with the highest yield to reduce transmission should be prioritized. These include cases with potentially large numbers of contacts, cases in congregate environments, and cases with more recent test results (when contact tracing is likely to have the greatest impact).	When resources are overwhelmed, prioritize contacts with the highest yield to reduce transmission, as well household contacts, and those with potentially poor outcomes. Unlike prioritization of cases, the possible transmission setting is more likely to be known for contacts after conducting case interviews.
Priorities	"High yield" cases (high contacts or congregate settings): • Young adults • Health care workers • People with addresses or with reports from health care facilities, nursing homes, jails, or other congregate sites Cases that may signal changes to local epidemiology: • Infection with a known variant of concern • People who are fully vaccinated • History of prior SARS-CoV-2 infection Cases with specimen collection date ≤4 days before case investigation (highest priority) Cases with specimen collection date 5-6 days before case investigation (lower priority) Cases with specimen collection date ≤7 days before case investigation (lowest priority, as modeling data indicates that contact tracing will not reduce reproduction number when delays are greater than the serial interval)	"High yield" contacts: • Health care workers and other essential workers • People with addresses or with reports from health care facilities, nursing homes, jails, or other congregate sites • Contacts of cases from highly vulnerable geographic areas, including communities with low testing rates or low vaccination coverage • Contacts of cases from large gatherings, including in schools and other congregate settings, sporting and social events, and health care settings Contacts of cases with symptom onset date <5 days before date of interview

Table 4. Comparison of case and contact prioritization

ACCELERATE TIME TO TESTING AND ENCOURAGE INDIVIDUAL ACTIONS TO IMPROVE CASE ISOLATION AND CONTACT QUARANTINE.

If time from symptom onset to testing is frequently greater than 24 hours, **public education and community engagement** are key interventions to ensure that symptomatic people get tested quickly. It is important to gather input from community members themselves to understand what the barriers are in accessing testing. Speaking with community leaders, having an active community advisory board, or holding formal or informal focus groups can help determine the reasons for lack of testing or distrust. This can range from fear of pain during testing to transportation and test site issues to financial barriers around isolation, and any number of other issues.

This package aims to increase demand for testing and communicate to populations through trusted messengers that they can take measures on their own to protect themselves and the people they care about from becoming infected. If possible, communications should be created in partnership with community leaders, particularly those from communities experiencing disparities; should focus on addressing the specific concerns and barriers for those communities; and should be tested and validated by community members. All communication campaigns should be created in languages commonly spoken in the community, particularly those that are the primary languages in communities experiencing disparities in testing or cases. Community leaders and community-based organizations (CBOs) should be partners in campaign rollout.. Even with limited resources, CBOs can be tapped to disseminate key messages through their existing networks, including social media.

Consider issuing guidance to communities to start isolation (except for testing and medical services) and identify contacts **before laboratory results are available**. This can decrease time to isolation and identification of contacts. Guidance should include strong recommendations that:

Symptomatic people should:	Contacts, upon notification by symptomatic people should:
• Seek testing immediately upon onset of symptoms consistent with COVID-19 • Self-isolate when ill, except for medical treatment or diagnosis, until a negative test result is received or 10 days after symptom onset • Prepare a list of contacts and notify contacts that they are waiting for test results	• Limit contacts with others until the case's test results are received • Prepare to quarantine if the case notifies them of a positive result (even before notification by the health department) • Fully vaccinated contacts may not need to quarantine

Table 5. Recommendations for symptomatic people and their contacts

Household quarantine for entire households of confirmed cases can reduce transmission substantially, without the resource requirement of contact tracing: studies suggest that this can be up to two thirds as effective as full contact tracing (an estimated 37% reduction in transmission versus 55% reduction for full extended contact tracing).

To ensure that the need for self-isolation does not discourage people from accessing testing, make clear resources available for people under isolation and quarantine, and communicate this availability broadly to the public through culturally competent messages in all major languages spoken in the community. Ensure that information is both empowering and useful by pairing isolation instructions with a list of community-based resources to meet basic needs. Resources that should be made available are described in Appendix B of this ASTHO report.

ASSESS LABORATORY BOTTLENECKS AND INCREASE THROUGHPUT USING POOLED TESTING STRATEGIES OR RAPID DIAGNOSTIC TESTS, WHERE POSSIBLE.

Conduct an assessment using micro-indicators (Annex 2) to map out delays in specimen transportation, specimen accessioning and processing, testing (including batch testing protocols) and sharing of results. Identify where the longest gaps are and revise workflows to reduce delays. Specimen transportation systems will require larger investments to accelerate; improvements in laboratory processes can be tested and adopted more quickly.

Despite efforts to increase testing capacity, laboratory resources might be constrained during community transmission scenarios or during the exponential growth phase of the epidemic. Use national (e.g., US CDC) or World Health Organization guidance on prioritizing cases for laboratory investigation if testing capacity remains low despite best efforts to scale up. Focus testing on the highest-risk populations and areas. When case positivity is low, but there are a large number of screening tests to perform, consider a pooled PCR testing strategy. The College of American Pathologists and Africa Centres for Disease Control have provided general guidance about the appropriate use of pooled testing.

Point-of-care screening using antigen testing has the potential to eliminate multiple bottlenecks in the testing and case investigation process simultaneously. These rapid diagnostic tests, which produce results while the patient waits, can reduce the testing interval immediately. When combined with on-site case investigation and contact tracing, significant improvements in systems performance can be made (Figure 4). Jurisdictions should develop local protocols for rapid testing confirmation[1] and integration into case investigation and contact tracing workflows.

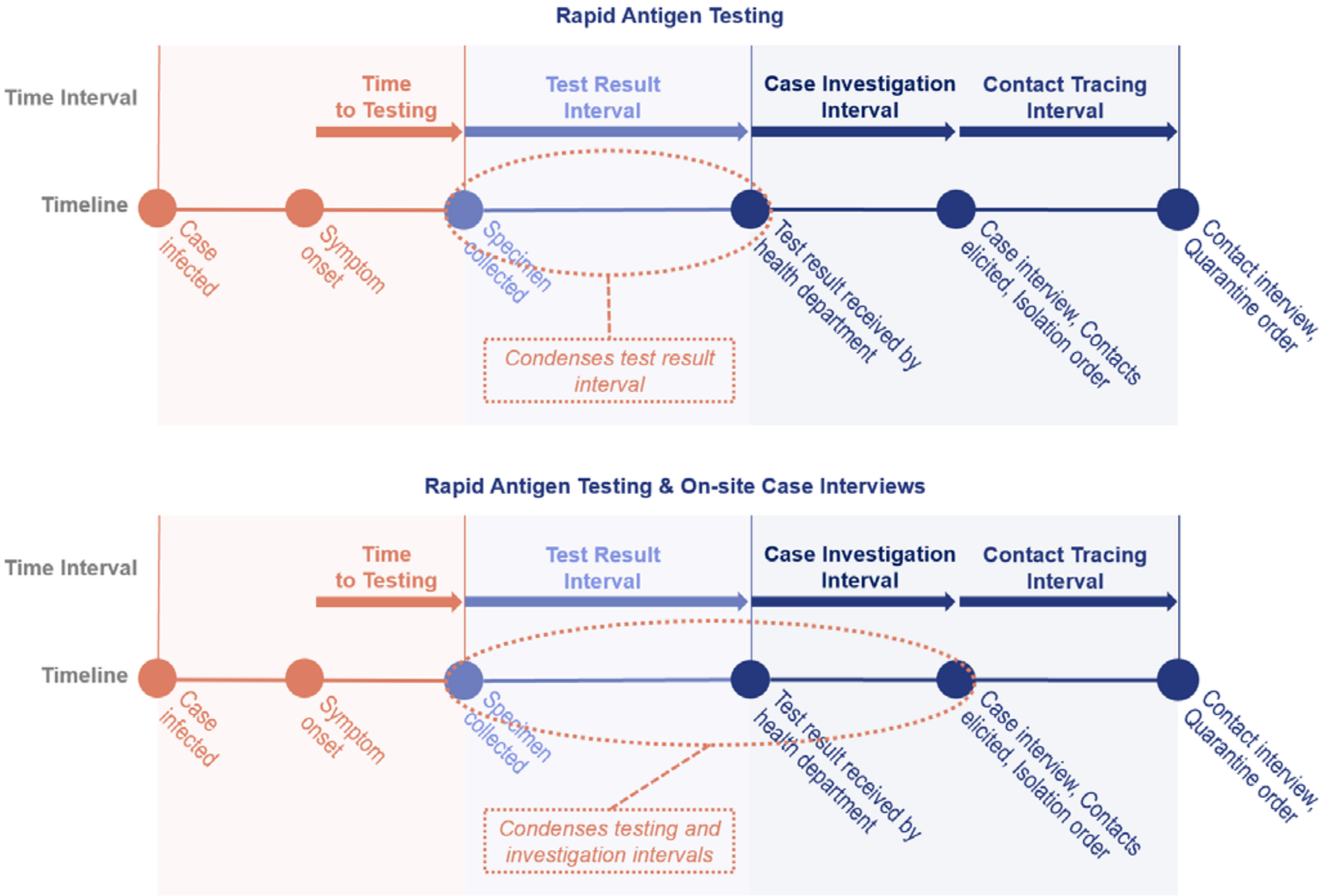


Figure 4. Effects of selected interventions on improving timeliness

REDUCE DELAYS CAUSED BY DATA USING TECHNOLOGY SOLUTIONS TO ACCELERATE DATA PIPELINE.

If the delay is caused by slow movement of data from laboratories (results) to case investigators, the bottleneck is the data pipeline. Technological solutions and business process improvements can relieve these bottlenecks, which are often caused by the need to filter out only positive results from the mass of negatives, eliminate duplicate reports and manage results of multiple tests provided to a single individual. Resolve to Save Lives has been working with US jurisdictions to develop digital tools to resolve these bottlenecks. Data pipeline work begins with conducting a landscape analysis of different testing platforms and their data systems, mapping interoperability and optimizing the pipeline of data for end users, including surveillance staff and case investigators. The Epi Viaduct system, installed in New York State, has reduced the time needed for data transfer from two and a half hours to less than one minute.

1 Caution must be used in the interpretation of a single rapid antigen test result. In practice, these tests are proving to have lower sensitivity and specificity in practice than laboratory PCR, and their use can be best viewed as one part of a multi-part testing algorithm.

Technology solutions also may help reduce delays in the data pipeline that contribute to longer contact tracing intervals. Specifically, smartphone applications for anonymous exposure notification may reduce the contact tracing interval by enabling immediate notification of contacts upon entry of a positive test result code by a confirmed case. These applications use smartphones to detect proximity between people, typically using Bluetooth or GPS technology. If widely used, this technology also may increase the completeness of contact tracing by identifying contacts between people who do not know each other. However, there are limited data on the sensitivity and specificity of these tools for identifying close contacts and broad public usage is required for them to be effective.

Annexes

Annex 1: Summary of Contact Tracing Models

A review of published COVID-19 case investigation and contact tracing models was conducted. The results summarized in the table below were used to inform the setting of targets recommended in this document.

Model	Assumptions	Results (Timeliness)	Results (Coverage)
Kretzschmar et al. (July 2020, Lancet)	• Effective reproduction number (R_e) = 1.2 (assumes physical distancing) • Best-case scenario defined as 80% testing and tracing coverage • 40% of transmissions occur before symptom onset • All traced infected contacts are isolated, regardless of symptoms, and isolated people do not transmit • 80% of infected people develop symptoms at some time during their infectious period (20% asymptomatic)	• **Testing interval** (symptom onset to test result): ‹3 days for R_e ‹1, even with perfect contact tracing coverage and no tracing delay • **Contact tracing interval** (case test result to quarantine of contacts): ≤1 day for R_e ‹1, assuming a testing delay ›1 day and 80% of those who develop symptoms get tested	• **Tracing coverage:** ›80% for R_e‹1 (assuming 80% testing coverage) • 60.7% of onward transmissions prevented per diagnosed index case, when targets recommended by this RTSL framework are achieved (1d testing delay, 1d tracing delay, tracing and isolation of 80% of infected contacts)
Peak et al. (May 2020, Lancet)	• Serial interval 4.8-days • "High feasibility" setting: 90% tracing coverage, 0.5-day tracing delay and frequency of monitoring symptoms, higher reduction in infectiousness during isolation and quarantine • "Low feasibility" setting: 50% tracing coverage, 2-day tracing delay and frequency of monitoring symptoms, lower reduction in infectiousness during isolation and quarantine	• In a low feasibility setting with 2-day tracing delay and 50% tracing coverage, outbreak control was not achieved with active monitoring and/or quarantine of con-tacts, even with R_0=1.5 and a longer 7.5-day serial interval	In a high feasibility setting: • When ›75% of infected contacts are individually quarantined, the outbreak is contained 84% of the time, in the absence of other interventions (R_0 = 2.2) • Tracing 90% of contacts resulted in mean reduction in R_e of 66% for individual quarantine, with physical distancing (R_e=1.25).

Model	Assumptions	Results (Timeliness)	Results (Coverage)

Bilinski et al. (Aug. 2020, JAMA)	• 40% of infections are asymptomatic
	• 90% isolation and quarantine efficacy
	• Duration of infectiousness:
	  • 1.5 days pre-symptomatic
	  • 4 days symptomatic
	  • 5.5 days asymptomatic
	• Confirmed cases have 50% lower rates of transmission than unconfirmed cases
			• **Testing Coverage and Tracing Coverage:** With 90% testing and tracing coverage, contact tracing could reduce overall transmission by >45%
			• **Tracing Coverage:** With tracing coverage <50%, no contact tracing strategy reduced R_e by more than 10% compared to corresponding scenarios without contact tracing
			• Median reductions in R_e were 29% for strategies that tested only symptomatic contacts, and 30% for strategies that tested all contacts

Ferretti et al. (May 2020, Science)	Assumptions can be adjusted in the Web Model • 5.2 day incubation time • 5 day average generation time • 10 day epidemic doubling time (R0=1.4) • 40% of individuals are asymptomatic	• **Combined interval** (case symptoms to quarantine of contacts): of 3 days or less will cause the epidemic to decline, assuming >50% success in quarantining contacts	• With tracing coverage >80%, the epidemic would likely decline if timeliness targets recommended by this RTSL framework are achieved; however, the model does not display results for total delays >3 days
Kucharski et al. (June 2020, Lancet)	• Baseline R_0=2.6 • 5 day incubation period • 50% relative infectiousness of asymptomatic cases vs symptomatic cases • **2.6 day delay from symptom onset to isolation** • **Quarantine within 2 days for successfully manually traced contacts** (immediate for app-based) • >90% of contacts are successfully traced and adhere to quarantine		• Contact tracing coverage often >90% to ensure Re <1 (in absence of other measures) • 64% transmission reduction for self-isolation and household quarantine with the addition of manual contact tracing of all contacts

Model	Assumptions	Results (Timeliness)	Results (Coverage)
Hellewell et al. (Feb 2020, Lancet)	• Delay from symptom onset to isolation: 3.43 days (short), 8.09 days (long) • 5.8 day incubation period • 15% transmission before symptom onset • 0% subclinical infection • Isolation prevents all further transmission in the model	• **Time to Testing and Testing and Investigation Interval:** The delay between symptom onset and isolation had the largest role in determining whether an outbreak was controllable when R0 was 1.5	• **Tracing coverage:** at 80% tracing coverage, the probability of achieving outbreak control fell from 89% to 31%, with a longer delay (8 vs 3.4 days) from symptom onset to case isolation. This probability is much lower in the presence of increased asymptomatic cases
Grantz et al. (Sep 2020, preprint)	Assumptions can be adjusted in the web model • All infected individuals are equally likely to transmit and be detected • Relative risk of infection for household vs community contact = 4 • Relative rate of onward transmission for asymptomatic individuals relative to symptomatic = 0.5 • Relative risk of detection and isolation for asymptomatic individuals relative to symptomatic = 0.5 • Generation time = 6.5 days • Incubation period = 5.1 days	• **Time from Symptom Onset to Isolation:** Because the vast majority of transmission occurs in the days immediately before and after symptom onset, improvements in the speed of case isolation that bring it to 4 days or fewer will yield the greatest reductions in transmission. Beyond this, there is limited opportunity to reduce onward transmission of the isolated case and thus little difference between delays of 6, 8, or 10 days • **Contact Tracing Interval:** Improvements in the speed of contact quarantine are most effective during the 4–8 day window after case symptom onset for similar reasons; this period corresponds to the greatest expected infectiousness of infected contacts	Consider a situation where you only detect and isolate 10% of cases through your community testing program, and it takes an average of seven days from symptom onset to do so. Whether you have highly effective contact tracing (70% of contacts quarantined on average 4 days after case symptom onset) or less effective contact tracing (30% quarantined on average 8 days after case symptom onset, little will be gained by improving the speed of case isolation, and the greatest reductions in transmission will be achieved by improving the proportion of infections detected and isolated.

Annex 2: Drilling Down Using Micro-Indicators

We recommend that COVID-19 control programs monitor key outcome (completeness) and process (timeliness) indicators biweekly or monthly. If these indicators aren't within target ranges, the next step is to drill down into the data by examining micro-indicators. These are the same outcome and process indicators, examined at a more granular level.

There are two basic ways to drill down into the data: by looking at population subgroups and by looking at shorter intervals of time. When designing or adapting data management systems to capture the key indicators, it is important to identify these subgroups and subintervals to ensure that you can capture those as well and generate cross-tabulations. Also look at the performance of different groups of case investigators or contact tracers on each indicator, to identify areas for improved training or recruitment.

KEY POPULATION SUBGROUPS INCLUDE:

- Symptomatic/asymptomatic
- Hospitalized patients/congregate settings/other outbreaks/community-based
- Testing type (PCR vs antigen), laboratory and/or screening site
- Populations undergoing regular screenings such as health care workers or university students
- Geographic areas by zip code or census tract of residence
- Age groups
- Gender identity
- Racial and ethnic groups
- Particularly vulnerable groups, as defined locally (e.g., based on location, language, income level, etc.)

Drilling down to shorter time intervals requires a deeper look at your systems and processes for testing, case investigation and contact tracing. Although every entity's systems will be slightly different, Figure 5, which shows Figure 2 in a more granular view, shows some common process milestones:

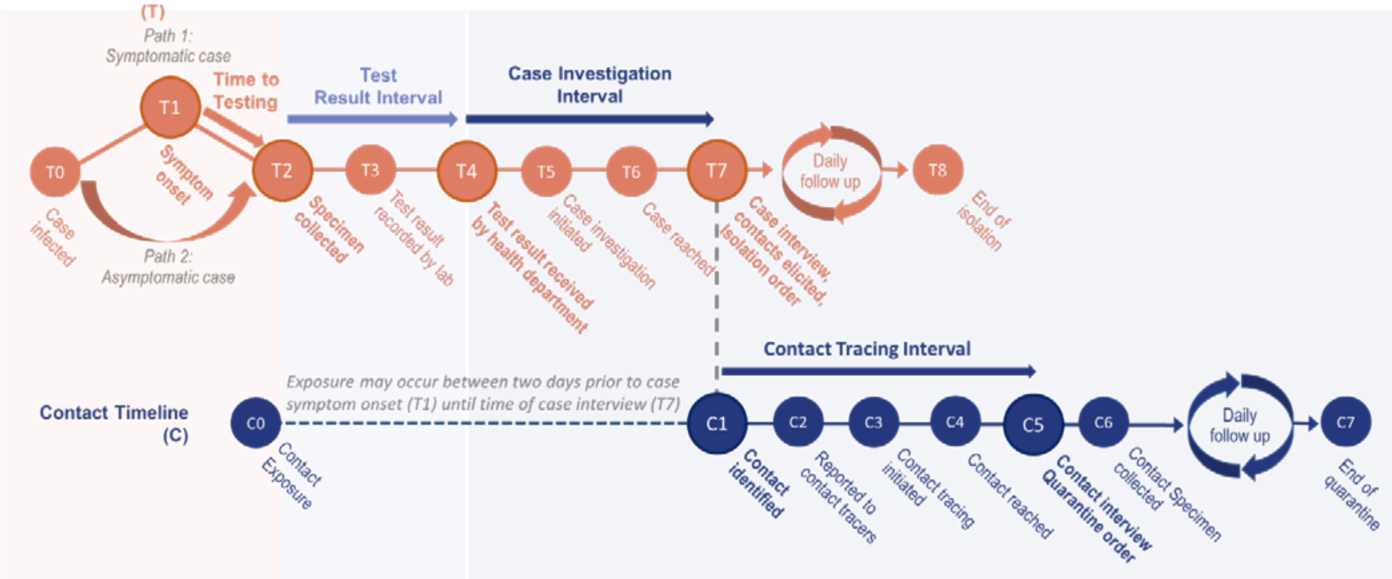


Figure 5. Detailed schematic timeline for COVID-19 testing, case investigation and contact tracing.

In Figure 5, you can see that our indicator for "Case Investigation Interval," is the time from receipt of a positive test result by the health department (shown as T4 in the diagram), to the interview in which contacts are elicited and the case is formally requested to isolate (shown as T7). We have drawn in two intermediate steps, T5—the time when the case investigation is initiated, and T6, the time when the case investigator first reaches the case in person or on the telephone. If case investigation intervals are routinely taking longer than 24 hours, you will want to drill down to look at the range of times required for T4 to T5, T5 to T6 and T6 to T7 to identify where the true bottleneck lies, as the strategy for addressing the issue may be very different depending on the problem's source.

The breakdown of the time intervals required for contact tracing are shown in the figure to be similar, with one distinction: there is an additional possible source of delay between the time the contacts are elicited by the case investigator (shown as T7 in the case timeline and C1 in the contact timeline) and the time this information is transferred into the contact tracing information system (shown as C2), which sometimes is a different information system from that used for case management.

We show the test result interval—the time from collection of a specimen (at T2) to reporting of the case to the health department (at T4)—as a simple 2-step process, with recording of the test result at the lab (T3) being the main intermediate step. In the US setting, the primary bottlenecks have proven to be in laboratory capacity, resulting in delays in test processing, and in filtering out unique positive results and communicating them to the local health department. In the US, specimen transportation is generally part of the laboratory-controlled process and is done by overnight express. In other countries and settings, specimen transportation to the laboratory can prove to be an additional bottleneck, handled by a separate entity, and may be drawn as an additional step on the diagram and measured as a separate micro-indicator.

Annex 3: Detailed Indicator Descriptions

Indicator	Denominator	Numerator	Calculation	Notes	Target
Epidemiologic links. Percent of all new cases interviewed for which the case reports an epidemiologic link to at least one other case. This assesses the completeness of the case investigation effort.	All new cases interviewed in given time period	Number of cases which report an epidemio-logic link to at least one other case	**(N reporting known source of infection/N at T7) x 100** Percent, by demographic group and geographic area	This assesses the com-pleteness of the case investigation effort, by comparing the overall number of cases with those known potential exposure. Cases will be consid-ered linked if any of the following are true: • the case fit the eligibility criteria for being part of an identified outbreak with at least one case; • a household contact of the case was also an identified COVID-19 case; • the case was a named contact of a previously identified case; • the case had recently arrived from another jurisdiction experiencing high levels of Covid-19 prevalence Otherwise the case will be considered unlinked. (RTSL Essential Indicator #2)	**›80%**
Contact trac-ing impact. Percent of all new cases that occur among quarantined contacts.	All new reported cases in given time period	Number of quarantined contacts matched to new cases	**(N cases who are under quarantine at T4/N at T4) x 100** Percent, by demographic group and geographic area	This assesses the completeness of coverage of testing, case investigation and contact tracing.	**≥50%**

Indicator	Denominator	Numerator	Calculation	Notes	Target
Test positivity: Percent of all diagnostic and screening tests that are positive for COVID-19			**(positive tests) / (total tests) x 100** Percent, by demographic group and geographic area	This assesses the completeness of testing coverage in the jurisdiction.	**›3%**
Self-isolation percentage: Percent of all cases interviewed who reported having self-isolated prior to the interview			**(N isolated before T7/ N at T7) x 100** Overall percent, percent reporting isolating at T1, T2, and receipt of test result.	This assesses compliance with recommendations to isolate at the time symptoms appear and not wait for a test result or a call from the health department. The jurisdiction can promote this through guidance provided at testing sites and public information.	**›70%**
Case isolation percentage: Percent of cases reported to the health department who are isolated	All new reported cases in given time period	Number of cases reported in given time period that were isolated (use the denominator to determine which iso-lated cases should be included in this calculation)	**(N at T7/N at T4) x 100** Overall and by case type (household, congregate setting)		**›80%**
Isolation completion: percent of isolated cases who have been verified to complete their required isolation periods			**(N verified at T8/ N at T7) x 100** Percent, by demographic group and geographic area		**›80%**

Indicator	Denominator	Numerator	Calculation	Notes	Target
Contact elicitation success rate: Percentage of cases reporting at least 1 contact	All case interviews in given time period	Number of case interviews in given time period eliciting one or more contacts	**(N at C1)/(N at T7)** Percent of cases reporting one or more contacts, median and IQR		**›70%**
Contact quarantine percentage: Percent of identified contacts who are quarantined	All new identified contacts required to quarantine in given time period	Number of contacts identified in given time period that were quarantined (use the denominator to determine which quarantined contacts should be included in this calculation)	**(N at C6/N at C1) x 100** Overall, by type of case and by type of contact (household, social, congregate setting, work)		**›80%**
Contact testing percentage: Percent of identified contacts who receive a COVID-19 diagnostic test during their quarantine period			Percent, percent by days after C5		**›80%**
Quarantine completion: percent of quarantined contacts who have been verified to complete their required quarantine periods			**(N verified at C7/ N at C5) x 100** Percent		**›80%**

Indicator	Denominator	Numerator	Calculation	Notes	Target
Time to testing: time from symptom onset to specimen collection, among symptomatic cases who undergo case interviews	All specimens for which symptom onset and specimen collection dates are known among symptomatic cases only	(T2-T1) Median days from symptom onset to specimen collection and interquartile range (25 and 75 percentile)	**T2-T1** Number of specimens collected in 1 day or less, with known symptom onset date and specimen collection date (Percent achieving target, median & IQR)	Symptom onset date might not be available in all settings. A rapid assessment at testing sites can be conducted to ask people presenting for testing when the date of symptom onset was. These data should be available from adapted IDSR-001 case investigation forms in the African setting.	**≤24 hours**
Test result interval: time between specimen collection and arrival of the lab test report at the local health department	All specimens for which specimen collection date and lab result date are known (among symptomatic and asymptomatic cases)	(T4-T2) Median days from specimen collection to health department notification of lab result, and interquartile range (25 and 75 percentile)	**T4-T2** Number of specimens with results available in 2 days or less, with known specimen collection date and test result date (Percent achieving target, median & IQR)	Data should be available from laboratory databases. Many laboratories report on average turnaround time, which can be used as a proxy in the absence of primary data. However, laboratory turnaround times might not include delays from specimen collection to accessioning in the laboratory, or delays to health department notification.	**≤48 hours**

Indicator	Denominator	Numerator	Calculation	Notes	Target
Case investigation interval: time between a report of a new confirmed or presumed case to the local health department and interview of the case for contact elicitation	All positive specimens with known date of lab result and date of investigation or isolation	(T7-T4) Median days from health department notification of lab result to case isolation (date of interview can be used as a proxy) and interquartile range (25 and 75 percentile)	**T7-T4** Number of positive specimens with case investigation and isolation conducted in 1 day or less, with known date of lab result and date of investigation or isolation (Percent achieving target, median & IQR)	If primary data are not available, a rapid assessment can be conducted at call centers/surveillance teams to determine how long cases will remain in a queue prior to investigation (i.e., confirmed contact with a positive case). This method of measurement might be subjected to negative bias, since it will measure time from notification to investigation, rather than when the lab result is available. This interval includes data delays from laboratory to public health officials (notification delay). If there is an investigation delay, further analysis is needed to determine whether there is a data pipeline bottleneck.	**≤24 hours**
Contact tracing interval: time between elicitation of a contact and the start of that contact's quarantine period; contact self-quarantined prior to contact tracing being scored as zero hours	All contacts of investigated cases, with known date of contact notification/ quarantine and known date of case investigation/ isolation	(C5-C1) Median days from case interview/ isolation to contact notification/ quarantine and interquartile range (25 and 75 percentile)	**C5-C1** Number of contacts who were notified and quarantined in 1 day or less after the case was investigated or isolated, with known date of contact notification/ quarantine and case investigation/ isolation (Percent achieving target, median & IQR)	If primary data are not available, a rapid assessment can be conducted at call centers/surveillance teams to determine how long it takes for investigators and contact tracers to reach contacts after they have completed the initial case investigation.	**≤24 hours**

Annex 4: Micro-Indicators and Targeted Improvement Strategies

These targeted strategies use micro-indicator data (Annex 2) to targeted intervention strategies. The first table provides targeted interventions based on identified bottlenecks, and the second table provides targeted interventions based on the completeness indicators.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Time to testing	Lack of knowledge about importance of testing right after symptoms appear.	Survey of residents about barriers to testing.	Risk communication package
	Fear of testing		Community engagement using key opinion leaders
	Don't want to show ID/ don't have insurance		In the US: work with non-government providers to make testing available with no ID/no insurance requirement.
	Inconvenient testing locations or times.		Rotate testing locations, open in hotspot areas, test in residential areas,and provide after work hours availability.
	Cost of testing		Provide free tests for underserved and key populations.
	Inability to get appointments, long lines		Expand specimen collection sites or hours.
Test result interval	Backlogs at particular labs	Intervals T2 to T3 (lab turnaround time), for each lab.	Laboratory accelerator package, including analysis of specimen collection, transportation, accessioning, and tracking systems and personnel—numbers and scheduling.
			Decentralize testing facilities and analyze test volume by facility.
			Promote use of rapid antigen tests. (Figure 6)
			Develop surge PCR capacity.
			Work with test sites and providers to actively redirect specimens to labs with faster turnaround times.
			Require labs to post turnaround times.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Test result interval (ctd.)	Backlogs at particular labs (ctd.)	Survey labs on any supply or reagent shortages	Procure stockpile of supplies, test kits and reagents to distribute as needed.
	All testing services are overwhelmed	Intervals T2 to T3 (lab turnaround time), for each lab	Implement prioritized testing strategy, prioritizing those with high risk of transmission.
	Delays in specimen transport from specimen collection site to lab	Time for transport of specimens	Procure/use rapid antigen tests for screening and transport only positives to lab for PCR confirmation.(Validate antigen tests in your population first) Contract with minibuses, other local transport to take specimens; purchase coolers to ensure cold chain.
	Clogs in the electronic data pipeline from ELR to the health department.	Interval T3 to T4, the reporting interval.	Data pipeline package
	Low rates of ELR	Percent of lab results delivered by ELR vs. fax or hand entry, by source.	Collaborate with labs and providers not using ELR to transition to it; develop tablet app ELR solutions for smaller providers and community testing. Consider whether technology solutions or confidentiality legal protections could enhance ELR use.
Case investigation interval	Insufficient staff for case investigation, particularly during surge/ exponential growth of cases	Interval T4 to T5 Cases per day over time Survey of staff on job satisfaction and issues	Hire additional staff; if recruitment is a problem consider alleviating barriers such as insurance and PPE.
			Reallocate staff flexibly from contact tracing to case investigation.
			Case prioritization package—triage to focus on cases at highest risk of transmission or that may signal changes in the virus.
	Unclear responsibilities for assigning cases to investigators		Within existing staffing structure, determine who will assign cases and how to support the designated staff member to conduct timely case assignment by prioritizing other duties.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Case investigation interval	Inflexible first-in-first-out case prioritization	Interval T4 to T5 Cases per day over time Survey of staff on job satisfaction and issues (ctd)	Case prioritization package
	Missing or incorrect case addresses and phone numbers	Interval T5 to T6. Survey of public attitudes toward contact tracing.	Use available databases, paid public databases to fill in missing information. Epi Locator is a Resolve to Save Lives product that integrates database lookup into a case management system.
	Cases unwilling to answer the phone		Laboratory accelerator package—antigen testing with onsite case investigation
			Public information campaign. Resolve to Save Lives has developed a campaign called "Be the One" that can be adopted by jurisdictions.
			Rebrand CI/CT program to emphasize support role (e.g., changing staff titles to "COVID Resource Coordinator," "COVID Care Specialist" or "Community Outreach Specialist"").
			Call twice in a row to show you are not a robocall.
			Ensure caller ID identifies case investigators as the local health deptartment.
			Send texts/letters/emails in advance of a call.
			Use home visits by vaccinated staff with adequate personal protective equipment; acceptance may increase if staff are able to deliver items like cleaning supplies, masks and food
	Staff work hours not matching hours when cases are reachable	Interval T6 to T7. Survey of public attitudes toward contact tracing. Rates of utilization of support services. Staff skills inventory	Reallocate work hours to allow evening and weekend calls

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Case investigation interval (ctd.)	Cases unwilling to cooperate with contact tracing	Interval T6 to T7. Survey of public attitudes toward contact tracing. Rates of utilization of support services. Staff skills inventory (ctd.)	Laboratory accelerator package—antigen testing with onsite contact elicitation.
			"Be the One" Public information campaign. (see above). CDC "Answer the Call" campaign.
			Use trusted community organizations as liaisons.
			Hire additional Disease Intervention Specialists.
			Train contact tracing staff in enhanced interviewing techniques.
			Provide/improve wrap around services or support for isolated cases and their families.
Contact tracing interval	Information system requires human intervention to transfer contacts from case investigators to contact tracers	Interval C1 to C2, Separately for type of contact (household, social, work, school, congregate setting)	Modify team processes or IT system so that contacts are transferred to contact tracers immediately upon identification and entry into the system.
	Household contacts communicated with separately from index case		Have case investigator speak with and manage quarantine for household contacts immediately after elicitation.
	Insufficient staff for contact tracing	Interval C2 to C3	Hire additional staff.
			Reallocate staff from case investigation to contact tracing.
			Contact prioritization package
			Implement smartphone applications for anonymous exposure notification.
	Unclear responsibilities for assigning contacts to contact tracers		Clarify responsibilities for case assignment and prioritization.
	Missing or incorrect contact addresses and phone numbers	Interval C3 to C4 Survey public attitudes toward contact tracing	Use available databases, paid public databases to fill in missing information. Epi Locator is a Resolve to Save Lives product that integrates database lookup into contact tracing.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Contact tracing interval (ctd.)	Contacts unwilling to answer the phone	Interval C3 to C4 Survey public attitudes toward contact tracing (ctd.)	"Be the One" public information campaign (see above)
			Call twice in a row to show you are not a robocall.
			Ensure caller ID names case investigators as local health depardment.
			Send texts/letters/emails in advance.
			Use home visits by vaccinated staff with adequate personal protective equipment; acceptance may increase if staff are able to deliver items like cleaning supplies, masks and food, or help eligible contacts sign up for a vaccination appointment.
	Staff work hours not matching hours when contacts are reachable	Interval C4 to C5. Survey public attitudes toward contact tracing Analyze data to identify groups or neighborhoods with low response rates and conduct targeted focus groups and community outreach	Reallocate work hours to match hours when contacts are most reachable.
	Contacts unwilling to cooperate.		"Be the One" public information campaign (see above)
			Provide/improve wrap around services or support for quarantined contacts and their families.
			Recruit members of the most impacted communities.
			If the contact is eligible for COVID-19 vaccination, help schedule vaccination appointment to protect from future exposures.
Self-isolation percentage (prior to contact from health department)	Lack of information or motivation	Disaggregate by demographic, geographic groups, types of provider, types of test site.	Risk communication package, co-created with and targeted to groups with gaps and health disparities.
	Economic problems		Mandate paid leave for COVID-19 if individual provides physician's note or positive test report to employer.
			Develop process for requesting isolation support services with physician's note or positive test report, without prior contact from case investigation/contact tracing.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Case isolation percentage	Bottlenecks in case investigation	Interval T4 to T5 Interval T5 to T6 Interval T6 to T7	See Bottlenecks table above.
	Insufficient knowledge and motivation about role of isolation in preventing transmission	Survey of public attitudes toward contact tracing. Issues captured in case investigation system Rates of utilization of support services	Risk communication package
			Hire additional trained and experienced Disease Investigation Specialists.
			Training for case investigators in Motivational Interviewing and Stages of Change counseling techniques.
	Insufficient space to isolate		Provision of cost-free flexible housing options with food and medical support services, including hotel rooms and vans/trailers that can be moved near a case's home.
	Economic problems—cannot afford to take leave from employment		Require employers to provide paid leave for isolation and guarantee job stability.
			Provide financial subsidies, food support.
	Family problems—case is a caregiver		Arrange for substitute caregiver for children, family members
	Medical problems		Hospitalize even if COVID-19 symptoms are mild; provide alternative care facilities for mild cases.
Isolation completion	Lack of motivation	Disaggregate by demographic, geographic group Self-reported reasons for breaking isolation	Work with universities to provide structure and incentives for case students to isolate (e.g. deactivating student cards, mobile phone green/red status).
			Conduct home visits for those not reached by telephone.
	Confusion about length of required isolation		Provide written instructions, SMS reminders daily.
	Pressure for infected health care workers, other essential workers to return to work		Work with employers to identify temporary and contingency staffing strategies to mitigate spread in these high-risk settings.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Isolation completion (ctd.)	Space, economic, family or medical problems	Disaggregate by demographic, geographic group Self-reported reasons for breaking isolation (ctd.)	Risk communication package
Contact elicitation success rate Contact elicitation index	Insufficient knowledge about the importance of contact tracing in controlling the epidemic	Disaggregate by demographic, geographic groups Survey of public attitudes toward contact tracing. Focus groups and targeted community outreach in communities with low participation	Public information campaign on the role of contact tracing in controlling the epidemic. Resolve to Save Lives has developed a campaign called "Be the One" that can be adopted by jurisdictions. CDC has an "Answer the Phone" campaign.
	Lack of recall of contacts		Distribute information and tools at testing sites to potential cases to start recalling and documenting their contacts. Provide electronic tools to record contacts.
			Implement smartphone applications for anonymous exposure notification.
	Unwillingness to force friends and colleagues to be quarantined or fear of stigma.		Require paid leave or provide financial subsidies. Inform interviewees about support services, paid leave, subsidies or vaccinations available to their contacts.
			Hire additional Disease Investigation Specialists.
			Risk communication package
Contact quarantine percentage	Insufficient knowledge and motivation about role of quarantine in preventing transmission	Survey of public attitudes toward contact tracing. Issues captured in case investigation system Rates of utilization of support services	Risk communication campaign
			If contact eligible for COVID-19 vaccination, offer vaccination appointment to protect during future exposures as motivation to engage in contact tracing.
	Insufficient space to quarantine		Recruit members of the most impacted communities .
			Train case investigators in motivational Interviewing.
			Hire Disease Investigation Specialists.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Contact quarantine percentage (ctd.)	Insufficient space to quarantine (ctd.)	Survey of public attitudes toward contact tracing. Issues captured in case investigation system Rates of utilization of support services (ctd.)	Provide cost-free, flexible housing options with food and medical support services, including hotel rooms and vans/trailers that can be moved near a quarantined person's home.
	Extended time for quarantine required due to multiple cases in the same household.		Require employers to provide paid leave for quarantine and guarantee job stability.
	Economic problems—case cannot afford to take leave from employment		
	Pressure from employers for exposed health care workers, other essential workers to return to work		Work with employers on contingency staffing plans.
			Allow "testing out" of quarantine for essential workers with two negative tests two days apart.
	Family problems—case is a caregiver		Provide financial subsidies.
			Arrange for substitute caregiver.
	Medical problems		Provide a home health nurse/aide who has complete PPE.
Contact testing percentage	Insufficient knowledge and motivation about importance of testing in preventing transmission	Disaggregate by demographic, geographic groups Reasons reported in contact tracing system for not testing	Risk communication package
			Training for contact tracers on persuasion techniques.
	Poor access to testing during quarantine due to geographic, transport, cost limitations		Provide home-based specimen collection or test kits, rapid antigen testing or refer contacts to community testing location (schedule appointment if possible).
	Testing does not change quarantine mandate		Allow testing out of quarantine after two successive negative antigen tests 2 days apart or after 7 days with a negative PCR test on day 5 or later.

If you identify a bottleneck in:	Consider the following potential causes:	Assess these micro-indicators:	Consider applying these improvement strategies:
Quarantine completion	Lack of motivation	Disaggregate by demographic, geographic group	Work with universities to provide structure and incentives for contact students to quarantine (e.g. deactivating student cards, mobile phone green/ red status , priority for vaccination [if eligible]).
			Conduct home visits for those not reached by daily telephone/SMS monitoring.
	Space, economic, family problems	Self-reported reasons for breaking quarantine	See indicator 11, contact quarantine rate