NOVEMBER 2020

Measures to Improve COVID-19 Response

End-to-End Quality Improvement of COVID-19 Testing, Case Investigation and Contact Tracing

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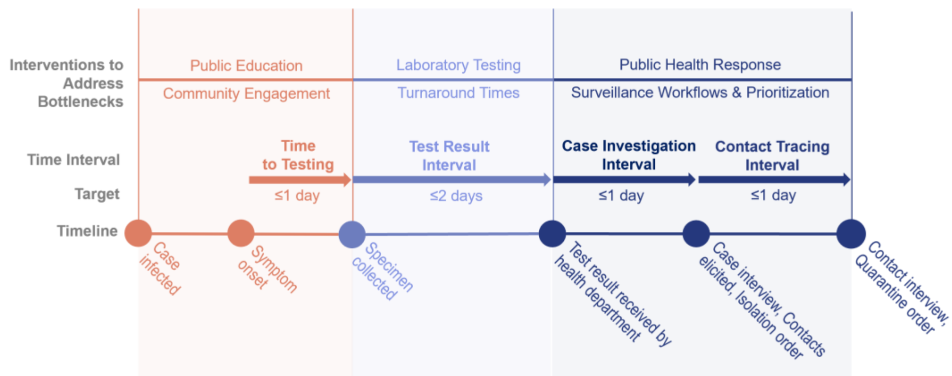
Prevent epidemics is a project of Resolve to Save Lives, an initiative of Vital Strategies.

Contents

Executive Summary

The world has not seen an epidemic like COVID-19 in >100 years. The speed and scale of the pandemic are posing severe challenges to the health ministries, regional authorities, and local health departments responsible for controlling disease. This framework focuses on improving key response activities of testing, case finding, and contact tracing; however, prevention efforts such as mask use, handwashing, and physical distancing are crucial prerequisites to a more effective COVID-19 response.

Effective case investigation and contact tracing requires a series of actions to occur in a timely and complete fashion by community members, health care providers, and public health staff — 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 identify specific systemic factors and use data to inform targeted interventions.

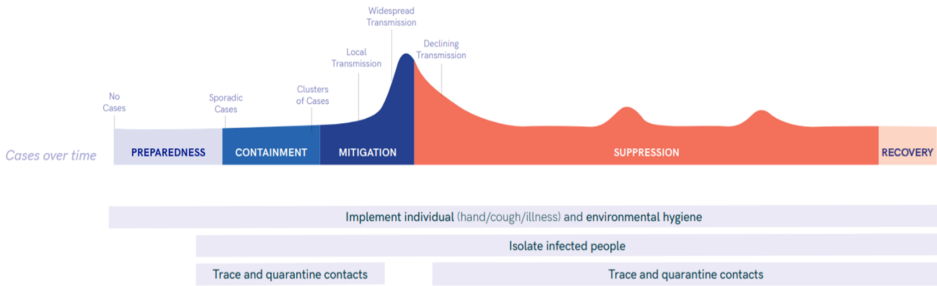


This document outlines targets for key completeness measures and timeliness intervals between activities, based on mathematical models of case investigation and contact tracing, to effectively reduce COVID-19 transmission. Applying the widely accepted methods of health care quality improvement, we provide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

This document:

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

This quality improvement framework can be applied both when case numbers are relatively low in communities, in order to suppress transmission, and when case numbers rise and overwhelm the capacity of public health officials to investigate every case and trace every contact. Resolve to Save Lives' "Adaptive Response" framework (see Figure 3), acknowledges that the ability of contact tracing to reduce transmission might be reduced when caseloads peak; however, there are no concrete thresholds for suspending contact tracing activities and this framework can help prioritize and adjust interventions based on performance.



When public health authorities lack the resources to respond with sufficient speed and scale, progress in measuring and reducing bottlenecks can still drive quality improvement and reduce transmission. Reductions in performance as measured by timeliness and completeness indicators can indicate to public health authorities that the ability to conduct widespread case investigations and contact tracing will be limited. The Bottlenecks Approach thus provides public health authorities a *capacity-based*, rather than incidence-based approach to determining thresholds. The decision to adapt widespread contact tracing and limit case investigations and contact tracing to priority cases will not be based on an absolute number of cases, but a jurisdiction's ability to implement these public health measures with the required speed and scale to control COVID-19 transmission, as defined in the quality improvement indicator framework herein.

During these times, case investigations should be prioritized based on persons who are likely to have high numbers of contacts (e.g., those from health care facilities, correctional facilities, other congregate settings, young adults) and those with more recent specimen collection dates to maximize the yield of contact tracing. During times of widespread transmission, the focus of contact tracing will likely shift to identifying super-spreading events through *retrospective* or *lookback* contact tracing. Identifying these types of events and settings might result in a larger number of contacts to notify, trace, and quarantine, as well as inform local decision-makers about high risk transmission settings in their jurisdictions.

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 still occur and the virus will not be contained. Asymptomatic persons 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 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, on average. 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. An unpublished 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 & 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.

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). For instance, 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 identify specific systemic factors and use data to inform targeted interventions.

This document provides guidance that any public health decisionmaker— 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, 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 to implement specific types of interventions can be used to prioritize quality improvement measures
    - 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 here 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 packages of changes that have worked elsewhere, you are going to try.
4. **Prototype and then scale interventions:** Monitor quality improvement data routinely (biweekly or monthly) to see whether the change you made has resulted in improvement. If the change worked well, institutionalize it permanently. If it worked partially, identify modifications or changes in approach to implement and re-evaluate 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.

Goals of Bottleneck Analyses

Increase efficiency and capacity, reduce delays in the process, and improve impact of the case investigation and contact tracing process by:

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

Outcome and impact indicators should be routinely monitored and included in COVID-19 dashboards and 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.

Table 1. COVID-19 Response Indicator Framework

Inputs	Process	Outputs	Outcomes	Impact
Resources, including equipment, human resources, and finances for technical response pillars. See appendix 1 of hyperlink here	**Timeliness measures** • Time to testing • Test result interval (turnaround time) • Case investigation interval • Contact tracing interval	**Completeness measures** • Self-isolation percent • Case isolation percent • Isolation completion • Contact elicitation success rate • Contact elicitation index • Contact quarantine percent • Contact testing percent • 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 (R_t) (target <1.0)

PROCESS INDICATORS: TIMELINESS METRICS TO IDENTIFY SYSTEM BOTTLENECKS

The Bottlenecks Approach

Measuring time intervals between key process milestones from the logical framework 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 the 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 multi-disciplinary partners, including leaders or organizations who have consistent contact with 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 (time intervals) 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.

If measured values exceed the targets for these intervals, specific interventions to address bottlenecks can be identified and implemented. These intervals are based on mathematical models of case investigation and contact tracing, which are summarized in Annex 1. To reduce COVID-19 transmission, these models suggest that the end-to-end time interval should be less than the serial interval (5 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.

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

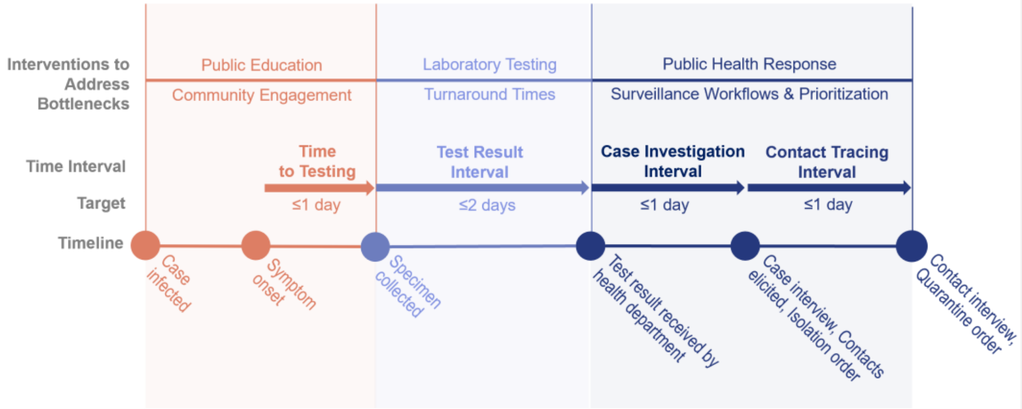


Table 2: Suggested Timeliness Indicators

Indicator	Target

Time to testing: 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**

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.

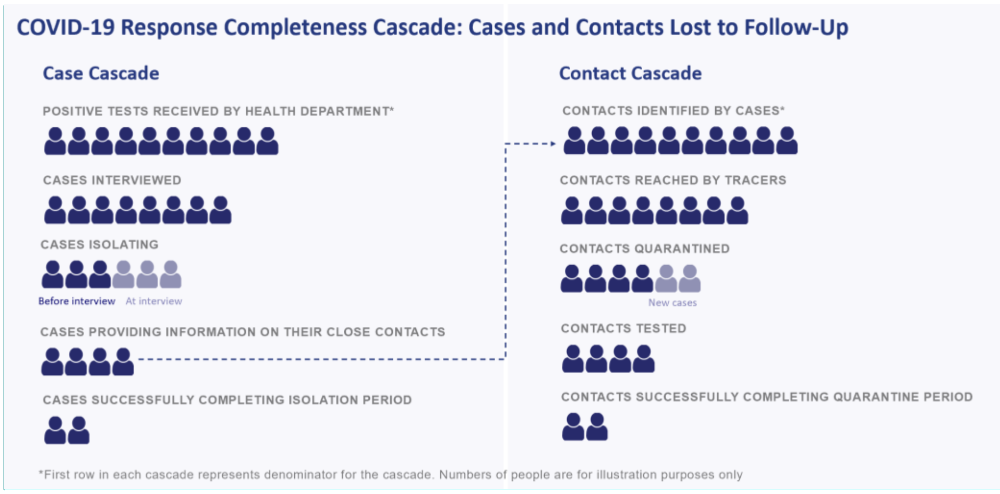
OUTPUT INDICATORS: COMPLETENESS AND THE COVID CONTROL CASCADE

Just as the Bottlenecks Approach dictates that timeliness metrics should be measured to identify and reduce bottlenecks in the end-to-end COVID-19 response process, completeness metrics should also 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 (see 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 (positive SARS-CoV-2 test), 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). These targets are unlikely to be used during a period of widespread transmission, when the capacity to do case investigation and contact tracing are limited and intervention efforts focus on individual and community measures, and retrospective or lookback contact tracing to identify super-spreading events.

When SARS-CoV-2 transmission is sporadic or declining, 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



Commented [HM1]: Figure to be revised to reflect indicator targets and to include self-isolation.

Table 3: Suggested Completeness Indicators

Indicator	Target
Self-isolation percent: Percent 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 information.*	**>80%**
Case isolation percent: Percent of confirmed cases reported to the health department who agree to isolate	**>80%**
Isolation completion: Percent 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 percent: Percent of identified contacts who are quarantined	**>80%**
Contact testing percent: Percent of identified contacts who receive a COVID-19 diagnostic test during their quarantine period	**>80%**
Quarantine completion: Percent of quarantined contacts who have been verified to complete their entire quarantine periods	**>80%**

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, completeness indicators are unlikely to be met; during these periods, timeliness indicators can still inform interventions for ensuring that testing is being quickly accessed, lab results are becoming available, and inform the prioritization of cases 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 in a given location, the explosive growth in cases may lead to a large backlog in cases pending investigation, and growth in the case investigation interval. 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 are 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 the case is 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 of the virus. The North Carolina state Department of Health and Human Services suggests 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 persons, and those living in geographic areas identified as highly vulnerable can be recognized by their date of birth and address. It may also be possible to match individuals to previous outbreak clusters and identify high risk healthcare personnel and first responders by matching against employment or licensure listings.

	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, contact tracing with the highest yield to reduce transmission and contacts with potentially poor outcomes should be prioritized. 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 • Persons with addresses or with reports from health care facilities, nursing homes, jails, or other congregate sites 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 • Persons with addresses or with reports from health care facilities, nursing homes, jails, or other congregate sites • 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

Accelerate time to testing, and encourage individual actions to improve case isolation and contact quarantine

If time from symptom onset to testing is frequently >24 hours, **public education and community engagement** is a key intervention to ensure that symptomatic people access testing 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 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 language in communities experiencing disparities in testing or cases. Community leaders and community-based organizations (CBOs) can be partners in campaign rollout, particularly in including grassroots, person-to-person component in a communications campaign. Even with limited resources, CBOs can be tapped to disseminate literature through their existing networks, including social media and at any in person gatherings.

Consider issuing guidance to communities to start isolation (except for accessing 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 Persons Should:	Contacts, Upon Notification by Symptomatic Persons 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, and prepare to quarantine if the case notifies them of a positive result (even before notification by the health department)

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 persons from accessing testing, make culturally appropriate 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. Pair isolation instructions with a list of community-based resources to meet basic needs so that the information is both empowering and useful. 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

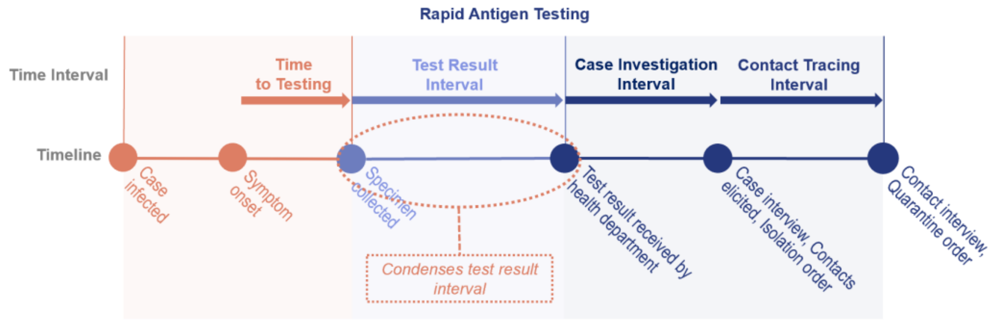
Conduct an assessment using micro-indicators (Annex 2) to map out delays in specimen transportation, specimen accessioning and processing, testing (including batch testing protocols), and sharing of results. Identify where the longest gaps are and revise workflows to reduce delays. Specimen transportation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

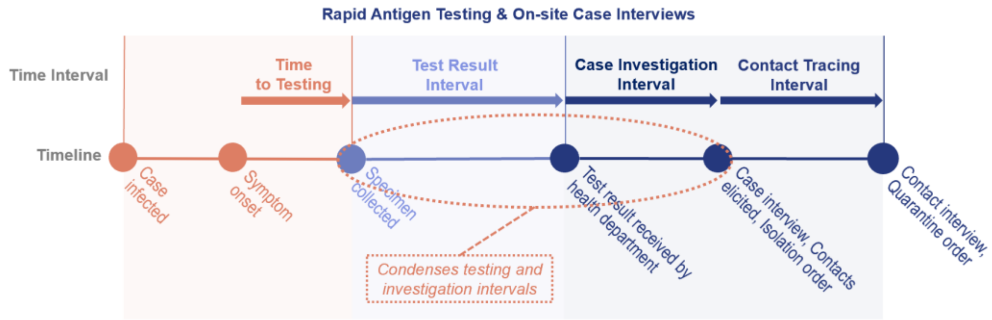
Despite efforts to increase testing capacity, laboratory resources might be constrained during community transmission scenarios or during the exponential growth phase of the epidemic. Use national (e.g., US CDC) or WHO guidance on prioritizing cases for laboratory investigation if testing capacity remains low despite best efforts to scale up capacity. 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

[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. If test positivity in the area is low (below 7% or so) then the percentage of positive antigen test results that are false positives will be high, just by the nature of the testing process. It is best in these situations to collect a second specimen for a confirmatory PCR test. While waiting for the PCR test result, the presumed case should be instructed to isolate and case investigation and contact tracing should be initiated. Similarly, if an asymptomatic person tests negative, the result should also be viewed as presumptive, as the person may be infected and in the early stages of the disease process. If the person has been recently exposed or is at continuing high risk, advise them to seek a second antigen test in two days to confirm their uninfected status.





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. Technology 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 2.5 hours to less than one minute.

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 (Re) = 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 Re <1, even with perfect contact tracing coverage and no tracing delay • **Contact tracing interval** (case test result to quarantine of contacts): ≤1 day for Re <1, assuming a testing delay >1 day and 80% of those who develop symptoms get tested	• **Tracing coverage:** >80% for Re<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	• 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 contacts, even with R0=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 (R0 = 2.2) • Tracing 90% of contacts resulted in mean reduction in Re of 66% for individual quarantine, with physical distancing (Re=1.25).

Model	Assumptions	Results (Timeliness)	Results (Coverage)
	frequency of monitoring symptoms, lower reduction in infectiousness during isolation and quarantine		
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 Re by more than 10% compared to corresponding scenarios without contact tracing • Median reductions in Re 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 R0=2.6 • 5 day incubation period • 50% relative infectiousness of asymptomatic cases vs symptomatic cases		• Contact tracing coverage often >90% to ensure Re <1 (in absence of other measures) • 64% transmission reduction for self-isolation and household

Model	Assumptions	Results (Timeliness)	Results (Coverage)
	• **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		quarantine with the addition of manual contact tracing of all contacts
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	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.

Model	Assumptions	Results (Timeliness)	Results (Coverage)
		period corresponds to the greatest expected infectiousness of infected contacts	

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.

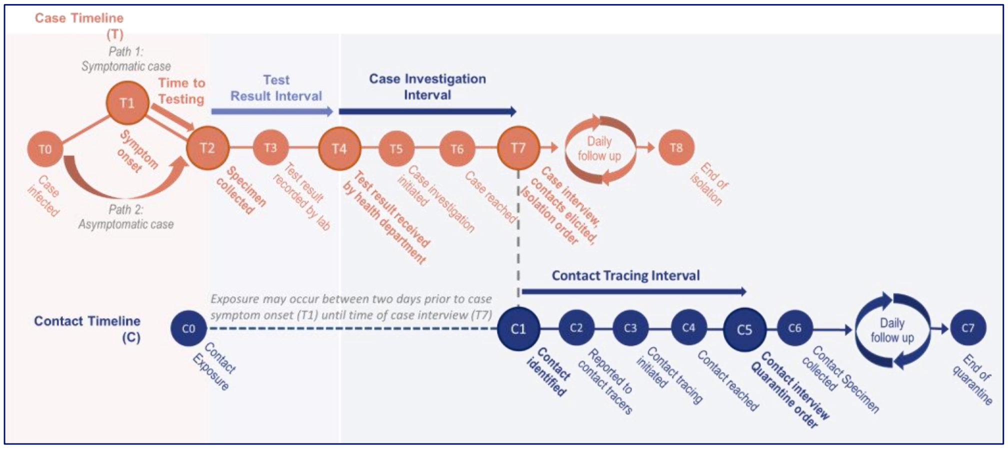
There are two basic ways to drill down into the data: by looking at population subgroups and by looking at shorter intervals of time. When designing or adapting data management systems to capture the key indicators, it is important to identify these subgroups and subintervals to ensure that you can capture 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, we attempt to assist here with Figure 5, which shows Figure 4 in a more granular view:

Figure 5.



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 ordered 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. That's because 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 epidemiologic 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 completeness of the case investigation effort, by comparing the overall number of cases with those known potential exposure. Cases will be considered linked if any of the following are true: i. the case fit the eligibility criteria for being part of an identified outbreak with at least one case; ii. a household contact of the case was also an identified COVID-19 case; iii. the case was a named contact of a previously identified case; iv. 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 tracing 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%**
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 percent: 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 percent: 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 isolated 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%**
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 percent: Percent of identified contacts who are quarantined	All new identified contacts in given time period	Number of contacts identified in given time period that were quarantined (use the denominator to determine which isolated 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 percent: 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			**(N verified at C7/ N at C5) x 100**		**>80%**

contacts who have been verified to complete their required quarantine periods.			Percent		
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 persons 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**
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	**≤24 hours**

				needed to determine whether there is a data pipeline bottleneck.	
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 positive and investigated patients, 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, 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
		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		Interval T4 to T5	Hire additional staff; if recruitment is a problem consider alleviating barriers such as insurance and PPE.

If you identify a bottleneck in:	Consider the following potential causes	Assess these micro-indicators	Consider applying these improvement strategies:
	Insufficient staff for case investigation, particularly during surge/exponential growth of cases	Cases per day over time Survey of staff on job satisfaction and issues	Reallocate staff flexibly from contact tracing to case investigation
			Case prioritization package—triage to focus on cases at highest risk of transmission
	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
	Inflexible first-in-first-out case prioritization		Case prioritization package (see main text)
	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.
			Call twice in a row to show you are not a robocall
			Ensure caller ID identifies case investigators as the local health dept.
			Send texts/letters/emails in advance of a call
			Use home visits as a last resort
	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
	Cases unwilling to cooperate with contact tracing		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	Interval C2 to C3	Have case investigator speak with and manage quarantine for household contacts immediately after elicitation
	Insufficient staff for contact tracing		Hire additional staff
			Reallocate staff from case investigation to contact tracing
	Unclear responsibilities for assigning contacts to contact tracers		Clarify responsibilities for case assignment and prioritization

If you identify a bottleneck in:	Consider the following potential causes	Assess these micro-indicators	Consider applying these improvement strategies:
	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
	Contacts unwilling to answer the phone		“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 dept
			Send texts/letters/emails in advance.
			Use home visits as a last resort
	Staff work hours not matching hours when contacts are reachable	Interval C4 to C5. Survey public attitudes toward contact tracing	Reallocate work hours to match hours when cases 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 communities most impacted

If you identify a gap in indicator:	Consider the following potential causes	Assess these micro-indicators	Consider applying these improvement strategies:
Self-isolation percent (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 coronavirus infection 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.
Case Isolation percent	Bottlenecks in case investigation	Interval T4 to T5 Interval T5 to T6 Interval T6 to T7	See Table 6, Indicator 11.
	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

If you identify a gap in indicator:	Consider the following potential causes	Assess these micro-indicators	Consider applying these improvement strategies:
	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)
			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.
	Space, economic, family or medical problems		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.	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.
	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 available to their contacts
			Hire additional Disease Investigation Specialists
			Risk communication package
Contact quarantine percent	Insufficient knowledge and motivation about role of quarantine in preventing transmission		Risk communication campaign
	Insufficient space to quarantine	Survey of public attitudes toward contact tracing. Issues captured in case investigation system Rates of utilization of support services	Recruit members of the communities most impacted
			Train case investigators in motivational Interviewing
			Hire Disease Investigation Specialists
			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 quarantined person’s home.
	Extended time for quarantine required due to multiple cases in the same household. Economic problems—cannot afford to take leave from employment		Require employers to provide paid leave for quarantine and guarantee job stability.
	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

If you identify a gap in indicator:	Consider the following potential causes	Assess these micro-indicators	Consider applying these improvement strategies:
	Medical problems		Provide a home health nurse/aide who has complete PPE
Contact testing percent	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 rapid antigen testing.
	Testing does not change quarantine mandate		Allow testing out of quarantine after two successive negative antigen tests 2 days apart.
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)
			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