Coronavirus disease (COVID-19)

Testing for COVID-19 in vaccinated populations

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Dépistage de la COVID 19 dans les populations vaccinées

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Purpose

This report presents evidence-informed recommendations for testing a vaccinated population and vaccinated individuals.

Testing a vaccinated population is done to:

- monitor the spread of SARS-CoV-2 and its VoCs, particularly potential vaccine escape variants
- determine the degree and duration of protective immunity conferred by full vaccination
- determine the rate at which transmission of SARS-CoV-2 occurs in vaccinated individuals

Testing vaccinated individuals is done to:

- minimize transmission and impact of SARS-CoV-2
- enable infected individuals to seek care if necessary

As vaccination increases across the country, diagnostic testing and asymptomatic screening strategies should be developed in collaboration with public health officials. (Asymptomatic screenings are testing programs that detect and identify COVID-19 in people who are asymptomatic and have no known or suspected exposure.)

Four key variables should inform diagnostic testing and asymptomatic screening strategies:

1. community prevalence of COVID-19
2. community prevalence of variants of concern
3. presence of outbreaks
4. populations with vulnerabilities

This report will be used as the foundation for an update to the Pan Canadian Testing and Screening Guidance.

Current state of COVID-19 testing

Role of government

The government plays an important role in the health and well-being of Canadians. Health care in Canada is an area of shared responsibility between federal and provincial/territorial governments. The provinces and territories are mainly responsible for health care delivery. The federal government plays a role in a number of areas, including:

- safeguarding the Canada Health Act
- coordinating responses to national emergencies
- managing health care delivery for certain populations
- providing financial support and expertise to provinces and territories
- publishing ethical and technical guidance on COVID-19 for various audiences
- regulating market access in Canada for drugs, medical devices and controlled substances
- communicating health information to people in Canada in a timely, accurate and accessible fashion

COVID-19 trends and vaccination

Rates of COVID-19 in Canada have been declining since the middle of April 2021 and rates of vaccination are increasing. As of July 30, 2021, over 80% of eligible Canadians have received at least 1 vaccine dose and 56% have been fully vaccinated.

As vaccination rates increase, the rate of transmission and incidence of COVID-19, as well as severe outcomes among infected vaccinated people, may decrease. (See *eLife* and Bailly and others.)

Nevertheless, COVID-19 infections and severe disease continue to occur mainly among unvaccinated people, including those who may face health, social and economic barriers. In June 2021, Yukon saw widespread community transmission for the first time, when about 75% of Yukon adults were fully vaccinated. However, 85% of the cases were in people who were not vaccinated.

Israel and the United Kingdom may also provide insight on expected COVID-19 trends in a vaccinated population. The number of cases rose in June in both countries despite high rates of vaccination and the presence of new variants. However, the number of hospitalizations remained relatively low compared to active cases, especially compared with trends earlier in the pandemic. This demonstrates the ability of vaccination to improve outcomes in vaccinated people (for example, reduce hospitalizations and deaths) even if they do become infected.

In response to the changing landscape, the Public Health Agency of Canada released guidance on June 25. This guidance outlines measures that need to be taken by vaccinated adults.

Some research indicates that vaccinated people who test positive for COVID-19 and do not carry the Delta variant are likely to have low viral loads (Teran and others, Bailly and others), particularly when symptoms are mild or the person is asymptomatic. There is also evidence that vaccination can greatly reduce rates of SARS-CoV-2 infections with high viral shedding and symptoms.

Emerging evidence for the Delta variant points to the possibility of high viral loads in some breakthrough cases in fully vaccinated people, which can be as high as in unvaccinated people. Preliminary data from the United States Centres for Disease Control and Prevention (U.S. CDC) and from Public Health England indicate that levels of virus in fully vaccinated people who become infected with Delta may be similar to levels found in unvaccinated people, and therefore they may be as likely to transmit the virus. Based on this evidence, U.S. CDC revised its masking guidance for vaccinated individuals on July 27 to recommend indoor masking in areas of high or substantial transmission. However, further studies are needed to confirm these levels of infectiousness and also the extent of vaccine effectiveness against Delta, which at present appears to be only slightly less than for other variants, such as Alpha. These new studies highlight the importance of monitoring and responding to the ever-evolving science.

COVID-19 epidemiology and evidence surrounding testing is changing rapidly. This guidance reflects the changing risk management approaches as more and more people in Canada are vaccinated. As new scientific and public health data emerge and the COVID-19 pandemic continues to evolve, our recommendations may change.

Testing landscape and regulation

In response to the pandemic, the Government of Canada supported scaling up diagnostic capacity to 238,000 tests a day across the country by procuring and distributing tests. We also procured over 42 million rapid tests and, since October 2020, shipped over 27 million to provinces and territories. As well, we have supported efforts to scale up rapid testing in the private and public sectors. Efforts include providing access to rapid test kits to support screening in workplaces deemed critical and where employees work in close contact.

There are 2 main categories of rapid tests for SARS-CoV-2:

- rapid molecular tests (such as rapid point-of-care (PoC) RT-PCR or RT-LAMP), which detect viral nucleic acids
- rapid antigen tests (RADTs), which detect specific viral antigens

Mechanisms to expedite access to medical devices, including 2 interim orders signed by the Minister of Health, were put in place starting in March 2020. The first interim order, the Interim Order respecting the importation and sale of medical devices for use in relation to COVID-19, speeds up the review of COVID-19-related medical devices without compromising the health and safety of people living in Canada.

To date, Health Canada has authorized over 70 testing devices under this first interim order, including 19 rapid tests. A second interim order, the Interim Order respecting drugs, medical devices and foods for a special dietary purpose in relation to COVID-19, allows certain medical devices that may not fully meet regulatory requirements to be imported and sold in Canada. Authorizations that are issued under the interim orders are only valid as long as the interim order is in place.

Health Canada will be proposing transition regulations in fall 2021 so that manufacturers may continue to sell their devices in Canada, while providing an opportunity to become fully licensed under the *Medical Devices Regulations* (MDR).

Social, economic and equity considerations

Some populations have been disproportionally negatively affected by the pandemic as their housing, economic and social conditions have placed them at greater risk. These determinants also contribute to the spread of SARS-CoV-2. Populations that are at high risk of infection and/or severe outcomes include:

- women
- people who are older
- racialized populations
- people with disabilities
- Indigenous populations
- people with co-morbidities
- people with mental health issues
- people who cannot be vaccinated
- people experiencing homelessness
- people working in high-risk workplaces
- immigrants, refugees, undocumented workers, temporary foreign workers
- people living in high-density arrangements (such as multigenerational housing or shared accommodations)

Note that the above list combines populations as well as exposure settings. People often experience multiple and intersecting disadvantages. Policy must address these inequalities.

As testing approaches shift in response to a changing pandemic, there is a need to consider approaches for disproportionally affected populations.

Evidence is building that appointment-based COVID testing presents a significant barrier for certain populations. Especially at risk are those without easy access to transportation, who have no or limited internet access, who have physical disabilities, language barriers and/or limited access to childcare. Similarly, people in low wage positions without access to sick leave are less likely to participate in asymptomatic screening programs for fear of a positive result and the impact to their salary as a result of self-isolation.

Although vaccination will reduce the incidence of COVID-19, sporadic outbreaks will continue to occur within groups at high risk of infection and/or severe outcomes (for example, among communities and demographics with low vaccination rates).

Reaching all populations requires a commitment to workplace safety, a community-centric approach, multi-sector collaboration, targeted funding, being innovative and being flexible or adaptable.

Key emerging themes in the data on addressing barriers to testing emphasize:

- importance of building and maintaining community trust
- benefits of developing and leveraging community partnerships
- workplace employment measures, such as sick leave and job protection
- effectiveness of using innovative testing methods (for example, mobile testing) to reach all populations
- importance of ensuring that programs and staff are sensitive to the mental health impacts of the pandemic
- opportunities to leverage expanded services to support health and health-related needs beyond COVID-19 (for example, HIV screening, blood pressure)

A literature search conducted on June 14, 2021, through COVID-END found no peer-reviewed or grey literature exploring the social or economic impacts of testing in a vaccinated population. The literature did not address implementation or scalability of testing.

Fall and winter outlook

Although in late spring COVID-19 cases had decreased in Canada, likely due to the vaccination rates, since mid-July, cases are already rising in some parts of the country. (See Merow and Urban, Sajadi and others, Liu and others.) The epidemiological situation into the fall will continue to evolve and public health will need to respond to increasing rates of vaccination and potential variants of concern. Public health guidance will evolve accordingly.

It's also possible that influenza and other infectious diseases (for example, tuberculosis, respiratory syncytial virus (RSV), other respiratory viruses) will make a resurgence. We may need to distinguish between these diseases and COVID-19 and shift testing capacity to these other illnesses.

Testing policies will no doubt shift to minimize or quickly respond to outbreaks of COVID-19 as the incidence of new cases decreases over the summer to manageable levels and there are fewer severe cases. Into the fall and winter of 2021, diagnostic testing should continue for symptomatic individuals regardless of vaccination status, including those with respiratory tract infections. Contact tracing and case finding during outbreaks will remain important.

Along with appropriate public health actions, an aggressive genomic sequencing strategy of positive specimens will help to identify early and limit the spread of potential vaccine-escape variants of SARS-CoV-2. To prevent transmission in workplaces, some private-sector representatives have also expressed interest in ongoing testing until at least winter 2022 in congregate settings such as warehouses and other essential services such as ground transportation, grocery chains and air transportation.

Variables informing testing and screening responses

Testing and screening strategies should be developed with consideration of 4 key variables:

1. community prevalence of COVID-19
2. community prevalence of variants of concern (VoC)
3. presence of outbreaks
4. populations with vulnerabilities

These variables can help inform decisions on when to:

- implement general asymptomatic screening strategies
    - for example, when all 4 variables are present, implement a more intense screening strategy)
- trigger surge testing capacity and allocate additional resources to address hotspots
    - for example, allocate more surge testing resources to outbreaks in populations with vulnerabilities in high-prevalence areas rather than to outbreaks in low-prevalence areas
    - consider local community considerations (for instance, health human resources and other implementation considerations)

Community prevalence of COVID-19

Community prevalence is the proportion of a population with COVID-19 at a given time. Definitions for what constitutes high or low community prevalence should be developed by jurisdictions based on their broader community context.

Along with test sensitivity and specificity, the pre-test probability of disease affects test performance. All other things being equal, when community prevalence of disease is lower, the pre-test probability is also lower. Positive results are more likely to be false positives when prevalence is low and negative results are more likely to be false negatives when prevalence is high. Also, when prevalence is low, it can take many tests to identify true positive cases. Testing and screening would be better indicated if prevalence in the overall population, prevalence among vaccinated people, or probability of severe outcomes is higher.

Community prevalence of variants of concern (VoC)

A variant of concern (VoC) is a mutation of SARS-CoV-2 and is associated with any of the following:

- increased transmissibility
- increased virulence or change in clinical disease progression
- decreased effectiveness of available diagnostics, vaccines or therapeutics
- decreased effectiveness of established public health measures

New VoCs are likely to emerge while the virus continues to circulate around the world. As of July 13, only 25.4% of the global population was vaccinated. As Canadian border restrictions are lifted, testing and surveillance at borders will continue to be necessary for the early detection and containment of VoCs. Thus far, existing testing technologies have been able to identify SARS-CoV-2 caused by a VoC.

Overall, it's not clear how VoCs will impact the pandemic in the coming year. If vaccine-escape VoCs develop, community incidence and pre-test probability of vaccinated populations will likely increase, necessitating a larger role for testing and screening. More VoC cases could also be transmitted in the fall as restrictions and border measures relax.

Presence of outbreaks

In areas where there are outbreaks, it's important to quickly identify cases in order to break chains of transmission and prevent the infection from spreading further. Unvaccinated populations are more likely to experience outbreaks, but it will be important to identify outbreaks in vaccinated populations as well to monitor potential vaccine-escape VoCs. Thus, testing and screening remain critical during outbreaks.

Populations with vulnerabilities

In some settings, such as long-term care and acute care facilities, tolerance for outbreaks is much lower because the risk of severe illness and/or more frequent potential exposures to infection is higher. In other settings, such as universities, tolerance may be higher as the risk of severe illness is lower.

People who benefit most from a targeted testing strategy are those who are:

- clinically vulnerable to more severe outcomes
- vulnerable to infection

There are also settings that are vulnerable because cases are difficult to manage due to limited access to healthcare services (i.e., rural and remote areas).

Some populations are more likely to experience a high incidence of outbreaks due to population characteristics, such as high rates of people who are unvaccinated. Multiple outbreaks are more likely in these populations, and are more difficult to manage than a single outbreak.

Among people who are vaccinated, those with comorbidities, who are older and who have suppressed immune systems are most vulnerable to breakthrough infection. Testing and screening is important in high vulnerability settings.

Review of available scientific evidence

A literature search on June 14, 2021, through COVID-END turned up only 3 peer-reviewed articles. One study referred to an antigen test for diagnostic purposes. Two studies, by Du and others and by Miyakawa and others, referred to serology tests used to assess exposure and immunity, but not diagnosis. Their rationale for continued testing in a vaccinated population focused on learning the degree to which the population has developed immunity, rather than testing the individual who provided the sample.

It's clear that evidence related to pre-test probability and test sensitivity and specificity should inform testing and screening strategies.

Testing, labelling and performance in vaccinated and low prevalence populations

Each test authorized for use by Health Canada varies in its ability (sensitivity and specificity) to detect SARS-CoV-2. (See Table 1.)

Table 1. Testing technologies

Testing Technology	Nucleic acid detects viral genetic material most accurate	Antigen detects viral protein less accurate
Laboratory performed by a trained person	**PCR** • Most sensitive/specific and used for diagnostic purposes • Slowest: up to 1 to 2 days turnaround time • Can screen for known VoCs • 70% to 90% sensitive* and 95% to 99% specific* when symptomatic	**N/A**
Rapid Point-of-Care performed or supervised by a trained person	**PCR** • Equally or slightly less accurate than lab-based PCR • 15 min to 1 h turnaround time **LAMP** • Equally or slightly less accurate than lab-based PCR • 15 min to 1 h turnaround time	**Rapid Antigen Detection Test (RADT)** • Less accurate than lab-based PCR • Low accuracy in asymptomatic people with low viral loads • 15 min to 30 min turnaround time
Self-test performed completely independently	**LAMP** • Less accurate than laboratory-based PCR • Decouples testing from public health reporting system • Up to 30 min turnaround time	**Rapid Antigen Detection Test (RADT)** • Least accurate vs lab-based PCR • Decouples testing from public health reporting system • 15 min to 30 min turnaround time

* https://www.publichealthontario.ca/-/media/documents/lab/covid-19-lab-testing-faq.pdf?la=enht tps://www.finddx.org/covid-19/sarscov2-eval-molecular/molecular-eval-results/ https://faseb.onlinelibrary.wiley.com/doi/10.1096/fj.202001700RR

Testing is recommended for symptomatic individuals independent of their vaccination status. This is because vaccinated individuals can still become infected with COVID-19; therefore, testing can prevent further transmission by guiding individual treatment and public health case and contact management. Close contacts of individuals who have tested positive should be tested as outlined in the National Guidance on Case and Contact Management. This Guidance also provides recommendations on isolation and self-monitoring for all individuals. Individuals are also encouraged to consult local public health guidance related to isolation and self-monitoring.

COVID-19 vaccination reduces both symptomatic and asymptomatic infections in randomized controlled trials and real-world effectiveness studies (see Related links below). Vaccines also remain highly effective against current VoCs (see the CDC update and The Lancet article).

Given the effectiveness of vaccines, all other things being equal, the pre-test probability of COVID-19 infection in people who are vaccinated will be lower than in people who are unvaccinated. This lower pre-test probability reduces the positive predictive value of testing, increasing the chance of false positives. False positives can be confirmed by repeating the test or using a more accurate test.

Most studies that assess performance use samples where positive specimens are over-represented, which may skew the sensitivity and specificity measurement. This is because the artificial high prevalence of COVID-19 in these sample sets increases the likelihood of tests being positive. This increases the likelihood of false negatives and decreases the likelihood of false positives. For example, a German study of 711 teachers evaluated using rapid antigen self-tests every 48 hours. A total of 10,386 tests were completed. Positive results were more likely to be a false positive when there was low incidence (<0.1%). Negative results were more likely to be a false negative predominantly when incidence was higher.

Lab-based PCR

The performance of tests is often compared to PCR tests, which are considered the main diagnostic test for COVID-19. While this can make it challenging to estimate the sensitivity and specificity of PCR tests, it's possible to estimate these performance characteristics when multiple PCR tests are used over time. Since performance of other COVID-19 tests are measured against the performance of the lab-based PCR, their stated performance may be overestimated.

The sensitivity of a single PCR test ranges from 70% to 90%, with specificity generally approaching 100% in symptomatic populations (see Public Health Ontario, FIND and Miller and others). In an Ontario study, where most participants had symptoms, sensitivity was found to be 85% and specificity approached 100%. When assessing the performance of other tests for COVID-19, most studies compare the test to a single PCR test. This approach may not accurately describe sensitivity.

Point-of-care (PoC) PCR molecular testing including LAMP (loop-mediated isothermal amplification)

PoC PCR and LAMP are rapid tests that are reportedly less sensitive and specific than PCR. Nevertheless, PoC tests are still useful in preventing the spread of COVID-19. Results are available quickly, which makes for timely action. They are also useful tools in rural and remote settings where lab capacity may be low. To address concerns related to sensitivity and effectiveness, frequent testing can improve the sensitivity and effectiveness of this testing strategy.

A June 2020 review noted that PoC PCR tests authorized in Canada had manufacturer-reported sensitivities ranging from 86% to 100% and specificities ranging from 88% to 100%. An Alberta Health Services report on 2 PoC tests states that sensitivity was 77% to 99% and specificity was 97% to 100%.

LAMP provides sensitive, accurate and specific results in a short time period. The sensitivity of LAMP tests was found to be 94% when applied to a purified RNA sample and specificity was greater than 95% in a meta-analysis.

Rapid antigen detection tests (RADTs)

RADTs are reported to be substantially less sensitive and slightly less specific than PCR tests. However, they also perform better (have greater sensitivity) in people with symptoms and those with higher viral loads, making them more likely to be infectious. A Cochrane review found that average RADT sensitivity was 72% among symptomatic people and 58% among asymptomatic people.

Since vaccinated people are less likely to have symptoms and have a lower viral load, RADTs can be expected to be less sensitive in this population group. Sensitivity was 95% for those with a high viral load and 41% for those with a low viral load.

However, RADTs may perform less well in a vaccinated population even when viral load is high. A study of health care workers showed that among those with known positive PCR test results and lower CT counts (higher viral loads), the proportion of positive antigen tests was significantly lower for vaccinated individuals. Data supports this finding for the Alpha variant, but it is unclear what the impact is of the Delta variant on RADT performance at this time.

Since RADTs are good at detecting infections with the most potential for transmission to others, their use has reduced community transmission (for example, through serial asymptomatic screenings). This is based in part on evidence of higher transmissibility in those who have symptoms and higher viral loads, for which RADTs have higher sensitivity. (See COVID-19 Scientific Advisory Group report, Koh and others, Buitrago-Garcia and others, Byambasuren and others, Marks and others.)

Nevertheless, if community incidence is low and vaccination helps to reduce COVID-19 incidence, screening programs are less likely to be cost-effective (see testing in schools briefing, testing in business sectors briefing, Testing and Screening Expert Advisory Panel report, Science Table report)

Additionally, positive results tend to be false positives when conducting asymptomatic testing with very low pretest probability. False positives may also result in missed work, waste public health resources, cause unnecessary closures and create psychological harms due to quarantine and anxiety. (See Stall and others, report by Ontario's Science Table.) False positive results in vaccinated people may also incorrectly portray vaccination as ineffective and contribute to vaccine hesitancy. Confirmatory testing of positive results with more accurate tests may place burdens on public health systems, but would also provide a means of VoC screening/sequencing.

RADTs are generally less expensive than rapid PCR or LAMP tests. If used as self-tests, they are also less expensive than lab-processed PCR tests. However, requiring someone to collect samples would reduce cost savings due to increased human resource costs.

Self-tests

As of June 10, 2021, the Lucira "Check It" COVID-19 Test Kit is the only self-test kit approved by Health Canada. "Check It" is a LAMP self-test that works with self-collected nasal samples. Results are produced in 30 minutes. This self-test is intended to be used as an over-the-counter self-test in people 14 years and older. Compared to lab-based PCR tests, the "Check IT" self-test has a sensitivity of 91.7% for people with symptoms.

Self-RADTs are not yet authorized for sale in Canada but a number of self-RADTs are under consideration with potential regulatory decisions expected by fall 2021. Depending on the size of a screening program, they may be the most feasible test to use because financial and human resource costs are reduced. As self-RADTs have a lower sensitivity than RADTs, follow-up lab-based PCR tests to screen and sequence variants would be required.

Also, there are often differences in RADT sensitivities reported by the manufacturer and those documented in real-life situations. The current cost of self-testing kits in the U.S. ranges from $12 to $55 USD (costs vary depending on test type). Self-RADTs are usually more affordable, while LAMP tests are more accurate but also more expensive.

In its fifth report, Canada's COVID-19 Testing and Screening Expert Advisory Panel recommends that self-tests be used to reduce mortality and morbidity from COVID-19 by reducing community transmission of SARS-CoV-2, support safer environments for more normal functioning of society and the economy and maintain, and if possible, enhance surveillance of SARS-CoV-2.

Multiplex tests

Multiplex tests can detect the presence of genetic material from multiple viruses/infectious agents using a single sample. For example, they can determine if a person in hospital with symptoms of respiratory illness is infected with SARS-CoV-2, influenza, both or neither.

Their use at sentinel surveillance sites can provide insight into the prevalence of COVID-19 and other respiratory viruses, such as influenza and RSV.

Multiplex tests may also be used to:

- inform treatment for immunocompromised people or those with severe illness in acute care settings
- identify the virus responsible in people living in congregate settings who present with symptoms

As these tests are more costly, priority should be for those at highest risk of severe outcomes, where test results can guide treatment and care, and where the results can contribute to overall respiratory viral surveillance.

Application of evidence

Symptomatic populations

Currently, testing is recommended for anyone with COVID-19 symptoms, regardless of vaccination status. There are several reasons for this. Vaccinated individuals can still become infected with COVID-19. Testing can therefore serve to guide individual treatment and public health case and contact management to prevent further transmission. In the United States the U.S. CDC recommends testing for symptomatic individuals who are fully vaccinated.

Testing vaccinated people who have symptoms can also be important for VoC surveillance. Determining the effect of VoCs on vaccine effectiveness with further precision and quickly detecting new variants that may have reduced vaccine effectiveness is critical. This information will help guide further public health measures, testing strategies and ongoing vaccine development.

PCR testing has higher sensitivity and therefore greater negative predictive value. This is important due to the higher pretest probability in people with symptoms and the importance of identifying vaccine-resistant VoCs quickly. As well, diagnostic lab-based PCR test results are sent to public health authorities, which allows for rapid screening and VoC identification.

Although there is little evidence currently to establish their performance in vaccinated populations, RADTs can detect infection in people with symptoms and the highest risk of transmission to others. They may also help reduce community transmission, while avoiding the unnecessary isolation of previously infected individuals who continue to test positive on PCR tests.

PoC LAMP or PCR tests have higher sensitivity than RADTs. If a rapid turnaround time is important (for instance, a congregate setting, rural or remote community), a PoC test such as a RADT or a PoC LAMP or PCR test may be preferable. When rapid tests identify a positive result, a lab-based PCR test should be done (as discussed earlier).

Lab-based PCR tests are most appropriate for symptomatic vaccinated populations as well as close contacts of individuals who have tested positive. However, a self-LAMP or self-RADT (the least sensitive potential option) is better than no test at all if individual behaviour changes as a result of the test.

Jurisdictions should consider their specific context in order to determine if self-testing makes sense. If self-RADTs are approved in Canada, they are likely to be less expensive than self-LAMP tests. Therefore, self-RADTs could have a role in making testing more accessible and acceptable to people who are vaccinated and have symptoms but would not opt for a lab-based PCR test or pay for a self-LAMP test.

Asymptomatic populations

The U.S. CDC recommends that people who are fully vaccinated not undergo testing as part of asymptomatic screening programs. Additionally, the Ontario COVID-19 Science Advisory Table recommends that long-term care staff who have been vaccinated not undergo asymptomatic screening with either RADTs or PCR tests for similar reasons. Conversely, a study considering evidence from long-term care homes in Israel recommends proactive surveillance programs for people who are vaccinated.

Asymptomatic screening in vaccinated populations could be considered if community prevalence rises above a pre-determined threshold to make screening worthwhile or during outbreaks. This pre-determined threshold will vary depending on the jurisdiction. It will also be important to monitor emerging evidence and surveillance data on SARS-CoV-2 variants. Screening programs using RADTs could be initiated should VoC incidence increase in vaccinated individuals. They could also target populations with vulnerabilities (for example, older adults, people with disabilities) and populations who have a higher risk of transmission (for example, travellers, health care workers, shift workers).

International examples

U.K.: RADT testing is available 2 times a week on request. Anyone may access the program, but the focus is on people who are not vaccinated, education sectors and populations with vulnerabilities and in vulnerable settings.

U.S.: U.S CDC recommends against routine asymptomatic testing for people who have been vaccinated. Vaccinated populations who are symptomatic are advised to seek medical consultation and potential testing.

E.U.: The EU CDC has suggested that public health authorities consider removing the requirements for routine asymptomatic testing for vaccinated populations.

OECD: The proportion of OECD countries with open public testing available to all asymptomatic people dropped dramatically, from over 40% in April 2021 to under 5% in May 2021. Almost all OECD countries continue to test symptomatic populations. However, asymptomatic screening may continue to be helpful when there's an elevated risk of SARS-CoV-2 exposure and potential exposure to new vaccine-resistant variants (for example, vulnerable sectors, frequent travellers). Comprehensive or random sampling screening programs could be considered. There may be constitutional or legal implications if these measures are mandatory.

A scan on June 14, 2021, through COVID-END did not find specific testing guidance for people who are fully vaccinated. Guidance that exists:

- exempts those who have recovered from COVID-19 and people who are fully vaccinated from testing requirements (Germany)
- recommends against serological or virological tests before or after vaccination (Spain)
- exempts people who are vaccinated from mandatory testing (Austria)

In its fifth report, Canada's COVID-19 Testing and Screening Expert Advisory Panel found that the usefulness of self-tests in people who are partially or fully vaccinated needs further evaluation.

Behavioural science and test-seeking behaviour

The number of tests performed every day in Canada has declined since the April 2021 peak. This coincides with increased vaccination rates. If someone is fully vaccinated, has no pre-existing conditions (co-morbidities) and prevalence is low, then the person may not perceive any benefit to testing, even if they have symptoms. Because the cost of a positive result (self-isolation, lack of work, for example) may be high, the person may be less likely to be tested. In addition to such a cost-benefit calculation, other factors may contribute to a reluctance to undergo testing:

- testing/pandemic fatigue
- minimized perception of risk from COVID-19
- increased difficulty to access testing

Complex cognitive biases and the evolving nature of the pandemic make it difficult to encourage people who are fully vaccinated to get tested.

It will be important to collaborate with behavioural scientists when preparing messages to address testing hesitancy and fatigue in a vaccinated population. Any communication must clearly explain the circumstances under which someone should be tested.

Surveillance tools

As COVID-19 shifts from being an epidemic to becoming an endemic or recurring disease, our response to the virus will also shift. We will move from widespread testing and screening to routine surveillance. Although the epidemiologic situation is encouraging, there is still some level of uncertainty about its stability. Surveillance will focus on timely identification, assessment and response to emergent variants, clusters and outbreaks. This will involve targeted testing, including conducting PCR testing on people who are fully vaccinated.

As the situation continues to stabilize, our long-term, routine monitoring system should leverage existing respiratory virus surveillance infrastructure. The following broad surveillance methods could be used to monitor populations for COVID-19 and VoCs:

- PCR testing
- antigen testing
- genomic sequencing
- wastewater monitoring
- health record screening
- serosurveillance (out of scope for this report due to the limited clinical utility of serology testing)

International example

U.K.: Public Health England published guidance on surveillance specific to vaccinated populations. It will monitor COVID-19 in vaccinated populations in various ways:

- routine surveillance
- enhanced surveillance
- electronic health records
- targeted longitudinal studies
- vaccine failure records (includes following up on viral whole genome sequencing)
- serosurveillance (includes blood donor samples, routine blood tests and residual sera)

Population surveillance

Successful testing and screening programs depend on individuals actively seeking tests. With test-seeking behaviour expected to decrease, we can employ more passive surveillance methods to monitor COVID-19 in the population.

Some jurisdictions are monitoring COVID-19 cases and emerging VoCs post-vaccination by:

- screening the population using PCR and/or rapid antigen tests
- doing genomic surveillance
- conducting wastewater surveillance
- using metagenomics
- testing air filters on public buses

There are also studies on screening with PCR and rapid antigen tests in health care settings, long-term care facilities, communities and workplaces with essential workers. However, there is limited data on population surveillance for COVID-19 using metagenomics and testing air filters in public buses.

PCR and rapid antigen testing

Communities and higher risk areas, such as long-term care homes, health care settings and essential workplaces, may benefit from regular population screening. Compared to PCR tests, antigen tests have lower sensitivity. While more cases may be missed when using RADTs, this issue also applies to PCR tests due to their sensitivity, quality of samples and timing of the test.

Evidence shows that when people are offered discretionary access to testing, the frequency of testing varies significantly from person to person. People's willingness to participate in testing also diminishes with time. Interestingly, a study with a prolonged follow-up period showed a progressive decline in the interest of the participants.

Surveillance of COVID-19 outbreaks with PCR and rapid antigen testing will enable timely intervention and insight into settings and/or populations most at risk. Specimens collected from outbreaks should be tested for both influenza and SARS-CoV-2 viruses.

The broad network of labs, including provincial, regional and some hospital labs, could expand sample analysis beyond confirming COVID-19. If possible, multiplex PCR tests for the simultaneous detection of influenza and SARS-CoV-2 viruses should be selected for efficient use of reagents, consumables and diminishing the need for administering multiple tests. As demand for multiplex test capacity may exceed supply, priority should be given when capacity is limited to symptomatic and populations with vulnerabilities at highest risk of severe illness from COVID-19 (for example, acute care settings, long-term care residents, people with co-morbidities or who are immunocompromised).

Genomic sequencing

Monitoring for VoCs through the genomic sequencing of positive test results is critical to surveillance. Genomic sequencing identifies the specific series of nucleic acids that make up genetic material (DNA or RNA). Although relatively time-consuming and resource-intensive, genome sequencing can identify known and emerging SARS-CoV-2 variants.

Some countries have made significant progress with their vaccination programs, while others have limited vaccine supply or a lack of resources. Thus, the potential for new VoCs to emerge will remain until the virus is controlled globally. It's essential to continue using genomic surveillance to monitor known and emerging VoCs and potential vaccine-escape variants. (See Wang and others and an article from Columbia University.)

Monitoring VoCs will require an integrated approach linking laboratory genome sequencing with epidemiology and modelling and sharing data between different organizations. An integrated approach allows for local laboratory and epidemiology analysis to be connected to sets of outbreak cases associated with mutations, which may lead to new variants of interest (VOI) being identified. Genomic surveillance undertaken by labs is a critical component of an integrated approach. More detailed transmissibility, virulence and immune escape analyses, based on epidemiology and lab results, are needed to determine if a VOI is a VoC.

Wastewater surveillance

Wastewater surveillance can detect changes in SARS-CoV-2 levels at a population or community level. It involves collecting wastewater from treatment plants, lift stations or further upstream in a community or institution and measuring levels of SARS-CoV-2 and variants of concern.

Using a lab-based PCR, the wastewater sample can detect the virus early on in the community and monitor an increase or decrease in the amount of viral particles in the sample. Wastewater samples can be used for genomic sequencing to detect existing and emerging VoCs. It does not depend on people going to testing sites or buying test kits. It does not involve collecting personal information (there are few or no privacy concerns).

Improved analysis and presentation of data would ensure that the information could be used in modelling and public health decision-making. In a vaccinated population, it may be more cost-effective and align with public health priorities to sample higher-risk areas (for example, university dorms, known unvaccinated neighbourhoods).

Illness and severe outcome surveillance

Similar to influenza monitoring, lab-based results along with increased primary care and emergency room visits for COVID-19 and outpatient care are tracked at a regional and provincial/territorial level. Equipping primary care providers with the capacity to test in situ and where technology is available to confirm if someone has COVID-19, influenza or RSV will enhance our geographic surveillance activities. More importantly, this will result in more

immediate intervention such as isolation and contact tracing. However, this decentralized testing approach will likely result in difficulties with data collection and further variant testing as not all primary care providers are equipped to provide public health data.

Health record screening

Electronic health data (for example, from provincial vaccination databases) can be shared with public health in order to monitor vaccination status and the incidence of COVID-19 and other respiratory infections. This can be done through family doctors, hospitals and other health care settings. One study used health record screening to track the incidence of COVID-19 infection in vaccinated and unvaccinated long-term care residents.

Similar to influenza vaccine monitoring, tracking COVID-19 vaccine coverage and effectiveness will provide critical information on the populations/sectors where vaccine coverage is low and ongoing testing and screening is warranted. Monitoring will also signal when a vaccine is becoming less effective, which may then warrant a vaccine booster and increased testing and screening.

Sentinel physician outpatient surveillance

The value of expanding the influenza sentinel physician surveillance system from a syndromic target (influenza-like illness) to laboratory detection will be assessed. Equipping primary care providers with the capacity to test in situ could improve Canada's ability to assess the burden of illness (capturing less severe cases) and determine the intensity of infection in a community. It will require regional and provincial/territorial laboratory capacity to process samples and a willingness of physicians to participate and provinces/territories to add COVID-19 surveillance to existing influenza sentinel physician surveillance systems.

Recommendations for fall and beyond

Canada must build on lessons learned and reassess its diagnostic testing and screening strategy to ensure the health, social and economic needs of Canadians are met. All vaccinated Canadians, especially for those at higher risk for exposure and/or severe disease and those with symptoms, should be given access to COVID-19 tests after the vaccine rollout to monitor VoCs.

However, without further data from manufacturers or others, regarding the performance of authorized tests in a vaccinated population, instructions will indicate that results have not been validated in a vaccinated population. This represents the majority of authorized tests. Manufacturers will be required to provide evidence obtained on a vaccinated population to support the clinical sensitivity on vaccinated/asymptomatic individuals to remove this limitation from the instructions for use.

Testing (symptomatic)

- Maintain responsive diagnostic testing capacity (lab-based PCR), with priority on surge preparedness, for both vaccinated and unvaccinated populations, and reassess at the end of 2021
- Focus on populations with vulnerabilities (for example, people who are not vaccinated, including children), employers and communities, and ensure readiness to respond to resurgence
- Make self-test available for general public, with appropriate advice and provide education for self-management of a positive test result, including going to seek confirmatory PCR testing
- Shift to multiplex tests to quickly diagnose COVID-19 versus other respiratory infectious diseases (for example, influenza, RSV), in particular for symptomatic and populations with vulnerabilities (for example, long-term care residents, people with comorbidities)

Screening (asymptomatic)

- Begin asymptomatic screening and allocate surge testing resources in consultation with public health officials when the following exist:
    - moderate/high community prevalence
    - a vaccine-escape VoC in the community
    - an active outbreak (2 or more cases of transmission of COVID within the setting)
    - populations with vulnerabilities
- Employ asymptomatic rapid testing to protect populations with vulnerabilities (long-term care homes, congregate settings, unvaccinated populations)
- Maintain outbreak management capacity to rapidly shift testing and deploy to hotspots
- Maintain partnership with private sector to continue a culture of disease prevention and health promotion in workplaces, building on the lessons learned from widespread workplace screening programs
- Maintain modest (at least one month) testing stockpiles of rapid tests for rapid surge testing and deploy to hotspots or if a VoC that escapes vaccination is detected, and follow up positive results with a lab-based PCR test
- Use distribution channels such as pharmacies and Chambers of Commerce to support agile response in hotspots
- Continue to test international travellers in light of the heightened risk of VoC importation and the likelihood of ongoing high SARS-CoV-2 transmission worldwide

Surveillance to inform testing strategies

- Leverage and enhance existing surveillance (laboratory and epidemiology) data and infrastructure (such as FluWatch) and public health alerting systems to identify vaccine-escape VoCs and/or high risk settings/locations
- Maintain capacity to detect new VOCs through genomic sequencing, particularly when a vaccinated person has a positive test result
- Use targeted wastewater surveillance and rapid tests for asymptomatic screening to improve general surveillance information
- Monitor ongoing reporting of hospitalizations, ICU admissions and deaths of people with confirmed COVID-19 test results on a weekly basis to provide insight into the ongoing burden of COVID-19. Multiplex testing could also be useful in key sentinel surveillance sites

State of science

- Use additional modeling to understand the rates of false positives resulting from low prevalence in communities with increased vaccination
- Fund clinical trials and research to best understand how the various tests approved in Canada will perform in the real world with vaccinated populations in low prevalence settings

Communication

- Collaborate with behavioural scientists to consider the behavioural aspects when preparing messaging around testing for COVID-19 to counter testing hesitancy and fatigue in a vaccinated population
- Use consistent messaging between jurisdictions and governments about disease prevalence, testing and screening (including rapid testing as an added layer of defence), vaccination and adherence to public health measures to encourage tolerance and avoid stigmatization

Economic and social

- Identify opportunities to improve race and ethnicity data combined with COVID-19 hospitalization and deaths from COVID-19 cases to improve targeted testing
- Support community response and resilience in populations with vulnerabilities and workplaces to mobilize rapid outbreak response, act collectively to reduce pre-existing health inequities and to remove structural and systemic barriers to health
- Develop tools and training for primary health care workers on COVID-19 and the mental health impacts on populations with vulnerabilities

Recommended tests for a vaccinated population

Diagnostic molecular tests

- Test all symptomatic people (unvaccinated, partially vaccinated or fully vaccinated) using diagnostic lab-based PCR to reduce the chance of false negatives and enable rapid and accurate VoC surveillance
- Follow up all positive RADT or non-diagnostic PoC molecular tests with a lab-based PCR to ensure it is a true positive result
- Opt for LAMP and PoC PCR tests rather than RADTs when there's an outbreak in a congregate setting or similar events requiring access to more definitive rapid test results. In response to outbreaks, positive test results should be followed by genome sequencing to monitor for VoCs
- Refine regulatory measures to promote decentralized testing and increase access to accurate diagnostic tests for communities (for example, rural and remote)

RADTs

- Consider the 4 key principles in determining the merits of pursuing asymptomatic screening in vaccinated people
- Use to screen unvaccinated (or partially vaccinated) asymptomatic people and as a first step for diagnosing unvaccinated symptomatic individuals, especially those working in close contact and other congregate settings (e.g., dormitories, shelters)
- Use RADTs serially for outbreaks, with a particular focus on populations with vulnerabilities
- Offer systems to support appropriate self-management of presumed positive test results, including easily accessible follow up PCR testing
- Monitor rates of false positives and negatives, as well as rates of participation

Self-tests

- Use to screen asymptomatic unvaccinated people and to quickly identify potential infections in people with symptoms if there's a COVID-19 resurgence
    - Provide self-tests at no cost at various locations in the community
- Any positive self-test should be followed-up by a lab-based PCR to ensure it is a true positive result
- Use self-testing as another tool during influenza season to rule out COVID-19 infection in people with symptoms, including those who are vaccinated, when risk of false negative is deemed more acceptable as severe outcomes have been mitigated by the vaccine

Conclusion

Vaccination reduces the risk of transmission of SARS-CoV-2 and severe illness in people infected with COVID-19. Testing and screening has a role to play in managing the eventual shift to endemic COVID-19.

However, it's important to recognize that widespread testing and screening programs (particularly asymptomatic screening) may not detect many cases when COVID-19 is not as prevalent among a vaccinated population. If there are symptomatic cases, they will probably be quite mild. Thus, general testing and screening programs may not use public resources efficiently. There will consequently be a shift to managing outbreaks, undergoing surveillance and distinguishing between COVID and other respiratory illnesses. As always, we adjust our responses as a pandemic evolves.

Public demand for testing in Canada has decreased steadily since the peak of the third wave. As things become more 'normal,' it will be important to distinguish between various respiratory illnesses, protect populations with vulnerabilities and monitor variants of concern, particularly one that escapes immunity. Surveillance will play a larger role in a vaccinated population. As well, Canadians will expect clear direction in terms of what behaviours to modify as vaccination increases and what testing, if any, should be undertaken when they exhibit symptoms.

Annex A: Description of current testing technologies

Lab-based PCR

Nucleic acid tests (also known as molecular tests) amplify very small amounts of genetic material for subsequent detection. They can detect small amounts of viral material, including dead/inactive virus, as well as the presence of known variants. The molecular test relied upon to diagnose COVID-19 is the PCR test performed in a lab. Lab-based PCR tests are recommended for people with COVID-19 symptoms or have been exposed to someone with COVID-19. These tests are the main diagnostic testing method used in Canada, with nearly 60,000 tests administered daily as of June 9, 2021.

Point-of-care PCR and LAMP

Point-of-care (PoC) PCR tests and LAMP (loop-mediated isothermal amplification) tests are rapid nucleic acid tests available outside of labs. With proper set-up, they can detect the presence of known variants.

Rapid antigen detection tests (RADTs)

RADTs are rapid PoC tests that detect viral protein without amplification, so they are less sensitive than nucleic acid tests. RADTs have been deployed as screening tests in some contexts, such as among asymptomatic long-term care staff in Ontario and in workplaces. Furthermore, Shoppers Drug Mart is now offering RADT screening for asymptomatic people in select stores in Ontario. In some settings, RADTs are being used as self-tests. However, there are currently no authorized RADT self-tests in Canada.

Self-tests

Self-tests can be administered by untrained individuals. Any PoC test has the potential to be a self-test. The Lucira Check It LAMP test was recently approved as the first fully self-administered test in Canada. Manufacturers are expected to submit applications for approval of other self-tests in the near future. The widespread availability of self-tests may negatively affect surveillance by decoupling testing from the public health system. However, they can continue to make testing accessible and easy to do, as formal testing centres and sites close when demand decreases.

Annex B: International guidance on testing in a vaccinated population

Source	Test type (date updated)	Key takeaways
EU CDC	Rapid tests (published May 6)	Suggests that public health authorities may soon consider exempting fully vaccinated individuals from repeat rapid testing. Still suggests the need for caution given risk of onward transmission to populations with vulnerabilities.
Forbes	Rapid antigen test, PCR	mRNA-based vaccines will not cause a Covid-19 PCR test to be positive. Similarly, these vaccines will not cause rapid antigen tests to be positive. If a vaccinated person does test positive (PCR or RAT), they were likely infected with SARS-CoV-2 just before or after being vaccinated.
HuffPost	Rapid antigen test, PCR	One should get tested following vaccination if one develops symptoms consistent with COVID-19. Some experts recommend a rapid antigen test for those who are fully vaccinated. Positive tests should be confirmed via PCR.
Ontario Science Table	Any test	The Ontario Science Table recommends not using routine asymptomatic screenings in long-term care staff who are vaccinated.
U.K.	Rapid lateral flow test	The U.K. provides twice weekly lateral flow tests (LFTs) to the public. It has also been providing twice weekly LFTs to certain groups (for example, NHS workers, care homes, schools, other congregate settings). The program is targeted to unvaccinated people. Those who test positive will continue to need to self-isolate.
U.S. CDC	Rapid antigen test (updated June 14, 2021)	A positive rapid antigen test in a fully vaccinated person should be confirmed with PCR testing. Public health authorities should be informed (in case of breakthrough infection). A separate specimen should be collected and sent to a lab for viral sequencing. Fully vaccinated asymptomatic people do not need to pursue rapid testing.
U.S. CDC	Any test (updated May 28, 2021)	Testing (but not quarantine) is still recommended following an exposure to someone with suspected or confirmed COVID-19. Exceptions are fully vaccinated residents and employees of correctional and detention facilities and homeless shelters.
U.S. CDC	Any test (updated June 17, 2021)	None of the authorized and recommended COVID-19 vaccines can cause positive tests.

Annex C: International case studies for testing in vaccinated populations

Source	Test type	Key takeaways
Austria	N/A	As soon as the relevant legislative basis is put into effect, vaccinated persons will also be exempt from mandatory testing. This exemption will apply for 1 year as of day 22 following initial vaccination.
Cyprus	Rapid antigen test	All employees who are fully vaccinated are no longer required to conduct weekly rapid tests.
Germany	PCR, point-of-care PCR	Germany no longer requires testing for travellers who have been vaccinated and/or have recovered from COVID-19 if they are not coming from a high incidence area or a variant of concern area. Otherwise, they require a negative PCR or point-of-care PCR test.
Israel	Any test	Rapid test providers must test anyone who wants to enter a venue that complies with Green Pass requirements and does not have a Green Pass. A Green Pass grants permission to enter places and buildings if you have been fully vaccinated or have recovered from COVID-19.
Seychelles	N/A	Data from Seychelles in May show a week where the 7-day rolling average shifted from 120 to 314 positive cases. Of those who tested positive, 37% had received 2 doses of a vaccine, of primarily Sinopharm or AstraZeneca.
U.A.E.	PCR	Fully vaccinated government employees need to take PCR tests to enter their workplaces every month. Non-vaccinated employees need to test every week. Employees are responsible for covering the costs of the tests.
U.K.	Rapid lateral flow test	The NHS is encouraging people who are vaccinated to continue using regular rapid testing. When people submit their results to the NHS portal, they are asked about vaccination status (no dose, 1 dose, 2 dose) and when they were vaccinated.
U.K.	Rapid lateral flow test	Personal care attendants, regardless of vaccination status, are encouraged to conduct 2 LFDs a week to reduce infection risk to clients with disabilities (regardless of vaccination status). The tests are mailed to their house.
U.S. CDC	Any test	Regular asymptomatic testing not recommended for asymptomatic people who have been exposed.
Sweden	Any test	People who have been vaccinated against COVID-19 in the past few days and experience symptoms that are common side effects after a vaccination do not need to get tested if the symptoms disappear within 24 hours.
Switzerland	Any test	People without symptoms may get tested in order to detect as many coronavirus infections as possible. This does not apply to people who are fully vaccinated or have recovered from the virus.

Annex D: Surveillance strategies upon reducing testing volumes

Source	Test type	Key takeaways
BCG	PCR, LAMP, NGS Multiplex panels	BCG predicts a peak-valley-peak demand for tests (in U.S., France, Germany, Italy, Spain) through 2021, then a progressive decline from tests in the first quarter of 2022 and beyond, driven by use cases (diagnostics, triage, population screening, safety screening). It expects a continued need for testing that lasts through 2023-2024 as disease becomes endemic. The importance of multiplex panels for respiratory illnesses and how fragmented testing reporting (for example, greater share of home testing) can affect general testing operations are described.
Brault and others (PLOS Computational Biology)	Group pooled testing	Sample pooling can help rapid testing among asymptomatic people. The authors describe surveillance screening modelling for non-diagnostic contexts to identify settings for targeted testing.
Daughton (2020), Sci Total Environ	Wastewater surveillance	Presents suggestions for wastewater surveillance for COVID-19. Major targets include schools, universities, congested public housing, hospitals, long-term care homes, prisons, manufacturing and warehouse facilities, meat packing plants, ships, airports/airlines, mass entertainment venues, indoor exercise facilities, other confined areas.
IDT DNA technologies	Multiplex assays	FDA granted EUA a Flu Multiplex Assay. PCR test differentiates RNA markers from COVID, influenza A and influenza B, as they share symptoms (especially in the coming fall months) Examples of multiplex assays from companies include: • BioFire Diagnostics Biofire Respiratory Panel 2.1 and Panel 2.1-EZ • GenMark Diagnostics ePlex Respiratory Pathogen Panel 2 • QIAGEN QIAstat-Dx Respiratory SARS-CoV-2 Panel • Roche Molecular Systems cobas SARS-CoV-2 & Influenza A/B and cobas SARS-CoV-2 & Influenza A/B Nucleic Acid Test • Cepheid Xpert Xpress SARS-CoV-2/Flu/RSV on the GeneXpert Dx and GeneXpert Infinity systems and GeneXpert Xpress System (Tablet and Hub Configurations) platforms • Quidel Sofia 2 Flu + SARS Antigen FIA • Quest Diagnostics RC COVID-19 + Flu RT-PCR
Ontario Public Health	Wastewater surveillance	PHO review on global wastewater surveillance activities through a literature search. Many regions in North America already use it

Source	Test type	Key takeaways
		(for example, NWT, Ohio, Michigan, Utah, Alaska, NYC, Ontario). Good list of references. Netherlands samples 300 sewage plants.
Pew Trust	Wastewater surveillance and rapid tests	Testing volumes are down significantly in the U.S. Arenas used for testing are now being converted to vaccine centres. Arizona, California and Massachusetts are using wastewater testing to identify localized outbreaks. Anecdotally, test manufacturers have had a lull in product demand but schools and businesses are particularly interested in acquiring rapid tests (especially home-based tests) for students, employees and customers.
Rockefeller Foundation long-term testing strategy for states	Long-term testing sites for communities that have experienced inequity Wastewater testing	Suggests developing long-term testing sites in priority communities and continuing to support mobile, pop-up and surge testing in response to hotspots. This strategy has been used in Connecticut, which has contracted with testing vendors to build sites at schools, parks, churches and community centers. The Rockefeller Foundation also simulated outbreak control after the pandemic starts to become more controlled, and found surge testing screening at least 25% of the population per day can control an outbreak in less than 1 month. RATs are preferable over PCR if it takes 2+ days to report results. Massachusetts and the University of Arizona have used wastewater testing. University of Arizona was a notable example because it was an early indication of a dorm outbreak.
U.S. CDC	Wastewater surveillance	Wastewater includes water from building use and non-household sources (for example, rainwater). It can be tested for RNA from SARS-CoV-2. CDC is in the process of developing the National Wastewater Surveillance System to help understand the extent of infection in communities. The virus can be detected in sewer shed several days before community cases are reported. CDC suggests sampling plans, including where to sample, how often to sample, what to sample, how to sample and how to safely store, collect and ship samples.