Returning to Workplaces Safely

How Modeling COVID-19 Testing Can Help Employers Make Informed Decisions

CVS Health

What makes COVID-19, caused by a novel virus Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a particularly complex challenge is the large amount of variation in its clinical presentation. While most infected individuals have minimal or mild symptoms, a subset of patients develop pneumonia and subsequent acute respiratory distress syndrome, putting a great deal of strain on the nation's intensive care capacity.[1,2] Patients who develop these severe respiratory symptoms tend to be older and have medical conditions such as heart disease, diabetes or cancer, though serious illness can occur in any individual regardless of health status or age.[3] In addition, there are limited therapeutic options available to treat COVID-19, though some treatments have been shown to reduce the severity of the illness.

Given the ongoing spread of the virus and its potential to cause severe illness, as well as the relatively limited roll-out of vaccines so far, prompt diagnosis and isolation are still the foundation for limiting the spread of this highly contagious pathogen.[4] For employers considering returning employees to workplaces or trying to keep facilities open, the optimal testing strategy to control potential outbreaks is key.

Employers need to know what type of test to use, whom and how frequently to test, and what percentage of employees should be tested each time.

Balancing the frequency and volume of testing, with cost and the potential for spread can be complex and challenging. In order to evaluate the relationship between diagnostic testing and infection control in a range of scenarios, we developed a model that shows the effects of varying testing strategies on the spread of COVID-19.

The model simulates realistic workplace specifications and interactions via configurable parameters, such as cohort size, fraction of time spent at and outside work, team network structure, and infection rates inside and outside the workplace.

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In this white paper we share the results of our modeling. For instance, we found that testing 50 percent of the population twice a week prevents more than 50 percent of cumulative 60-day infections when compared to symptomatic testing only, and that point-of-care testing improves outcomes more than laboratory-based testing and reduces daily infections.

We hope that this will enable employers to make informed decisions about the right level of testing to safely return employees to the workplace.

COVID-19 Transmission

COVID-19 spreads mainly from person-to-person when individuals are in close contact with one another within about six feet, or through respiratory droplets produced when an infected person coughs or sneezes. Exposures that occur either after, or within two days before the onset of symptoms are considered significant. Data suggests that patients infected with COVID-19 are most infectious in the early stages, starting at about two days before symptom onset and peaking at 0.7 days prior to symptom onset.[5,6] Every individual infects, on average, two additional individuals.[7] An estimated 17 to 45 percent of those infected may never develop symptoms, but may still transmit the virus to others for extended periods of time.[8,9]

More easily transmissible strains of SARS-CoV-2 are emerging worldwide and appear to spread faster than the 'wild type' original virus.

Also known as 'variants of concern,' the new strains bind to human cells more easily and are more capable of evading immune responses from prior infection, vaccination, and monoclonal antibodies. While current tests can identify these variants, vaccine efficacy might vary with the type of variant circulating at a given time. This means reaching 'herd immunity' will likely require higher vaccination rates and timely boosters.

Testing will continue to be critical in slowing down the spread and controlling outbreaks in the foreseeable future.

COVID-19 Testing

The sooner someone who has been infected can be identified, the faster they can be isolated and treated, thus preventing transmission of the virus to others.

While no test is perfect, a variety of technologies and testing modalities now exist on the market, allowing us to use the most appropriate test for the specific needs of the target population. Most commonly a nasal or nasopharyngeal swab is collected and either sent to a laboratory for processing or run on-site. Molecular tests are typically send-out and antigen tests are point-of-care, though there are exceptions.[10] Antibody tests can identify if a person had been infected previously but are not diagnostic.

Since the start of the pandemic, CVS Health has carefully planned and deployed wide scale testing to help control outbreaks at the consumer level through testing at community sites and CVS Pharmacy locations, and in employer and university settings. As of December 2020, we had administered nine million COVID-19 tests. The wealth of data gathered from these tests, coupled with the epidemiology of COVID-19 can generate insights that enable us to evaluate the relationship between diagnostic testing and infection control in different scenarios.

Who Should Be Tested?

Anyone with symptoms predictive of COVID-19 should be tested. Close contacts of a patient with confirmed or suspected COVID-19 also warrant testing with the possible exception of fully vaccinated people, per recent Centers for Disease Control and Prevention (CDC) guidance. However, given that pre-symptomatic individuals still pose an infection risk to others, and require isolation until they are no longer contagious, testing those who may be infected but are asymptomatic can lower infection rates.[11] Ongoing active monitoring may also serve as a leading indicator of any potential new infections, which in the event of a positive case, would allow for more prompt wide scale testing, tracing and isolation, limiting risk of a widespread outbreak.

Median incubation period of the virus that causes COVID-19 is estimated to be approximately five days, and 98 percent of those who develop symptoms, do so within 12 days of exposure. This suggests that weekly testing, though not fail-safe, is a reasonable option.[12] Besides slowing the spread, this approach can also minimize the effect of false negative tests that may result from the level of detection accuracy or the real-world application of the test administered. The effectiveness of screening strategies can be determined by tracking the positivity rate.[13]

9M

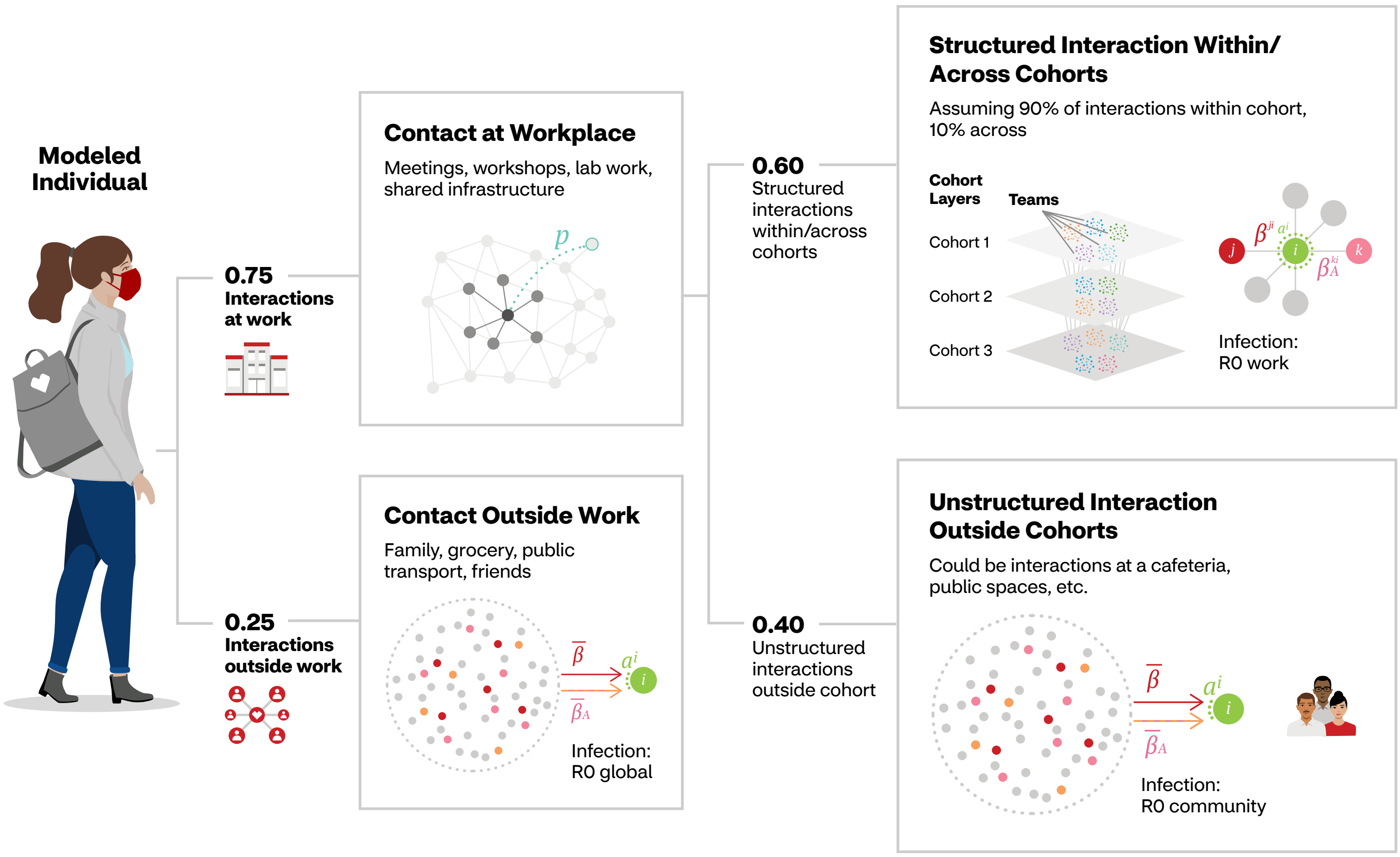
COVID-19 tests administered by CVS Health by December 2020

Testing those who may be infected but are asymptomatic can lower infection rates[11]

Determining the Source of Infection

Our model assumes different rates of interaction within and outside the workplace. We also factor in model-structured interactions within, and across, cohorts at work. We also model 'R0 work,' which refers to the infection reproduction rate in the workplace in question, such as an office building or a university campus. In addition, we model the contagiousness of infection in the community outside the workplace including parking lots, public transportation connecting the organization, and nearby shops and restaurants. This is called 'R0 community.' Because indoor interactions among a fixed subset of people in a closed environment can facilitate transmission in a workplace to a greater extent than interactions in the community, we chose a value of 2.0 for R0 work, and 1.0 for R0 community for our study.

Based on the length of time individuals spend at, and outside, the work environment we estimate that 75 percent of all interactions leading to transmission occur within the workplace and 25 percent in the community. In the workplace, 60 percent of interactions are expected to be within, and 40 percent outside an individual's own cohort.



We developed a model that enables easy evaluation of impacts from testing strategies, quarantining, and other interventions. It utilizes extended SEIRS+, a state-of-the-art network model that can replicate a complex workplace environment and allows access to realistic parameter customization.

Simulated Testing Strategy

The simulation assumes a certain percentage of the population being tested each day. Those who are symptomatic are given priority, with asymptomatic patients with potential exposure to someone who has been infected being tested in a second tier. If additional testing capacity is available, asymptomatic individuals are randomly selected until the target threshold is reached.

Those who test positive are isolated and their groupmates are quarantined. The model assumes 100 percent compliance among those who test positive. They are reintroduced into the workplace network after 14 days.

Modeling Methodology

As employees return to the office, multiple factors can contribute to COVID-19 spread. Some are difficult to control, and we allocate assumptions for them, while others are configurable based on business decisions. We took a range of factors into account when developing the model.

- **External incidence rate:** Cases will continue to be introduced into the workplace from outside. We take a data-driven approach to determine external incidence rate — or the estimated percentage of new COVID-19 cases per month in a specific state, also known as the case incidence rate. We have been closely tracking the rate of infection across the U.S. and projecting estimated cases through mid-2021. We also use the real incidence of COVID-19 spread in different states — the estimated number of new cases per million in the trailing month — to determine the external incidence rate.

  We then leveraged a range of forecasting models, including our own, and one recommended by the CDC, which predict new case counts in the coming month.[14] This is done using actual infection numbers from our own testing data and that from www.covidtracking.com and extrapolating them to obtain new case estimates after factoring in hospitalizations, deaths, and unreported cases. To simulate relevant scenarios across the spectrum, we assigned a value of 0.25 percent for post-vaccine, low incidence, 1 percent for medium incidence, and 4 percent for high infection incidence.

- **Workplace incidence:** Incidence of COVID-19 within the workplace varies depending on adherence to safety protocols such as social distancing and sanitation policies.

- **Company structure:** Companies are divided into cohorts of people who interact with each other with different frequencies. We assumed employees interact within their own teams — or cohorts — 60 percent of the time, and with colleagues outside their teams, 40 percent of the time.

- **Test result turnaround:** Depending on the type of test, turnaround time (TAT) for results varies from zero for point-of-care tests, to two days for polymerase chain reaction (PCR) tests that are sent to a laboratory for analysis. Turnaround time for PCR tests may be longer depending on the circumstances.

- **Testing frequency:** How frequently employers decide to conduct testing depending on their needs and workplace structure — daily, weekly, twice-a-week, or monthly.

- **Tested population:** Whom and what proportion of their workforce employers choose to test.

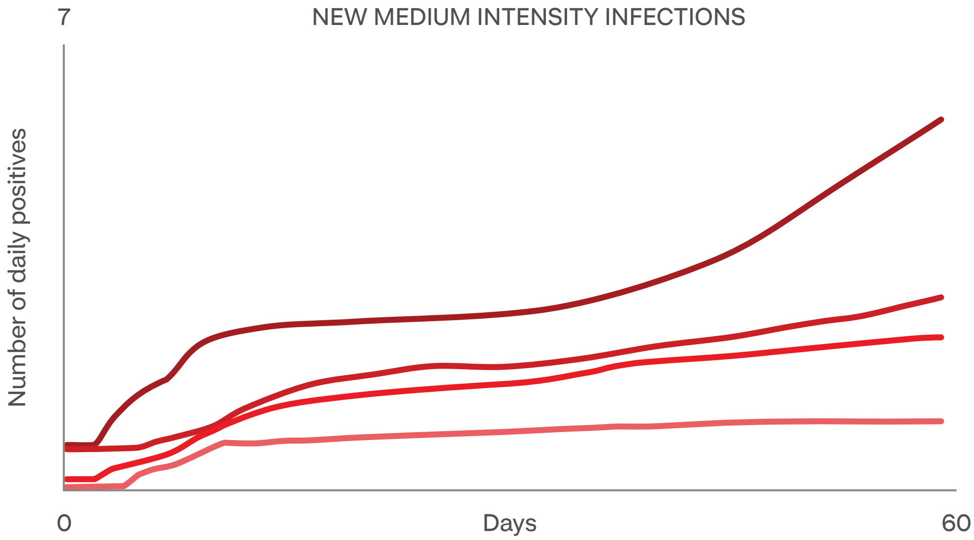
Medium Intensity Simulation

At the current stage in the pandemic, with vaccine availability limited, the external incidence rate is about 1 percent.

In our first example, 11 individuals are considered to be initially infected out of an employee population of 3,000. If no testing was being conducted, the total number of cases would climb to 303 within 60 days. Only conducting symptomatic testing would prevent more than 100 infections, with 178 total cases in 60 days. Adding asymptomatic testing at specific frequencies and volumes can significantly reduce the number of cases.

Testing effect on incremental cases

Adding asymptomatic testing at specific frequencies and volumes significantly impacts the number of cases compared to no testing and symptomatic-only testing.



Cumulative new cases after 60 days

No testing
303

Symptomatic-only testing
(TAT=0 days)
178

10% tested weekly
139

50% tested twice a week
75

RHODE ISLAND LOCATION CASE STUDY

Assumptions:

External incidence: **1% (med)**
Company structure (cohorts): **3,000**
(30 groups of 100 each)

Transmission at workplace: **2 (med)**
Starting number of cases (on day 0): **11**
Turnaround time: **0 days**

Medium intensity simulation after 60 days:

10%
weekly testing

↓ **30%**
total cases

50%
twice-a-week testing

↓ **62%**
total cases

MEDIUM INTENSITY SIMULATION

Turnaround times for testing results will also impact the spread. For instance, if an employer with 3,000 employees chooses to test 50 percent of employees twice-weekly, a point-of-care test would prevent 30 more cases in 60 days than a test with a two-day turnaround.

Employers can use these estimates to make decisions regarding the frequency and percentage of workers to test, to lower infections to acceptable levels.

Simulated benefits of testing and number of tests required for a variety of testing strategy options

BASELINE CUMULATIVE
NEW CASES AFTER 60 DAYS

No testing: **303**

Symptomatic only (TAT=0 days): **178**

Used as baseline comparison since symptomatic testing is a known necessity

EXAMPLE OF RESULTS FOR TESTING
10% weekly

139 new cases within 60 days

30% prevented cases

EXAMPLE OF RESULTS FOR TESTING
50% twice-a-week

75 new cases within 60 days

62% prevented cases

25.7K tests distributed within 60 days

Effect of testing frequency and volume on cases after 60 days

Compared to symptomatic-only testing

% Population tested	Bi-weekly	Weekly	Twice-a-week	Everyday
10%	**165 cases** 16% prevented	**139 cases** 30% prevented	**123 cases** 37% prevented	**112 cases** 43% prevented
20%	**155 cases** 21% prevented	**129 cases** 34% prevented	**117 cases** 40% prevented	**64 cases** 67% prevented
50%	**138 cases** 30% prevented	**116 cases** 41% prevented	**75 cases** 62% prevented	**34 cases** 83% prevented

RHODE ISLAND LOCATION CASE STUDY

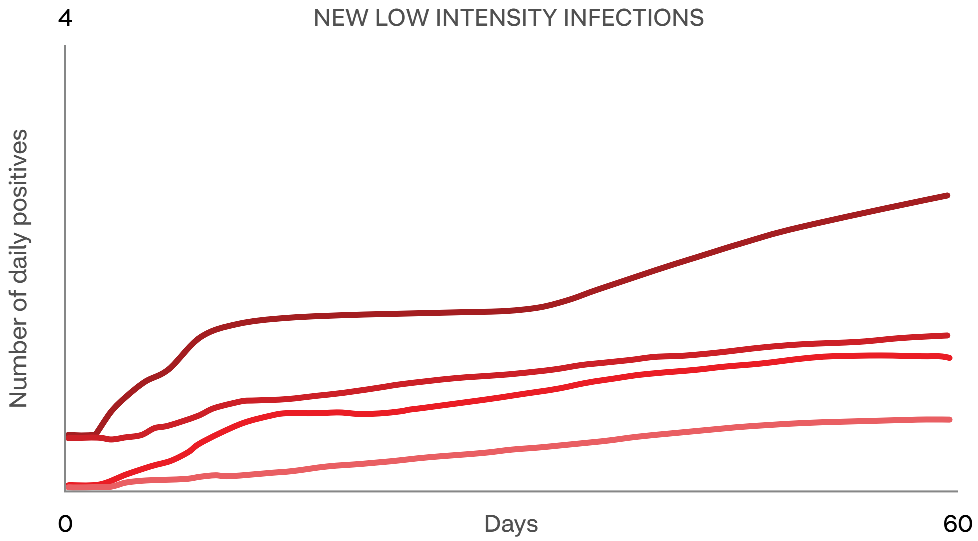
Low Intensity Simulation

So far, three vaccines have received Emergency Use Authorization from the U.S. Food and Drug Administration. There are many other vaccine candidates in the pipeline including several in Phase 3 trials, and others that have been approved for use in other countries. Once priority populations have been vaccinated, and enough supply is available, vaccines will be available more widely to the general population. CVS Health will play a key role in administering vaccinations to clients, their plan members, and those in the communities we serve nationwide. Once a certain percent of the population has been vaccinated, the external incidence rate should fall to 0.25 percent or lower.

In this scenario, we would expect three initial cases of infection as a result of external incidence. Even with such a low level of incidence, with no testing, cases would climb reaching 150 infections in 60 days. Symptomatic testing alone would help the infections plateau somewhat, preventing more than 50 of infections and reaching only 99 cases in 60 days. As before, adding asymptomatic testing at specific frequencies and volumes would help lower infection rates further.

Testing effect on incremental cases

Adding asymptomatic testing at specific frequencies and volumes still impacts the number of cases compared to no testing and symptomatic-only testing.



Cumulative new cases after 60 days

No testing
150

Symptomatic-only testing
(TAT=0 days)
99

10% tested weekly
83

50% tested twice a week
50

Assumptions:

External incidence: **0.25% (low)**
Company structure (cohorts): **3,000**
(30 groups of 100 each)

Transmission at workplace: **2 (med)**
Starting number of cases (on day 0): **3**
Turnaround time: **0 days**

Low intensity simulation after 60 days:

10%
weekly testing

↓ **16%**
total cases

50%
twice-a-week testing

↓ **50%**
total cases

LOW INTENSITY SIMULATION

Once again, point-of-care tests would help lower the rate further, preventing 17 more cases in 60 days than a test with two-day turnaround.

Simulated benefits of testing and number of tests required for a variety of testing strategy options

BASELINE CUMULATIVE NEW CASES AFTER 60 DAYS

No testing: **150**

Symptomatic only (TAT=0 days): **99**

Used as baseline comparison since symptomatic testing is a known necessity

EXAMPLE OF RESULTS FOR TESTING

10% weekly

83 new cases within 60 days

16% prevented cases

EXAMPLE OF RESULTS FOR TESTING

50% twice-a-week

50 new cases within 60 days

50% prevented cases

25.7K tests distributed within 60 days

Effect of testing frequency and volume on cases after 60 days

Compared to symptomatic-only testing

% Population tested	Bi-weekly	Weekly	Twice-a-week	Everyday
10%	**90 cases** 9% prevented	**83 cases** 16% prevented	**80 cases** 19% prevented	**52 cases** 48% prevented
20%	**84 cases** 16% prevented	**82 cases** 17% prevented	**59 cases** 40% prevented	**50 cases** 49% prevented
50%	**64 cases** 35% prevented	**59 cases** 41% prevented	**50 cases** 50% prevented	**39 cases** 61% prevented

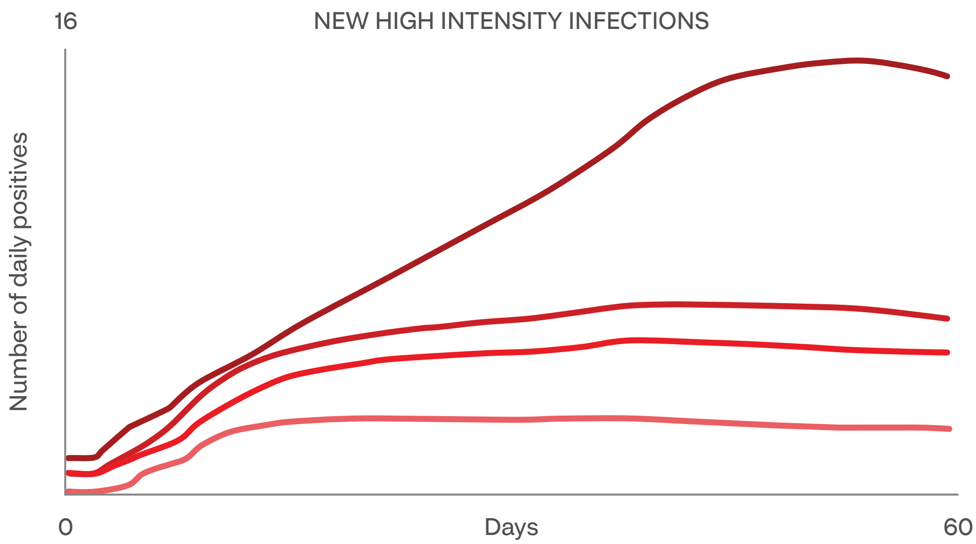
High Intensity Simulation

It is possible that in some instances, the external infection incidence will be as high as 4 percent, with 44 initial infections. This may mean that offices have to be shut down. The high intensity simulation is designed primarily for facilities where shutting down may not be an option, such as penitentiaries and long-term care locations.

In case of a high infection incidence, without testing, cases would climb very quickly reaching 751 infections in 60 days. Symptomatic testing would prevent more than half of them, but there would still be 402 new cases in 60 days, with asymptomatic testing needed to further lower infections.

Testing effect on incremental cases

Adding asymptomatic testing at specific frequencies and volumes significantly impacts the number of cases compared to no testing and symptomatic-only testing.



Cumulative new cases after 60 days

No testing
751

Symptomatic-only testing
(TAT=0 days)
402

10% tested weekly
307

50% tested twice a week
155

ARIZONA LOCATION CASE STUDY

Assumptions:

External incidence: **4% (high)**
Company structure (cohorts): **3,000**
(30 groups of 100 each)

Transmission at workplace: **2 (med)**
Starting number of cases (on day 0): **44**
Turnaround time: **0 days**

High intensity simulation after 60 days:

10%
weekly testing
↓ **24%** **total cases**

50%
twice-a-week testing
↓ **62%** **total cases**

HIGH INTENSITY SIMULATION

Point-of-care tests would prevent more than 100 more cases in 60 days than a two-day turnaround test.

Business decisions can be made on levels and frequency of testing to lower infections to acceptable levels. The table below shows the simulated benefits of testing and number of tests needed for a variety of testing strategy options. Test turnaround time continues to have an impact on total number of infections.

Simulated benefits of testing and number of tests required for a variety of testing strategy options

BASELINE CUMULATIVE NEW CASES AFTER 60 DAYS

No testing: **751**

Symptomatic only (TAT=0 days): **402**

Used as baseline comparison since symptomatic testing is a known necessity

EXAMPLE OF RESULTS FOR TESTING

10% weekly

307 new cases within 60 days

24% prevented cases

EXAMPLE OF RESULTS FOR TESTING

50% twice-a-week

155 new cases within 60 days

62% prevented cases

Effect of testing frequency and volume on cases after 60 days

Compared to symptomatic-only testing

% Population tested	Bi-weekly	Weekly	Twice-a-week	Everyday
10%	**350 cases** 13% prevented	**307 cases** 24% prevented	**290 cases** 28% prevented	**193 cases** 52% prevented
20%	**333 cases** 17% prevented	**306 cases** 24% prevented	**255 cases** 37% prevented	**119 cases** 70% prevented
50%	**282 cases** 30% prevented	**200 cases** 50% prevented	**155 cases** 62% prevented	**46 cases** 89% prevented

ARIZONA LOCATION CASE STUDY

Variables That Can Be Customized:

Certain parameters remain the same for each simulation because they align with COVID-19 infection incidence rates and the use-case. For parameters that are variable, we chose values that best aligned with the settings we were simulating. However, the variables can be customized to study their effect on testing cadence, modality, and percentage.

Customizable parameters include:

- Contact network graph (Graph specifying the contact network)
- Number of cohorts
- Number of people per cohort
- Number of teams per cohort
- Mean intra-cohort degree (number of people interacting daily within a cohort)
- Percentage inter-cohort contacts
- Population exposed initially
- Percentage asymptomatic
- Percentage hospitalized
- Percentage fatalities
- Community R0
- Work R0
- Incidence of disease in external population
- Susceptibility to infection
- Duration of simulation

Return Ready™ by CVS Health®

A comprehensive COVID-19 testing solution

Return Ready for workplaces, our comprehensive, fully configurable testing solution was developed using the data from our nationwide testing effort, epidemiological models, and simulations of workplace infections under different testing strategies.

It enables easy evaluation of impacts from testing strategies, quarantining, and other interventions. It is easy to deploy and fully customizable.

It utilizes extended SEIRS+, a state-of-the-art network model that can replicate a complex workplace environment and allows access to realistic parameter customization.[15] SEIRS+ models options for quarantining and testing, and applies isolation-based interventions. It also takes into account different stages of infection with varying levels of contagiousness. SEIRS+ explicitly models quarantining effects including people's compliance to symptom reporting and testing.

Next Steps

Once implemented, Return Ready can be refined based on:

- **Vaccine availability:** Current implementation assumes that the entire workplace population is 100 percent susceptible, but this parameter can easily be changed as vaccine rollout continues and more people are vaccinated.
- **Flu severity:** The current model and simulations only consider COVID-19. We can redefine the test sensitivities, for instance, to account for false negative rates in scenarios where a patient who has the flu show symptoms of COVID-19 and requests a test.
- **Contact tracing availability:** The implementation can be extended to allow for more contact tracing to different degrees. For example, we can assume employees in the workplace are always connected to the internet, so their interactions can be tracked.

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