Understanding the Coronavirus & Situational Characteristics:
A Framework for Individuals and Businesses for Mitigating Risk

By John Poelman, Patricia Doxey, Alan Hanson, and Zoë Heins

As state and local leaders announce plans for reopening, Americans are venturing out of various levels of isolation to participate in the economy, as workers and consumers. Federal and local governments, public health entities (including the World Health Organization and the Centers for Disease Prevention and Control), business associations, and others are issuing guidelines to help businesses and individuals know how to open while mitigating risk. These guidelines provide important recommendations for activities and precautions to help slow virus transmission. However, communities, businesses, and individuals will need to learn how to apply this guidance in practice, adapted to their own environments and abilities.

While there is still much to learn about the novel coronavirus, the scientific community does have a fundamental understanding of how the virus spreads. By understanding this contagion, we can fashion a key set of principles and levers that can be applied to mitigate risk. The levers, informed by the contagion principles of the virus, are specific interventions (e.g., social distancing or wearing a mask). Some levers are binary, like a light switch that is either “on” or “off,” while other interventions are more effective when treated like a light dimmer, warranting a spectrum of more or less vigorous application depending on the circumstances. While the levers available to individuals are limited to altering their personal behaviors, businesses have an opportunity to engineer creative interventions to help facilitate safe interactions for their customers, employees, and communities.

To this end, this paper offers a framework for:

- Understanding the virus and its contagion principles
- Identifying and understanding the core principles or levers for mitigating the spread of the virus
- Applying levers based on situational characteristics of unique environments

By understanding how the virus spreads and by applying these principles, each agent—whether individual, business, or government—can evolve their COVID-19 strategy and implement risk-mitigating strategies while re-engaging in the economy.
### WHAT THE VIRUS IS DOING.

<table>
<thead>
<tr>
<th>Reproduces</th>
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**Incubation period of the virus roughly 14 days.**

Patients are contagious 2 1/2 days before and 7-9 days after symptoms.

**The reproduction number (or “R”) measures the virus’ spread. If R>1, the virus will spread exponentially.**

R can go up or down based on social behavior.

### HOW THE VIRUS IS DOING IT.

<table>
<thead>
<tr>
<th>Close Contact</th>
<th>Respiratory Droplets</th>
<th>“Fomite” Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreads through close contact (roughly 3-6 feet).</td>
<td>Spreads through respiratory droplets from the nose or mouth (i.e., breathing, coughing, sneezing, laughing).</td>
<td>Spreads through touching surfaces or objects and then touching the eyes, nose, or mouth.</td>
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### Slow what the virus is doing.

- Isolate Symptoms
- Minimize Outbreak Probability

**Isolate/quarantine for 14 days or at least 7-9 days after symptoms subside. Engage in contact tracing.**

- Minimize group interactions to reduce outbreak probability.

**Maintain appropriate distance from others.**

**Exceptional respiratory hygiene to reduce or stop the spread of droplets.**

**Exceptional physical hygiene.**

### Mitigate how the virus is doing it.

- Physical Distancing
- Respiratory Hygiene
- Physical Hygiene

- Testing
- Contact tracing
- Symptom monitoring
- Self-isolating

- Group size
- Interaction with multiple groups

- Maintaining distance
- Close physical interaction
- Frequency of travel

- Face masks/coverings
- Appropriate covering of sneeze/cough
- Reduce duration spent face-to-face
- Air circulation and filtering

- Personal hygiene
- Physical space hygiene
- Personal protective equipment

*By understanding what the virus is doing and how the virus is doing it, we can better understand what we can do to slow the spread.*
COVID-19 VIRUS TRANSMISSION AND KEY PRINCIPLES FOR REDUCING SPREAD

Understanding how the virus works—how it spreads from person to person—is essential for understanding and applying appropriate mitigation strategies based upon the setting. The following are the key principles of the “what” and “how” behind the virus’ contagion. We present example mitigation levers to slow what the virus is doing and how the virus is doing it. These levers are presented as “low” or “high” options, meant to indicate a range of intensity with which the lever might be applied.

Slow what the virus is doing.

**REPRODUCTION:** The virus reproduces and “sheds.” → Isolate symptoms.

Individuals become contagious as the virus is “shed.” This shedding is what brings the virus in contact with others, allowing it to propagate. Individuals who are shedding the virus may be asymptomatic, pre-symptomatic, or symptomatic.

Existing research indicates the incubation period (the time from exposure to the development of symptoms) ranges from 2 – 14 days. Recent research suggests there may be a median incubation period of five days.

Therefore, in order to impede the reproduction and shedding of the virus, levers that can be applied include testing (to identify those infected that are both showing and not showing symptoms), contact tracing (to identify those individuals who have come into contact with those who have been infected), monitoring of symptoms (either through a local health department or through a self-monitoring process), quarantining of those in close-contact with confirmed cases or self-isolating of confirmed cases (removing oneself as much as possible from interactions with others, including those from the same household).

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*Viral shedding occurs when the virus is released from the infected host. For more information about how SARS-CoV-2 behaves, see: Nature Medicine, 2020. "Temporal Dynamics of Viral Shedding and Transmissibility of COVID-19." Retrieved from: [https://www.nature.com/articles/s41591-020-0869-5](https://www.nature.com/articles/s41591-020-0869-5)

*The exact proportions of asymptomatic, pre-symptomatic, and symptomatic individuals are currently unknown. A recent literature review of asymptomatic studies suggests that between 4 and 80 percent are asymptomatic. See: The Centre for Evidence-Based Medicine, 2020. "COVID-19: What Proportion are Asymptomatic?" Retrieved from: [https://www.cebm.net/covid-19/covid-19-what-proportion-are-asymptomatic/](https://www.cebm.net/covid-19/covid-19-what-proportion-are-asymptomatic/)


CLOSE CONTACT: The virus spreads over short distances. → Increase physical distancing.

The virus most often spreads when individuals are in close proximity for a certain duration. The CDC defines close contact as being within approximately 6 feet of a COVID-19-infected individual. Persons can become infected through respiratory droplets emitted through the nose or mouth within this proximity and duration of exposure. Airborne transmission may also be possible in settings where procedures or support treatments that generate aerosols are performed (intubation, disconnecting patient from ventilator, dental drilling, etc.). Practicing physical distancing and reducing one’s travel can mitigate the frequency with which this type of close contact occurs.

INFECTIOUSNESS: The rate of the virus spreads. → Minimize outbreak probability.

A common measure of the rate of spread of a virus is the effective reproductive number, or “R.” This epidemiologic measure is used to describe the transmissibility of infectious agents at a given point in time (referred to then as “Rt”) and can be thought of as the average number of secondary cases produced by a single infected person. When the effective reproductive number is greater than one, it indicates exponential spread and can be a signal of community outbreak.

How quickly and intensely a novel pandemic virus moves through a community will affect everyday life and the local health care system’s ability to meet the community’s needs. The rate of spread, therefore, has implications for what level of response must be organized to manage the pandemic. This is a common way in which R is applied in public health. Exponential spread means more cases in a short period of time and, with a deadly virus, a risk of overwhelmed health systems. Minimizing the probability of an outbreak that overwhelms the health care system involves keeping the value of R low, below 1 if possible. To bring the level of spread down to a manageable level in a region that has already had a large outbreak, it may be necessary to hold R far below 1 for a period of time. Leavitt Partners Insight, using data from the Torch Insight platform, has been estimating R at the county level since March 25, 2020, allowing for analysis of the trend of disease spread as states and counties have implemented various policy responses. This information—along with other COVID-19 planning tools designed for state, local, and health care leaders—can be found at: https://covid19.torchinsight.com/.

Mitigate how the virus is doing it.

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<th>LOW</th>
<th>HIGH</th>
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<td>Group size</td>
<td>Limit groups to 100</td>
<td>Limit groups to 10</td>
</tr>
<tr>
<td>Unique groups</td>
<td>Intermingle between multiple groups of people</td>
<td>Intermingle with a small group of consistent individuals</td>
</tr>
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</table>

*Ro (R “naught”) refers to the value of the effective reproductive number at the initial outbreak with no interventions in place. Rt refers to the value of the effective reproductive number at a given time beyond the initial outbreak with interventions in place.


RESPIRATORY DROPLETS: The virus spreads through the transfer of respiratory droplets. → Increase respiratory hygiene.

The SARS-CoV-02 virus is primarily found in the upper and lower respiratory tract. Although the virus may spread through blood and stool, the primary mode is through the transfer of respiratory droplets expelled by breathing, speaking, laughing, sneezing, and coughing over a sustained period of time. Respiratory droplets, their size, trajectory, and the viral load within each droplet, have direct influence on whether the virus is spread from one person to another. If a person coughs or sneezes in someone’s direction, some of those viral particles hang in the air, some fall on surfaces, and others fall to the ground. Common respiratory maneuvers like speaking, cheering, singing, or breathing heavily (such as during exercise) can increase the amount of droplets that could land on another person’s face or linger in the air.

Exceptional respiratory hygiene can reduce or stop the spread of droplets from infected persons to non-infected persons. Covering one’s mouth when coughing or sneezing is always a best practice. The science surrounding the effectiveness of face coverings continues to evolve. However, there is growing evidence that even simple cloth coverings can reduce the risk that individuals will spread to others.

FOMITE CONTACT: The virus spreads through fomite contact. → Increase physical hygiene.

Respiratory droplets released into the environment can land on objects and surfaces. Persons can become infected through touching “fomites” (surfaces or objects) with viral contamination and then touching the mouth, nose, or eyes. A preprint study published in May 2020 suggests that the virus may remain viable for up to one week on smooth and could survive for several hours in feces between 3 to 4 days in urine.

Because the virus can spread through fomite contact, it is prudent to increase physical hygiene, both personal hygiene and that of different spaces. Think of the grocery stores cleaning the credit card terminal between patrons or providing hand sanitizer at the entrances and doorways. As risk of infection increases, so too should the extent to which physical hygiene is enforced.
ASSESSING SITUATIONAL CHARACTERISTICS TO MITIGATE RISK OF TRANSMISSION

As individuals return to onsite work and venture out into the community, it will be up to these individuals and business owners to apply the guidance of federal and local health authorities to their unique situations and everyday activities. Available guidelines may dictate the phase of reopening (such as in the White House’s *Opening Up America Again* or the state of Utah’s color-coded risk phases in the *Utah Leads Together* plan). These plans—and others like them—provide general considerations for preventing disease transmission, but it is impossible and unrealistic to expect guidelines to address every situation.

The following situational framework can be used to systematically assess unique situations that—given the key principles described above explaining how the virus spreads—might introduce risk. Understanding which elements of a situation make it more or less “risky” allows individuals and businesses to choose the appropriate levers necessary to mitigate that risk, even if their specific situation is not addressed directly by published guidelines.

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Situational Characteristics

The framework consists of seven “situational characteristics,” which describe elements of environments or situations and categorize them as more or less risky: movement, duration, proximity, respiratory output, group size, touch, and congestion.

<table>
<thead>
<tr>
<th>Situational Characteristic</th>
<th>Lower Risk Characteristic</th>
<th>Higher Risk Characteristic</th>
</tr>
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<tbody>
<tr>
<td><strong>Movement</strong>&lt;br&gt;How do people move around in the space?</td>
<td>Directed&lt;br&gt;Movement is restrained or highly controlled, people are confined to a specific area, little intermingling.</td>
<td>Undirected&lt;br&gt;Movement is unrestrained or uncontrolled, people can wander in the space, frequent intermingling.</td>
</tr>
<tr>
<td><strong>Duration</strong>&lt;br&gt;How long are people in this space?</td>
<td>Less than 15 minutes&lt;br&gt;Less than 15 minutes is typically spent in the space.</td>
<td>Greater than 15 minutes&lt;br&gt;More than 15 minutes is typically spent in the place.</td>
</tr>
<tr>
<td><strong>Proximity</strong>&lt;br&gt;How close are people in this space?</td>
<td>Greater than 6 feet&lt;br&gt;It is possible, either naturally or with minimal interventions, to maintain a 6-foot distance.</td>
<td>Less than 6 feet&lt;br&gt;It is not possible to maintain a 6-foot distance; the activity cannot be done if distance is maintained.</td>
</tr>
<tr>
<td><strong>Group Size</strong>&lt;br&gt;How many people are in the space?</td>
<td>Less than recommended limit&lt;br&gt;A small group of people, mostly part of the same social circle.</td>
<td>Greater than recommended limit&lt;br&gt;A large group of people from different households and social circles.</td>
</tr>
<tr>
<td><strong>Respiratory Output</strong>&lt;br&gt;How are people breathing in the space?</td>
<td>Normal&lt;br&gt;People are breathing normally, low respiratory output.</td>
<td>Increased&lt;br&gt;People are breathing heavily, from exercising, laughing, cheering, singing, etc.</td>
</tr>
<tr>
<td><strong>Touch</strong>&lt;br&gt;How do people engage with objects or fixtures in the space?</td>
<td>Low&lt;br&gt;People do not interact much with each other or with objects in the space.</td>
<td>High&lt;br&gt;People frequently interact with each other or touch objects in the space.</td>
</tr>
<tr>
<td><strong>Congestion</strong>&lt;br&gt;Are there points of high congestion?</td>
<td>Low&lt;br&gt;The design of the space and activity do not result in congregations of people (e.g. entry points, lines, security, etc.)</td>
<td>High&lt;br&gt;Because of the design of the space or the nature of the activity, people must gather closely together at times.</td>
</tr>
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*These situational characteristics help categorize the “risk” level of a space and can be used as a prompt to think through what mitigation strategies can be employed to offset risk.*
MOVEMENT: How do people move around in the space?
Movement describes the way individuals move around in and interact with a space and directional oversight their movement has. Directed movement is guided and controlled, with individuals fixed within a specific area without intermingling. For example, spectators in reserved seating, students in assigned seats, or restaurant patrons seated at a table. Undirected movement is less guided, and individuals freely wander or mingle throughout the space. Consider visitors at a park, library, or museum. Because the coronavirus is spread through close contact or touching shared surfaces, spaces where people remain separated and controlled are less risky.

If you have undirected movement, consider if there are ways that you can introduce control levers to prevent people from unintentionally crossing paths or coming in close proximity. Can you indicate where people should stand? Should you have staff manage the flow of foot traffic to help people maintain a safe distance? If the nature of the setting won’t allow you to direct movement, consider what other mitigation strategies you can employ to offset the uncontrolled movement.

DURATION: How long are people in this space?
Duration is an important factor to consider. The more time an individual spends in proximity with a COVID-19 positive case, the more likely they are to be exposed to enough viral shedding to cause infection. Though the exact duration of exposure necessary to cause infection is influenced by other factors, generally interactions longer than 15 minutes are considered risky while short interactions—such as passing one another in the hallway—are considered less risky.

You may be able to reduce the amount of time that someone spends in a space. For example, restaurants can encourage to-go options so that patrons are only there a short time. However, some activities require that people spend more than 15 minutes in a space. It is unlikely that someone will be able to be at a bowling alley for less than 15 minutes or that a student would only briefly be in a classroom. In these instances, consider the level of risk in the area. If you are in an area with a high-rate of infection, consider if you can introduce enough mitigation strategies to off-set the long duration or if it’s best to avoid the interaction altogether. If your community’s infection rate is low, you may be able to introduce other strategies, such as creating distance between parties at the bowling alley or between rows of students. You could also introduce more stringent cleaning measures, check/ask about symptoms of patrons and employees, and keep a logbook of contact information in case public health officials trace a case back to your establishment.

PROXIMITY: How close together are people in this space?
In addition to the length of time individuals spend together, the distance between them contributes to how much of the virus they may be exposed to. These elements together make up the CDC’s definition of “close contacts” described above. Based on the average distance respiratory particles can travel, staying more than six feet apart is generally considered safe, while standing closer than six feet is considered risky.

For some situations, like grocery shopping, maintaining a six-foot distance is not difficult. Signs or employees can direct customers to stay spaced at certain intervals. Many grocery stores have already implemented one-way aisles and have introduced floor stickers at check-outs to help people know how far to stand. For others, like getting a haircut, the nature of the activity requires that individuals be within six feet of each other, increasing the potential for virus transmission. A hair salon, however, could introduce different

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20Ibid.

mitigation strategies, such as: spreading out booths, scheduling customers so that there isn’t overlap, asking patrons to wait in their cars, regularly cleaning high-touch areas, and relying on contactless payment.

**RESPIRATORY OUTPUT: How are people breathing in the space?**
Respiratory output describes the direction and velocity of an individual’s expired breath. When people are breathing normally, a majority of their respiratory droplets do not travel farther than six feet, but when they are breathing heavily from exercising, coughing, or even laughing and singing, respiratory droplets can travel much farther.22,23 Airflow also has an impact on the movement of respiratory droplets. Fans, ventilation intakes and outputs, and even the wind can spread droplets in unexpected directions and infect people across longer distances than ambient air.24 Consider having a building engineer assess the ventilation of the space to make sure air is circulating properly.

Consider if activities within your establishment would require normal or increased output. It’s likely that you can’t change how people are breathing. For example, at a gym, individuals are likely to have increased respiratory output. What could you do to compensate for the increased output? What could you do to space people further apart? Would you continue to have group classes? Would you limit their size? Could you ask employees to wear face coverings? Could you provide face coverings to your customers? What else could you do to mitigate risk?

**GROUP SIZE: How many people are in the space?**
The intent of reducing group size is to decrease the probability that someone in the group is sick and passes it along to others. As R decreases and the prevalence of COVID-19 in the community diminishes, it becomes safer for a greater number of people to gather because the likelihood that someone in that group is hosting the virus is lower. Local health authorities will likely recommend a safe group size based on the R in each community. Group sizes that adhere to the recommendation are less risky than groups larger than the recommendation.

Also consider how different groups are interacting. For example, if four people spend time only with each other, and one of them develops symptoms, it is relatively easy to track down the other three. But what if those three people spent time with four others? It increases the people you have to track down to 12.

As a business, what can you do to limit group size? If you can’t limit group size, consider other strategies to mitigate risk. Perhaps you could collect people’s contact information so that it is easier to perform contact tracing. You can provide hand sanitizer at entry points, clean high-touch areas frequently, or stagger groups’ arrival time.

**TOUCH: How do people engage with objects or fixtures in the space?**
As described in more detail above, COVID-19 can be spread by touching objects, called fomites, which respiratory droplets have settled on or those that have been touched by someone with the virus on their hands. Situations in which people share supplies or interact with high touch surfaces are riskier than those in which surfaces can easily be cleaned between uses or where touching can be avoided altogether.

Consider a library, a grocery store, or even a playground. People in those spaces are touching a lot of shared objects. Think of all the things that people touch even while seated at a restaurant. Saltshakers, menus, tables, chairs, door handles, etc. Are there items you can remove altogether or make one-time use? Can you encourage patrons to order online so that a monitored employee can pick out the items? What cleaning regimen could you install? Could you offer sanitation products to your customers?

CONGESTION: Are there points of high congestion?

It is important not only to consider the features of the ultimate destination, but also how people get there and whether there may be periods where individuals congregate together or form a line. These points of high congestion—such as when students are filing into a classroom or patrons in a restaurant are waiting for their table—introduce risk because of the close proximity and shared air. Areas of low congestion where people enter at different times or remain spaced apart are less risky.

If there are points of high congestion, consider what you could do to mitigate this risk. For example, you could assign arrival times at events, consider ways to make security screenings more efficient, use signage to help people know where to stand, ask individuals to wait elsewhere until you are ready for them.

Application of the Framework

Consider different situations you find yourself in, either at work or in your personal life. Comparing the experience of dropping off clothes at the dry cleaner to that of going to the gym can be useful for illustrating how this framework is used to assess risk and how these situations can be made safer by identifying the characteristics which make them risky.

Dry Cleaner

When visiting a dry cleaner, a customer enters the premises, walks to the counter, hands their items to the employee, and walks out. The experience is short, there are unlikely to be lines, and both customers and employees are likely breathing normally. The two potentially risky characteristics of the experience are touching a few shared spaces (e.g. the door handle, a counter, a pen) and being within six feet of the employee when exchanging clothing and/or paying.

These risks can easily be mitigated. The door can be propped open, the handle can be cleaned, and customers can use hand sanitizer after touching it. To reduce the risk of transmission between the customer and employee while they are in close proximity, both can wear masks, items can be dropped off in a designated area away from the employee, or a plexiglass barrier can be installed. The establishment could also use contactless payment methods or clean the terminal between each customer.

Gym

Viewed through the lens of the situational characteristics, a gym is a much riskier environment. Patrons move through the space unrestrained, interact with many pieces of equipment, and are inside the building for longer than 15 minutes.

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Consider that 112 persons associated with fitness dance classes at 12 sports facilities were infected over a 24-day period in South Korea. See: The Centers for Disease Control and Prevention, 2020. “Cluster of Coronavirus Disease Associated with Fitness Dance Classes, South Korea.” Retrieved from: https://wwwnc.cdc.gov/eid/article/26/8/20-0633_article.


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Some of these levers can help individuals protect themselves and their families; others are more directly applicable to businesses and can help employers think through and understand what structures to put in place to keep employees and customers safe. Ideas for mitigation interventions are offered throughout the framework but when designing their own strategies, businesses should keep in mind the unpredictable nature of human behavior and the challenges that may arise when trying to influence it.

Though useful and informative, this framework is intended to be used in concert with sound data and public health practices. Shifts in broad public health strategies should be informed by prevalence of community spread and the availability of crucial public health tools (including testing and contact tracing capacity). If we’re attentive to our environments and react appropriately, we can continue to make progress and mitigate risk as much as possible.

**CONCLUSION**

Public health authorities will continue to provide guidance as we learn more about COVID-19, but the CDC and other government entities face real barriers in providing comprehensive guidance with enough granularity to address every industry, employer, setting, and scenario. The approach to understanding the novel coronavirus outlined in this framework can help individuals, businesses, and governments apply existing guidelines to a broader range of unique environments and interactions.

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- Behavioral reactions to public health recommendations

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