COVID-19 Back-to-Work Planning Briefing

DOCUMENT INTENDED TO PROVIDE INSIGHT AND BEST PRACTICES BASED ON CURRENTLY AVAILABLE INFORMATION FOR CONSIDERATION AND DOES NOT CONSTITUTE SPECIFIC ADVICE
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Have assembled a team of experts to help operationalize the White House “Opening America” framework
Executive Summary: The War on COVID-19

- Global cases & deaths continue to rise. Mitigation efforts have led to some level of “flattening”, but with severe economic consequences
  - The US new daily cases are beginning to decline, but still account for 1/3 of global daily new cases
  - MA new daily cases still high, but are seeing frequent periods of declining. Hospital ICU beds only ~54% filled
  - JP Morgan estimating Q2 GDP down ~40% QoQ. MA unemployment ~2x the GFC, with low income workers particularly hard hit

- Determining when to re-open is dependent on modeling out “supply and demand”
  - Key supply considerations include availability of beds and healthcare workers (taking into account burden of other illness/need) and therapeutic availability and effectiveness
  - Key demand considerations include a manageable current new case trajectory (“flattened curve”), confidence in ability to track case counts, and anticipated effectiveness of segmentation & worker safeguards

- If reopening causes a demand imbalance, risk a rolling lockdown scenario
  - 1918 Spanish Flu data warns of opening too early or with too little preparation – could result in a second, larger spike in cases than the first
  - Spain re-opened once COVID-19 cases reached 20% of their prior peak, but was still too soon – cases rapidly rose and Spain was forced to shut again

- Critical to design a “back-to-work” plan that does not overload hospitals and keeps people safe

We can defeat COVID-19 by implementing: (1) strategic population segmentation, (2) effective therapeutic treatments and longer term a vaccine, (3) full adoption of $R_0$ reduction protocols

Source: US Department of Labor, Google
Contents

• Summary COVID-19 History & Economic Impact

• Timing: *When* to Return to Work

• The Key Three Steps: *How* to Return to Work
Global COVID-19 Cases Update

Daily New Cases (Area of Chart = Total Cases)

Global cases and deaths continue to rise. The US may be in early stages of “flattening” & Europe cases declining, but the rest of the world is still experiencing growth

3,057,957
global cases

212,056
global deaths

988,469
US cases

56,253
US deaths

56,462
MA cases

3,003
MA deaths

As of 4/27/20
Sources: WHO situation reports, Johns Hopkins University, press search, McKinsey
Why is COVID-19 so serious?

**Fatality Rate v. R₀**

- Fundamental issue: COVID-19 has a **high fatality rate** and a **high R₀** (high rate of infection)
- Additionally, COVID-19 has a **high rate of hospitalization** (~10%+), which combined with high rate of spread creates **large tax on hospital capacity**
- Finally, COVID-19 is **indiscriminate**, causing serious long term health consequences in all ages
- In order to return to work, need to adopt policies & procedures to **reduce R₀**

COVID-19 has a high spread & high rate of hospitalization / death – to return to work, need to adopt policies & procedures to reduce spread (R₀)

*Note: Infection fatality rate used where available, otherwise case fatality rate used to approximate IFR
Sources: NY Times [https://www.nytimes.com/2020/02/18/learning/whats-going-on-in-this-graph-coronavirus-outbreak.html], World Health Organization, Institute for Disease Modeling, BMC Infectious Diseases*
Economic Impact of Shutdowns

JP Morgan projecting US GDP to be down 40% QoQ in Q2; EU GDP to be down 45-55% QoQ

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<thead>
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<tbody>
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<td>-7.7</td>
<td>6.2</td>
<td>2.1</td>
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<td>46.0</td>
<td>23.6</td>
<td>12.9</td>
<td>12.0</td>
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<td>Western Europe</td>
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<td>81.3</td>
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<td>4.1</td>
<td>1.1</td>
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<td>Euro area</td>
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<td>0.7</td>
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<td>-45.0</td>
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<td>6.0</td>
<td>4.5</td>
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<td>-6.6</td>
<td>6.8</td>
<td>0.1</td>
<td>-66.7</td>
<td>83.7</td>
<td>7.8</td>
<td>4.1</td>
<td>1.1</td>
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<td>4.1</td>
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<td>-45.0</td>
<td>75.0</td>
<td>6.0</td>
<td>4.5</td>
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<tr>
<td>Spain</td>
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<td>-4.1</td>
<td>5.5</td>
<td>0.7</td>
<td>-33.2</td>
<td>-33.2</td>
<td>59.0</td>
<td>5.1</td>
<td>3.3</td>
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<td>Norway</td>
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<td>5.5</td>
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<td>-66.7</td>
<td>-66.7</td>
<td>59.0</td>
<td>5.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.1</td>
<td>-4.0</td>
<td>8.0</td>
<td>0.6</td>
<td>-66.7</td>
<td>-66.7</td>
<td>119.9</td>
<td>12.4</td>
<td>3.6</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1.4</td>
<td>-6.0</td>
<td>8.0</td>
<td>0.6</td>
<td>-66.7</td>
<td>-66.7</td>
<td>119.9</td>
<td>12.4</td>
<td>3.6</td>
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MA Unemployment approaching 2x+ ’09 levels

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</thead>
<tbody>
<tr>
<td>USA</td>
<td>5.7%</td>
<td>2.3%</td>
<td>2.1%</td>
<td>2.1%</td>
<td>2.3%</td>
<td>5.2%</td>
<td>8.7%</td>
<td>10.1%</td>
</tr>
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</table>

MA Job Vulnerability by Income Band

- Jobs at risk
- Jobs not at risk

<table>
<thead>
<tr>
<th>Income Band</th>
<th>Jobs at risk</th>
<th>Jobs not at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>$20-25K</td>
<td>0.7</td>
<td>76%</td>
</tr>
<tr>
<td>$25-30K</td>
<td>0.5</td>
<td>54%</td>
</tr>
<tr>
<td>$30-40K</td>
<td>0.7</td>
<td>41%</td>
</tr>
<tr>
<td>$40-70K</td>
<td>1.0</td>
<td>82%</td>
</tr>
<tr>
<td>&gt;$70K</td>
<td>0.9</td>
<td>98%</td>
</tr>
</tbody>
</table>

Mitigation efforts are having a significant impact on the economy, and impact is most severe in low income workers.

Source: 4/17/20 JP Morgan Economic Outlook, US Department of Labor, LaborCUBE; BLS OES, Moody’s, McKinsey Global Institute analysis

Note: Analysis determines vulnerable jobs as a function of physical distancing policies and their immediate knock-on economic consequences – assumes maximum physical distancing (defined by shelter-in-place policy)
COVID-19 History & Economic Impact: Summary

• Global cases and deaths continue to rise. The US & Europe may be in the early stage of “flattening,” but the rest of the world is still experiencing growth.

• COVID-19 is particularly serious because of its high hospitalization & death rate and high rate of spread ($R_0$). Unmitigated spread can quickly overwhelm hospitals.

• While mitigation efforts are contributing to the early curve “flattening,” they will have a dramatic economic impact in the U.S., with some analysts forecasting Q2 GDP declines 2-3x that of the great depression.

• Workers earning less than $40K/year and employed by small businesses are most vulnerable.

Mitigation efforts are aiding in the fight against the virus, but are also having a significant impact on the economy, and impact is most severe in low income workers.

Source: Bain Capital Partners Analysis
Contents

- Summary COVID-19 History & Economic Impact
- **Timing:** *When to Return to Work*
- The Key Three Steps: *How to Return to Work*
Determining When to Reopen

**Supply**
- Availability of supply inputs: beds, HC workers
- Timeline & supply of therapeutic options
- System readiness for policies to reduce $R_0$ (e.g., testing, tracing, PPE capacity)

**Demand**
- Current new case trajectory manageable / “curve flattening”
- Confidence in ability to track cases
- Model projecting anticipated hospital burden based on # ppl returning to work & projected spread

### Case Studies

**China Return to Work**
- Waited until new cases practically eradicated. Since then, new cases returned, but at much lower rates
- Firm workplace rules, rigorous testing, travel restrictions
- Comprehensive smartphone tracking

**Spain Return to Work**
- Waited until new cases ~20% of peak
- Handed out 10M masks and 1M+ testing kits
- Allowing non-essential construction, manufacturing to return to work
- New cases since rose to ~80% peak levels, requiring immediate scale back – opened too soon

**Need to model out supply and demand and reopen with a buffer on total capacity utilization**

# of new cases have been declining the past week; growth rate has slowed since people movement slowed

MA growth rate has dramatically slowed since stay-at-home mitigation efforts, and new cases / day may be in early stages of declining

56,462 total cases
5,236 hospitalizations
1,089 in ICU
3,003 total deaths

Note: There is day-to-day variability in cases reported by testing laboratories and no single day change in indicative of overall cases trends
Source: Mass.gov; as of 4/27/20
MA Hospitalization Rate & Capacity Data

MA Case Counts as of 4/27*

<table>
<thead>
<tr>
<th>Tests Performed</th>
<th>Positive Tests</th>
<th>Currently Hospitalized Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>244,887</td>
<td>56,462</td>
<td>3,879</td>
</tr>
</tbody>
</table>

- **Not positive**: 97%
- **Not hospitalized**: 91%
- **Not in ICU**: 94%
- **Positive**: 23%
- **ICU**: 28%

~21% of hospital beds and ~54% of ICU beds occupied with COVID-19 patients

<table>
<thead>
<tr>
<th>Hospitalization Rate</th>
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</thead>
<tbody>
<tr>
<td>Positive Cases</td>
</tr>
<tr>
<td>Hospitalized Cases</td>
</tr>
<tr>
<td>ICU Cases</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

- **5,236 hospitalizations**
- **1,089 in ICU**

% of Staffed Hospital Beds Filled by County

<table>
<thead>
<tr>
<th>County</th>
<th>% of Staffed Hospital Beds Filled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plymouth</td>
<td>36%</td>
</tr>
<tr>
<td>Essex</td>
<td>27%</td>
</tr>
<tr>
<td>Suffolk</td>
<td>26%</td>
</tr>
<tr>
<td>Middlesex</td>
<td>20%</td>
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<tr>
<td>Norfolk</td>
<td>20%</td>
</tr>
<tr>
<td>Hampden</td>
<td>19%</td>
</tr>
<tr>
<td>Worcester</td>
<td>17%</td>
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<tr>
<td>Barnstable</td>
<td>13%</td>
</tr>
<tr>
<td>Irambelle</td>
<td>8%</td>
</tr>
<tr>
<td>Hampden</td>
<td>6%</td>
</tr>
<tr>
<td>Berkshire</td>
<td>4%</td>
</tr>
<tr>
<td>Dukes</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td>21%</td>
</tr>
</tbody>
</table>

Source: Mass.gov

Approximately ~9% of positive cases in MA hospitalized

~21% of hospital beds and ~54% of ICU beds are currently filled by COVID-19 patients

*Hospitalization rate does not include patients previously hospitalized but since discharged, so likely higher than demonstrated by existing data
Critical to “Avoid the W”

What we need to prevent:

Sub-optimal public health approach creates the bad/bad box of ineffective lockdowns and high burden on healthcare systems – creating wider, deeper “U” or “W” that only ends with vaccine

Source: Bain Capital Partners analysis
1918 Spanish Flu Precedent

Philadelphia – too late to shut, overwhelmed

- Philadelphia acted too late to curb the death rate – after waiting until after a massive parade to close the city, the virus overwhelmed hospitals
- But because initial rate so high, no second peak

St. Louis – reopened too early

- St. Louis acted early to curb the death rate – but opened too soon, causing a second spike much higher than the first

Denver – reopened with too little public guidance

- Denver acted early to curb the death rate – but opened with too little public guidance, causing a second spike with similar magnitude as first
- After initial closure was lifted, the public thronged the streets by the thousands, and new cases rapidly spiked to rates higher than previous

City closures & social distancing highly effective if instituted early – but second waves are likely and can be worse than the first if proper measures not taken before re-opening

Source: Proceedings of the National Academy of Sciences, InfluenzaArchive.org, Markel et. al., Journal of the American Medical Association (2007), Bain Capital Analysis
When to Return to Work: Summary

• **Building a dynamic hospital capacity / demand model** based on current infection rate and system readiness for reopening critical to determining when to return to work

• MA new daily cases still trending **around peak**, although have shown signs of “flattening.” Managing hospital capacity well so far, with **ICU beds only ~54% filled** with COVID-19 patients

• However, **critical to not reopen too soon** – a demand imbalance could lead to a second peak more severe than the first, as evidenced by St. Louis’ re-opening during the 1918 Spanish Flu

Need to focus on developing policies and protocols to keep hospital capacity balanced with demand and minimize the risk of another lockdown

Source: Bain Capital Partners Analysis
Contents

• Summary COVID-19 History & Economic Impact

• Timing: When to Return to Work

• The Key Three Steps: How to Return to Work
The Key 3 Steps to Achieve Hospital Balance & Worker Safety

**Segmentation:** Sequence segments returning to work according to risk to lower hospitalization rate

**Effective Therapeutics:** While waiting for vaccine, implement effective treatments to curb hospitalization rate & fatality rate

**Reduce $R_0$:** Implement policies & procedures to reduce the rate of spread

Source: Bain Capital Partners analysis
The Age Funnel

<table>
<thead>
<tr>
<th>MA Hospitalization Rate by Age</th>
<th>MA Death Rate by Age</th>
<th>MA Pop. by Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COVID Cases</strong></td>
<td><strong>Deaths</strong></td>
<td><strong>Population by Age</strong></td>
</tr>
<tr>
<td>56,462</td>
<td>56,462</td>
<td>60-75</td>
</tr>
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<td>5,236</td>
<td>3,003</td>
<td>45-60</td>
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<td>60-69</td>
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<td>35-45</td>
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<tr>
<td>20-60</td>
<td>20-60</td>
<td>20-35</td>
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<tr>
<td><strong>Hospitalization Rate</strong></td>
<td><strong>Death Rate</strong></td>
<td></td>
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<tr>
<td>70</td>
<td>70</td>
<td></td>
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<tr>
<td>60-69</td>
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<tr>
<td>20-60</td>
<td>20-60</td>
<td></td>
</tr>
<tr>
<td><strong>Hosp Rate</strong></td>
<td><strong>Death Rate</strong></td>
<td></td>
</tr>
<tr>
<td>22%</td>
<td>18%</td>
<td></td>
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<tr>
<td>12%</td>
<td>4%</td>
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<tr>
<td>5%</td>
<td>0.4%</td>
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</table>

Excluding those aged 60+ from initial return to work segment may greatly reduce the hospital burden without affecting a large portion of the working population.

Source: mass.gov COVID-19 dashboard; U.S. Census, BCP Analysis, data as of 4/27/20
The Industry Funnel

Typically considered critical by states

Typically considered critical by states

Ability to Work From Home

<table>
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<tr>
<th>Easier</th>
<th>Harder</th>
<th>Hardest</th>
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<tr>
<td>Government</td>
<td>Social services &amp; healthcare</td>
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<tr>
<td>Utilities</td>
<td>Retail (food, grocery, pharmacy)</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Transportation (public)</td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>Agriculture</td>
<td>Recreation</td>
</tr>
<tr>
<td>Finance, Real estate</td>
<td>Mining</td>
<td>Food &amp; accommodation</td>
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<tr>
<td>Professional services</td>
<td>Construction</td>
<td>Retail (discretionary)</td>
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<tr>
<td>Management</td>
<td>Manufacturing</td>
<td>Transportation (private)</td>
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<tr>
<td>Wholesale</td>
<td>Administrative</td>
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% of US GDP¹

<table>
<thead>
<tr>
<th>% of US GDP¹</th>
<th>% of US employment¹</th>
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<tbody>
<tr>
<td>Easier</td>
<td>Harder</td>
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<tr>
<td>41%</td>
<td>36%</td>
</tr>
<tr>
<td>19%</td>
<td>39%</td>
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Need to Determine How To Group & Sequence Sector Reopening

1. Critical sectors that cannot work from home – will be harder to safeguard, but may need to be part of first wave

2. Critical sectors with some ability to WFH – may be able to encourage portions to continue remote work

3. Less critical sectors that cannot work from home – Less critical, so possible to delay, but may need to be part of initial wave

4. Less critical sectors able to work from home - - encourage these sectors to continue working from home where possible

Possible to phase industries returning to work by criticality and ability to continue working from home

1. Sum is less than 100%, due to other minor sectors not depicted

Comprehensive “Funnel Framework”

A handful of key segmentation decisions can greatly reduce the hospitalization rate while still enabling large portions of the economy to restart.

Other Considerations

- **Returning population’s exposure to excluded population**: how many excluded ppl will still be exposed by household members returning to work?
- **Nursing Homes**: how to deal with isolated high-risk populations interacting with workers?
- **Workforce enablers**: (childcare / education) – need enough capacity to support segment returning to work

Source: Bain Capital Partners analysis
Other Considerations: Families with At-Risk Relatives

Up to ~40% of 65+ population could be living with individuals returning to work. To manage these at-risk populations, may need to set up alternative living arrangements in hot spots.

Source: 2018 American Community Survey Living Arrangements of Adults 18 Years and Over By Age
Other Considerations: Education

Reopening Schools

<table>
<thead>
<tr>
<th>Earliest to Open</th>
<th>Latest to Open</th>
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</thead>
<tbody>
<tr>
<td>Reopened schools in low-risk areas outside Tokyo</td>
<td>Schools opening potentially next school year</td>
</tr>
<tr>
<td>Reopening kindergartens and primary schools</td>
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<tr>
<td>Considering reopening schools to graduating students</td>
<td></td>
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<tr>
<td>Many regions with low case count, but limited risk for children themselves</td>
<td>Opening after a month in lockdown, disinfecting schools twice a day</td>
</tr>
<tr>
<td>Opening after bars, cinemas, and restaurants</td>
<td>Oldest students can keep masks on, but still risk of asymptomatic transmission</td>
</tr>
</tbody>
</table>

Key Considerations

- Schools should consider risk to children themselves (likely low) and their transmission to others (higher)
- Criticality for economic activity a concern, school reopening often a prerequisite to parents returning to work
- Transpiration and child care also necessary preconditions to allowing people to return to work, will need mitigating safety measures

Reopening schools and child care precondition to returning to work, but carries key risks. Will also need plan for other key enablers (e.g., transportation)

The Key 3 Steps to Achieve Hospital Balance & Worker Safety

**Segmentation:** Sequence segments returning to work according to risk to lower hospitalization rate

**Effective Therapeutics:** While waiting for vaccine, implement effective treatments to curb hospitalization rate & fatality rate

**Reduce $R_0$:** Implement policies & procedures to reduce the rate of spread

Source: Bain Capital Partners analysis
## Types of Solutions & Timeline

<table>
<thead>
<tr>
<th>Use Case</th>
<th>First Wave “Repurposed” Therapeutics</th>
<th>Second Wave New Therapeutics</th>
<th>Third Wave Vaccines</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Acute remediation</td>
<td>Prevent and treat</td>
<td>Long-term cure</td>
</tr>
<tr>
<td>Drug Candidates</td>
<td>• Remdesivir</td>
<td>• Human antibodies</td>
<td>• Inactivated virus particles</td>
</tr>
<tr>
<td></td>
<td>• Niclosamide</td>
<td>– Monoclonal and polyclonal</td>
<td>• Live-hybrid viruses</td>
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<tr>
<td></td>
<td>• Favipiravir</td>
<td>• New compounds targeting essential viral proteins</td>
<td>• RNA-based vaccines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Moderna, CureVac, BioNTech</td>
<td></td>
</tr>
<tr>
<td>Challenges</td>
<td>• Dose likely higher than existing use cases, supply limited</td>
<td>• FDA approval timelines are usually 30 days for testing, 3-6 months for approval</td>
<td>• Unknown if vaccines will need to be seasonal (like influenza) or durable long-term (like measles)</td>
</tr>
</tbody>
</table>

**Use Case**
- **Acute remediation**
- **Prevent and treat**
- **Long-term cure**

**Timeline**
- **April-June 2020**
- **July-September 2020**
- **April 2021-April 2022+**

**Effective Therapeutics in development, but vaccine 18+ months away**

Source: Scientists to Stop COVID-19, Newpath Partners, Nature, Bain Capital Partners analysis
First Wave – “Repurposed” Therapeutics

## Repurposed Therapeutic Development Timeline

<table>
<thead>
<tr>
<th>Remdesivir Trial Results</th>
<th>Remdesivir Production</th>
<th>Continued Production, combined with second wave therapies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niclosamide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Favipiravir</td>
<td>Trials, Results</td>
<td></td>
</tr>
<tr>
<td>Camostat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Example Early Candidates Progress

<table>
<thead>
<tr>
<th>US Status</th>
<th>Use Case</th>
<th>Earliest Trial End Date</th>
<th>Initial Clinical Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under development (Ebola, SARS)</td>
<td>Treatment</td>
<td>May 2020</td>
<td>Positive outcomes on clinical improvement in global program</td>
</tr>
<tr>
<td>Investigational (influenza)</td>
<td>Treatment</td>
<td>March 2020</td>
<td>Positive results on viral load and clinical recovery in Chinese trials</td>
</tr>
</tbody>
</table>


With rapid FDA approval and ramped production will be available in next six to nine weeks, but limited to acute remediation.
Second Wave – New Therapeutics

New Therapeutic Development Timeline

- IND Application, FDA Approval
- Clinical Trials
- Large Efficacy Trials
- Scale Production
  - NDA, FDA Approval
  - Broad Administration
- April-June 2020
- June-August 2020
- August-Sept 2020+

Example Early Candidates Progress

<table>
<thead>
<tr>
<th>Compound</th>
<th>Monoclonal antibodies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developers</td>
<td>Biogen, Regeneron</td>
</tr>
<tr>
<td>Description</td>
<td>Isolated antibodies from SARS survivors, GE mice</td>
</tr>
<tr>
<td>Target Trial Start Date</td>
<td>June-August 2020</td>
</tr>
<tr>
<td>Additional Research</td>
<td>Can prevent short-term and treat COVID-19 patients</td>
</tr>
<tr>
<td></td>
<td>Hyperimmune globulin isolated from survivor plasma</td>
</tr>
<tr>
<td></td>
<td>September 2020</td>
</tr>
<tr>
<td></td>
<td>9 candidates profiled already</td>
</tr>
</tbody>
</table>

With regulatory flexibility and ramped production, may be available by late summer 2020, but still not a cure

Source: Scientists to Stop COVID-19, Newpath Partners, Milken Institute, BioCentury, FiercePharma, FierceBiotech, Bain Capital Partners analysis
# Third Wave - Vaccines

## Vaccine Development Timeline

<table>
<thead>
<tr>
<th>Phase</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preclinical Animal Studies</td>
<td></td>
</tr>
<tr>
<td>Phase I/II Clinical Trials</td>
<td>18-24 Months</td>
</tr>
<tr>
<td>Additional Clinical Trials</td>
<td></td>
</tr>
<tr>
<td>Dead Virus Vaccines</td>
<td></td>
</tr>
<tr>
<td>DNA/viral Protein-based Vaccines</td>
<td></td>
</tr>
<tr>
<td>First 18 Months</td>
<td>18-24 Months</td>
</tr>
<tr>
<td>24+ Months</td>
<td></td>
</tr>
</tbody>
</table>

## Example Early Candidates Progress

<table>
<thead>
<tr>
<th>Type</th>
<th>Developers</th>
<th>Country</th>
<th>Development Phase</th>
<th>Clinical Trial Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNA</td>
<td>Moderna</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNA/Viral</td>
<td>INOVIO</td>
<td>USA</td>
<td>Preclinical - Clinical Ph I</td>
<td>March 2020 – June 2021</td>
</tr>
<tr>
<td></td>
<td>BioNTech</td>
<td>Germany</td>
<td>Preclinical - Clinical Ph II</td>
<td>April 2020 – November 2020</td>
</tr>
<tr>
<td></td>
<td>StemRNA</td>
<td>China</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CanSinoBIO</td>
<td>China</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vaccine likely to take 18+ months to develop

**VACCINES**

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Company</th>
<th>Platform</th>
<th>Stage</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. mRNA-1273</td>
<td>Moderna</td>
<td>RNA</td>
<td>Phase 1 (First Patient Dosed)</td>
<td>First to date a human in the U.S. Vaccine consists of an mRNA strand designed to elicit an immune response to produce antibodies against SARS-CoV-2</td>
<td></td>
</tr>
<tr>
<td>2. Ad5-nCoV</td>
<td>CanSino Biologics</td>
<td>Non-replicating Viral vector</td>
<td>Phase 1</td>
<td>Benefits from previous success in the Ebola virus (time to market ~5 years). Vaccine being developed is based on viral vectors genetically altered to deliver antigen to express the SARS-CoV-2 spike protein</td>
<td></td>
</tr>
<tr>
<td>3. ChAdOx1 nCoV-19</td>
<td>University of Oxford</td>
<td>Non-replicating Viral vector</td>
<td>Phase 1/2</td>
<td>Enrolling more individuals to test its vaccine candidate, which uses a non-replicating virus to deliver RNA instead</td>
<td></td>
</tr>
<tr>
<td>4. CV-SMIRN-DC</td>
<td>Shenzhen Geno-Immune Medical Institute</td>
<td>Lentiviral</td>
<td>Phase 1/1II</td>
<td>Begins early testing of its vaccine candidate. The vaccine uses a lentiviral vector to deliver SARS-CoV-2 antigens to dendritic cells and CD8+ T cells</td>
<td></td>
</tr>
<tr>
<td>5. BCG Vaccine</td>
<td>Research Group, Netherlands</td>
<td>Live Attenuated Virus (LAV)</td>
<td>Phase 1/1/II</td>
<td>Figuring using the BCG vaccine, originally for TB, to fight SARS-CoV-2 in healthcare workers at high risk of infection. Up to 100 individuals will be enrolled from hospitals to receive the vaccine or placebo</td>
<td></td>
</tr>
<tr>
<td>6. BCG Vaccine</td>
<td>Murdoch Children's Research Institute</td>
<td>Live Attenuated Virus (LAV)</td>
<td>Phase 1/1II</td>
<td>The DEmC2Z trial will conduct a randomized, multi-center study of the BCG vaccine on 1100 healthcare workers across Australia</td>
<td></td>
</tr>
</tbody>
</table>

*For query
Source: Visual Capitalist, FDA, WHO, company websites, Professor Florian Krammer

Effective Therapeutics

**SARS-CoV-2 vaccines currently in clinical trials**

<table>
<thead>
<tr>
<th>Entity</th>
<th>Vaccine</th>
<th>Clinicaltrials.gov#</th>
<th>Stage</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Oxford</td>
<td>ChAdOx1 nCoV-19</td>
<td>NCT04324606</td>
<td>Recruiting</td>
<td>Phase I</td>
</tr>
<tr>
<td>CanSino Biologics Inc.</td>
<td>Ad5 Vectors</td>
<td>NCT04313127</td>
<td>Active, not recruiting</td>
<td>Phase I</td>
</tr>
<tr>
<td>CanSino Biologics Inc.</td>
<td>Ad5 Vectors</td>
<td>NCT04341389</td>
<td>Recruiting</td>
<td>Phase II</td>
</tr>
<tr>
<td>Sinovac</td>
<td>Inactivated virus vaccine</td>
<td>NCT04352608</td>
<td>Recruiting</td>
<td>Phase I/II</td>
</tr>
<tr>
<td>Symvivo Corporation</td>
<td>Bifidobacterium vector</td>
<td>NCT04334980</td>
<td>Not yet recruiting</td>
<td>Phase I</td>
</tr>
<tr>
<td>NIAID</td>
<td>mRNA-1273</td>
<td>NCT04283461</td>
<td>Recruiting</td>
<td>Phase I</td>
</tr>
<tr>
<td>Inovio</td>
<td>DNA</td>
<td>NCT04336410</td>
<td>Recruiting</td>
<td>Phase I</td>
</tr>
</tbody>
</table>

Source: Visual Capitalist, FDA, WHO, company websites, Professor Florian Krammer
How to Accelerate Therapeutic Development

**Rapid FDA Approval**
- **Issue:** Companies must wait 30 days after submission to implement trials
- **Solution:** FDA should ask relevant questions before receiving IND, allow trial initiation immediately

**Government Funding**
- **Issue:** Insufficient PPE including gloves, gowns, masks, and N95s
- **Solution:** Provide companies financial guarantees above market prices, regulatory relief

**Scale Production**
- **Issue:** Individual companies cannot produce enough of emerging therapies
- **Solution:** Facilitate manuf. of promising candidates by other U.S. drug cos

**Investigational New Drug Review**
- **Issue:** FDA review of an NDA typically takes 3-6 months
- **Solution:** FDA communicate daily with relevant companies, complete NDA review within 1 week

**New Drug Application (NDA)**
- **Issue:** Hospitals, others lack supplies to conduct fastest tests
- **Solution:** Provide funding guarantees for viral testing and serological test to detect antibodies

**Test and Trace Funding**
- **Issue:** Need capacity to scale treatments prior to approval
- **Solution:** FDA should approve new plants for the production of other medicines

**Purchase Guarantees**
- **Issue:** Provide companies financial guarantees above market prices, regulatory relief

**Free Up U.S. Plant Capacity**
- **Issue:** Insufficient PPE including gloves, gowns, masks, and N95s
- **Solution:** Provide financial guarantees to companies scaling production

**Commentary**

Government action can turbo charge vaccine and therapeutic development & deployment

**What we can do to help:**
- Encourage frequent communication between FDA & companies & push for rapid FDA approval
- Provide financial stability to companies scaling production
- Help U.S. plants be ready and able to produce therapeutic candidates

New therapies and vaccines months to years off, but targeted government action can accelerate development
The Key 3 Steps to Achieve Hospital Balance & Worker Safety

**Segmentation:** Sequence segments returning to work according to risk to lower hospitalization rate

**Effective Therapeutics:** While waiting for vaccine, implement effective treatments to curb hospitalization rate & fatality rate

**Reduce \( R_0 \):** Implement policies & procedures to reduce the rate of spread

Source: Bain Capital Partners analysis
Reducing $R_0$: Why It Matters

MA New Cases Under Different $R_0$

<table>
<thead>
<tr>
<th>$R_0$ = 2.4</th>
<th>$R_0$ = 1.0</th>
<th>$R_0$ = 0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph showing New Cases" /></td>
<td><img src="image2.png" alt="Graph showing New Cases" /></td>
<td><img src="image3.png" alt="Graph showing New Cases" /></td>
</tr>
</tbody>
</table>

Lower spread can significantly reduce the number of daily new cases, despite greater population exposure.

Source: Prof. Uri Alon, Prof. Ron Milo, Prof. Nadav Davidovich, Prof. Amos Zahavi, Dr. Hagit Ulanovsky; Intermittent Work: A feasible strategy for a return to economic activity that can prevent a second wave of COVID-19; Weizman Institute of Science; Business Insider; WSJ.com
## Potential Policies to Reduce $R_0$

<table>
<thead>
<tr>
<th>Group A</th>
<th>Less Expensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPE / Masks</td>
<td>Mandated mask &amp; PPE use</td>
</tr>
<tr>
<td>Personal Hygiene</td>
<td>Frequent hand washing or sanitizing. Avoid touching eyes, nose and mouth. Good respiratory hygiene</td>
</tr>
<tr>
<td>Self-Diagnosis</td>
<td>Comprehensive check-list of symptoms each worker considers before leaving home</td>
</tr>
<tr>
<td>Distancing / No Large Groups</td>
<td>Social distancing at work where possible. Staggered shifts and lunch times</td>
</tr>
<tr>
<td>Workspace Cleaning</td>
<td>Frequent workplace deep cleaning. Hygiene zones with mandatory sanitization checkpoints in between</td>
</tr>
<tr>
<td>Employer Screening</td>
<td>Temperature measurement and symptom screening upon entry</td>
</tr>
<tr>
<td>Re-designing Workspace</td>
<td>Re-modeling of workspace to ensure greater spacing between employees. Improved air filtration and ventilation. Touch-free handles and interfaces</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group B</th>
<th>More Expensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telework</td>
<td>Encourage telework where possible</td>
</tr>
<tr>
<td>Travel limitations</td>
<td>Discourage travel unless absolutely necessary. Before traveling, ensure virus levels low at home &amp; destination</td>
</tr>
<tr>
<td>Smaller Transport Methods</td>
<td>Limit use of mass transit when possible. Encourage carpooling or deploy corporate vans where hygiene easier</td>
</tr>
<tr>
<td>Tracing</td>
<td>Team of ~5,000 tracers in MA conducting manual interviews with positive cases and alerting and quarantining those who were in contact with a positive case</td>
</tr>
</tbody>
</table>

**Large variety of possible strategies to help reduce $R_0$ – should begin with most effective & lowest cost, but will likely need higher cost effective measures as well (testing, tracing)**

Source: Bain Capital Partners Analysis, Scientists to Stop COVID-19, McKinsey: Coronavirus COVID-19: Securing the workplace
Large variety of possible strategies to help reduce $R_0$ – should begin with most effective & lowest cost, but will likely need higher cost effective measures as well (testing, tracing)

Source: Bain Capital Partners Analysis
Potential Policies to Reduce $R_0$

- **Group A:** Masks, Self-Diagnosis and Employer Screening
- **Group B:** Testing & Tracing
Theoretical Effectiveness of Masks & PPE

### Theoretical Mask Use Impact on $R_0$

- **Adherence:** Higher adherence, even with less effective masks, can greatly reduce $R_0$. Consider making PPE mandatory.
- **Supply & Efficacy:** Is there adequate supply of the necessary level of efficacy? (i.e., easy to supply cloth masks but lower efficacy)

### Mean % Filtration Efficiency of Various Masks

<table>
<thead>
<tr>
<th>Mask Type</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scarf</td>
<td>49%</td>
</tr>
<tr>
<td>100% Cotton Masks</td>
<td>51%</td>
</tr>
<tr>
<td>Tea Towel</td>
<td>72%</td>
</tr>
<tr>
<td>Surgical Masks</td>
<td>89%</td>
</tr>
<tr>
<td>N95</td>
<td>95%+</td>
</tr>
</tbody>
</table>

Note: Data based on Bacteriophage MS2 (23 nm in diameter) - COVID-19 virus particles are ~125 nm in diameter.

Widespread use of masks, even lower quality cloth masks, can have a significant impact on $R_0$.

Source: The Atlantic, L Tian et al, "Calibrated Intervention and Containment of the COVID-19 Pandemic" (2020); "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?", Anna Davies, Katy-Anne Thompson, Karthika Giri, George Kalatos, Jimmy Walker, Allan Bennett
Self-Diagnosis

Daily Symptom Checklist

<table>
<thead>
<tr>
<th>Symptom</th>
<th>% of Cases w/ Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>64%</td>
</tr>
<tr>
<td>Sinus Pain</td>
<td>50%</td>
</tr>
<tr>
<td>Cough</td>
<td>46%</td>
</tr>
<tr>
<td>Altered sense of smell</td>
<td>44%</td>
</tr>
<tr>
<td>Expectoration</td>
<td>32%</td>
</tr>
<tr>
<td>Stuffy nose</td>
<td>25%</td>
</tr>
<tr>
<td>Chills</td>
<td>18%</td>
</tr>
<tr>
<td>Fatigue</td>
<td>18%</td>
</tr>
<tr>
<td>Sore throat</td>
<td>13%</td>
</tr>
<tr>
<td>Headache</td>
<td>13%</td>
</tr>
<tr>
<td>Difficulty breathing</td>
<td>11%</td>
</tr>
<tr>
<td>Joint or muscle pain</td>
<td>10%</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>6%</td>
</tr>
<tr>
<td>Vomiting</td>
<td>3%</td>
</tr>
</tbody>
</table>

Potential Policy & Considerations

- **Mandate employees / students certify** (via smartphone app / website for example) they are not experiencing any of the listed symptoms
- **Incentivize adherence** with paid sick leave policies
- Provided adherence is high, **self-certification could detect a significant amount of symptomatic cases**, including mildly symptomatic cases
- Recent studies suggest **true number of asymptomatic cases quite rare (2-6%)**, suggesting **meticulous and accurate daily symptom surveying** and self-reporting can be highly affective in lowering $R_0$

Meticulous and accurate daily symptom surveying and self-reporting can be highly effective in lowering $R_0$

Source: Scientists to Stop COVID-19
Employer Screening

Example Employer Screening Case Studies

- **Wuhan, China** – all arriving employees must submit to at least **four temperature checks daily**
- **Amazon** – using **thermal cameras** at its operations facilities to screen workers for fevers
- **Some grocery stores** are using **non-contact forehead infrared thermometers** to temperature test associates as they arrive for work
- **Colorado** – governor announced **temperature checks at workplaces** will be part of reopening plan

Potential Considerations

- **Not effective at reducing $R_0$ on its own**: only **64% of cases present with fever**, and carriers are contagious in the period of time before fever manifests. Will need to be combined with other norms & screening measures
- **Implementation could be challenging**: will require additional PPE and thermometers that could be difficult to acquire
- **Medical information will have to be safely stored**: all temperatures taken should be treated as confidential medical information and stored as such

Temperature checks and other employer screening are useful tools when used in combination with other policies

Source: Scientists to Stop COVID-19, Bloomberg, CNN, supermarketnews.com, CPR.org, Bain Capital Partners analysis
Potential Policies to Reduce $R_0$

- **Group A**: Masks, Self-Diagnosis and Employer Screening

- **Group B**: Testing & Tracing
Combined Testing & Tracing Program Effectiveness

Testing and tracing strategies can more than double the impact on $R_0$ of self-isolation alone. Three important factors to a testing & tracing strategy: (1) how many infected are ID’d and isolated, (2) how many contacts are traced and quarantined, and (3) how quickly each is done.

Impact of Testing & Manual Tracing

Impact of Testing & App-Based Tracing

Study Conclusions

- **Self-isolation** of symptomatic cases alone: reduces $R_0$ by 32%
- **Household quarantine + self-isolation** reduces $R_0$ by 37%
- **Self-isolation + app-based tracing** reduced $R_0$ by 44%
- **Self-isolation + manual tracing of all known contacts** reduces $R_0$ by 57%
- **Self-isolation + manual tracing of all contacts** reduces $R_0$ by 67%

Source: Adam Kucharski, Petra Klepac, Andrew Conlan, Stephen Kissler, Maria Tang, Hannah Fry, Julia Gog, John Edmunds, Centre for Mathematical Modelling of Infectious Diseases COVID-19 working group
The Importance of Prolific Testing

% of Test that are Positive

Countries that are overwhelmed have very high rates of positive tests – likely are not testing enough

Countries that have controlled the epidemic test enough such that only ~3% of tests come back positive

The countries that have contained the pandemic only find ~1-3% positive cases during testing ~20% of MA cases come back positive – need to significantly increase level of testing

Source: Tomas Pueyo and Genevieve Gee analysis, based on data from worldometers: https://www.worldometers.info/coronavirus/#countries
The Importance of Tracing

Estimated COVID-19 Transmission Sources

- If you only test and isolate people with symptoms, you can reduce $R_0$ by 40% at most – this will not be effective enough on its own

- If you also trace contacts and test them, possible to also catch the pre-symptomatics, reducing $R_0$ by up to 85%

Recent research suggests ~45% of infections are caught from pre-symptomatic carriers

If only test symptomatic individuals, can only reduce $R_0$ by 40%. But a combined testing & tracing program that catches asymptomatic carriers can reduce $R_0$ by up to 85%

Source: “Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing” by Luca Feretti, Chris Wymant, Michelle Kendall, Lele Zhao, Anel Nurtay, Lucie Abeler-Domer, Michael Parker, David Bonsall, Christophe Fraser, Oxford University, Tomas Pueyo
The Importance of Speed

How Quickly Infections Happen

- 50% of presymptomatic infections happen **within 5 days**
- 50% of symptomatic infections happen **within 6 days**

If contact tracing & testing take too long, will limit the impact such a program can have on $R_0$

Testing & Tracing Speed v. Impact on $R_0$

<table>
<thead>
<tr>
<th>1-day delay</th>
<th>2-day delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>If testing &amp; tracing happens within 1 day, only need to successfully isolate 70% of cases &amp; 60% of infected contacts to reduce $R_0$ below 1</td>
<td>But if takes 2 days to test &amp; trace, will need to successfully isolate 80% of cases &amp; 75% of infected contacts to reduce $R_0$ below 1</td>
</tr>
</tbody>
</table>

Speed is vital – the larger the delay between onset and successfully testing & tracing, the lower the impact on $R_0$. Need a program that can successfully test & trace 70-80% of contacts **within 2 days**

Source: Tomas Pueyo, adapted from “Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing” by Luca Ferretti, Chris Wymant, Michelle Kendall, Lele Zhao, Anel Nurtay, Lucie Abeler-Domer, Michael Parker, David Bonsall, Christophe Fraser, Oxford University
Testing: Who to Test

### Possible Testing Plans

<table>
<thead>
<tr>
<th>Population Tested</th>
<th># Tests Required / day in MA</th>
<th>Cost¹</th>
<th>% Pop. Tested</th>
<th>Example Countries</th>
</tr>
</thead>
</table>
| **Bare Bones**    | Those with strong symptoms, other causes ruled out in hot spots | ~10K / day  
*Current testing capacity* | ~$6M / month | **MA Today** |
| **Minimal**       | Those with strong symptoms | ~20K / day  
~1,500 positives @ 8% detection rate | ~$12M / month |  
**Goal**  
~100K / day  
~1,500 positives @ 3% detection rate |
| **Moderate**      | Those with mild symptoms | ~50K / day  
~1,500 positives @ 3% detection rate | ~$30M / month |  
~100K / day  
~1,500 positives @ 3% detection rate + 30 contacts/positive |
| **Expansive**     | Those with mild symptoms + contacts traced | ~100K / day  
~1,500 positives @ 3% detection rate + 30 contacts/positive | ~$60M / month |  
~100K / day  
~1,500 positives @ 3% detection rate + 30 contacts/positive |
| **Universal**     | Everyone every week | ~1M / day  
~7M residents × 7 days a week | ~$600M / month |  
~1M / day  
~7M residents × 7 days a week |

### Example Countries

- **MA Today**
- **Expansive**
- **Universal**

---

Need to prioritize who to test today and make testing as efficient as possible, while working to increase capacity to ~100K/day

---

Source: Edmond J. Safra Center for Ethics at Harvard University: Roadmap to Pandemic Resilience, Worldometer, Tomas Pueyo

1: Assumes $20 / test
Testing: How to Test

**Case Study: Drive-Thru Testing**

- **South Korea** has set up drive-through testing centers. Tests take 10 minutes and **results texted to you the next day**. Able to test ~10 ppl/hour.

- At this point, **all 50 U.S. states** have also adopted drive-through testing centers. However, currently can take **up to a week to get results**.

**Other Potential Testing Locations**

- Drive-Thru
- Pharmacy
- At Work
- Hospital / Urgent Care Center

Should utilize current healthcare infrastructure to make testing **widely available** and **easy to access**.

**Goal is to make testing easy and quick, in order to test & track as many individuals as possible within the first 2 days of exposure**

Source: NPR.org, Bain Capital Partners Analysis
Making Testing More Efficient: Test Pooling Case Study

Stanford's Test Pooling

• In early testing, Stanford pooled samples into groups of 9-10 and tested the group

• Of the 292 groups pooled, only two came back positive – further analysis showed that one person in each group was positive

• Concluded pooling can make mass testing far more efficient, but only works when prevalence is low

Recent COVID-19 Sample Pooling Study

• A recent study showed pooling samples in groups up to 48 samples/group preserved accuracy (all positives identified, with no false negatives)

• Group recommends pooling methods for asymptomatic carriers (e.g., in expected low prevalence groups) – can make such testing far more efficient

Research still emerging, but may be possible to pool samples in groups of 10-50, significantly increasing testing efficiency (able to run 100K pooled tests in the same time as 10K individual tests)

What Tests to Use: Viral Testing Overview

Key Considerations

**How it works:** Viral genetic information extracted using swab and amplified in a machine using PCR

**What it detects:** If you currently have COVID-19

**Average cost:** TBD

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Detects current infection</td>
<td>• Slow results</td>
</tr>
<tr>
<td>• High throughput</td>
<td>• Requires many swabs, limited reagents</td>
</tr>
<tr>
<td>• Inexpensive</td>
<td>• High throughput machines require trained technicians</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Abbott Molecular</td>
</tr>
<tr>
<td>• BD</td>
</tr>
<tr>
<td>• BioGX</td>
</tr>
<tr>
<td>• Cepheid</td>
</tr>
<tr>
<td>• DiaSorin Molecular</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Testing Companies &amp; Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hologic</td>
</tr>
<tr>
<td>• LabCorp</td>
</tr>
<tr>
<td>• NeuMoDx</td>
</tr>
<tr>
<td>• PerkinElmer</td>
</tr>
<tr>
<td>• Quest Diagnostics</td>
</tr>
<tr>
<td>• Quidel Corporation</td>
</tr>
<tr>
<td>• Roche Molecular Systems</td>
</tr>
<tr>
<td>• Thermo Fisher Scientific</td>
</tr>
</tbody>
</table>

**Sample High Throughput Machines / Products**

<table>
<thead>
<tr>
<th>Company</th>
<th>Machine / Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott</td>
<td>m2000</td>
</tr>
<tr>
<td>BD / BioGX</td>
<td>BDMax</td>
</tr>
<tr>
<td>Cepheid</td>
<td>GeneXpert Infinity</td>
</tr>
<tr>
<td>Hologic</td>
<td>Panther Fusion</td>
</tr>
<tr>
<td>NeuMoDx</td>
<td>288 Molecular</td>
</tr>
<tr>
<td>Roche</td>
<td>COBAS 8800</td>
</tr>
<tr>
<td>Thermo Fisher</td>
<td>TaqPath</td>
</tr>
<tr>
<td>Labs incl. Quest, LabCorp, etc.</td>
<td>Lab Developed Tests</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Daily Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>470</td>
</tr>
</tbody>
</table>

Ideal for combination testing and tracing program because of ability to detect infection in real time

Sources: Company websites, FDA, Centers for Medicare & Medicaid Services
What Tests to Use: Antibody Testing Overview

Key Considerations

How it works: Samples blood, test device detects antibodies created by body to fight virus

What it detects: If you previously had COVID-19

Average cost: TBD

Pros
- Can identify previous infections
- Takes seconds to test
- Doesn’t require swabs
- Can detect previous asymptomatic cases

Cons
- Antibodies slow to develop
- Unclear how protected those with antibodies are
- Program based on antibody testing could encourage ppl to catch virus
- False positives

Testing Companies & Accuracy

<table>
<thead>
<tr>
<th>Company</th>
<th>BioMedomics</th>
<th>Bioperfectus</th>
<th>DecomBio</th>
<th>DeepBlue</th>
<th>Innovita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity</td>
<td>87%</td>
<td>95%</td>
<td>90%</td>
<td>84%</td>
<td>96%</td>
</tr>
<tr>
<td>Company</td>
<td>Premier</td>
<td>Sure</td>
<td>UCP</td>
<td>VivaChek</td>
<td>Wondfo</td>
</tr>
<tr>
<td>Specificity</td>
<td>97%</td>
<td>100%</td>
<td>98%</td>
<td>95%</td>
<td>99%</td>
</tr>
</tbody>
</table>

Ideal for identifying percentage of population that has been infected, but less ideal for testing/tracing

Sample Test Specificity

Sources: Company websites, FDA, Johns Hopkins Centers for Health Security, “Test performance evaluation of SARS-CoV-2 serological assays” – Whitman et. al, UC San Francisco, MGH
# What Tests to Use: Saliva v. Nasal Testing

## Nasal or Throat Swabs
- Currently **most broadly administered** test
- **Recommended by the CDC**
- **Invasive** (involves a long Q-tip-like swab stuck up the nose or into the back of the throat)
- Can take **1-5 hours** to run the test
- Requires a **trained professional to administer**
- Can have a **false-negative rate of ~30%+**

## Saliva Tests
- **Recently received FDA emergency use authorization**
- **Minimally invasive** (simply spit into vial)
- Can be **reliably self-administered**
- Requires **less PPE and personnel** to administer
- Not enough information to determine accuracy, but recent studies estimate ~90% to ~95% as effective as nasal or throat swabs

## Other Emerging Options
- **DNA test** that can deliver results in 40 minutes using CRISPR
- **Take-home test** – FDA recently authorized the first take-home kit; receive kit with doctor approval and mail back

---

*Should keep track of emerging testing technologies and focus on options that make the testing process as easy and quick as possible while retaining accuracy*

*Sources: Scientists to Stop COVID-19, “Saliva is More Sensitive for SARS-COV-2 detection in COVID-19 patients than nasopharyngeal swabs”, medRxiv, Yale (study has not yet been peer reviewed), cnet.com*
Current Testing Capacity

New Tests Per Day

MA Testing capacity higher than rest of the US on a per capita basis, but both need to expand dramatically to reach goals of 30M national tests / week

Source: https://covidtracking.com/data/us-daily, Mass.gov

Week of 4/25
1,485,717
US tests
64,714
MA tests
Building the Necessary Testing Capability

Proposed Rapid Centralized Solution

- **MA contracts directly** with a large/multiple large diagnostics company(s) who can handle 100K+ tests/day

- Provider sets up **6-10 centralized testing centers** to take advantage of scale and ramps up ability to perform **100K tests/day**

- In addition to centralized facilities, **utilize current healthcare infrastructure** and local facilities (hospitals, urgent care clinics, pharmacies, etc.)

- Diagnostics companies require **6-8 weeks** to ramp production – vital to set up contracts **as soon as possible**

Given shortage of testing capacity, Massachusetts should **rapidly** explore avenues to secure capacity

Source: Discussions with Industry Experts, Bain Capital Partners Analysis
Testing: Timeline of Solutions

**More expensive & difficult**

**Short-Term**
- Centralized testing through a handful of large diagnostic companies
- 6-10 centralized testing centers
- Existing HC infrastructure used whenever possible
- Production ramped to ~100K/day

**Medium-Term**
- Frequent saliva-based testing administered once a week
- 10 centralized testing centers continue to process tests, each able to process ~100K/day
- Production ramped to ~1M tests/day

**Long-Term**
- Universal at-home testing kits
- Saliva-based
- Cheap & easy to administer

**Less expensive & easy**

Should work towards a more universal at-home testing program (infeasible today given technology and capacity constraints)

Source: Bain Capital Partners Analysis
Contact Tracing: Five Key Questions

1. **Who Qualifies as a Contact?**
   Identifying who should be traced and their risk category

2. **What Procedures Should Contacts Follow?**
   Isolation and self-assessment based on risk level

3. **How Many Contacts Do You Need to Trace?**
   Extensive tracing of 70-90% of contacts needed to slow spread

4. **How Many Investigators Do You Need?**
   Thousands of investigators needed to trace 70-90% of contacts

5. **How Do You Use Technology to Help?**
   Digital tracing can increase efficacy considerably

Contact tracing necessary to slow spread and will require large manual and digital effort

Source: Bain Capital Partners Analysis, Tomas Pueyo
Who Qualifies as a Contact?

How Far Back to Trace

- Median incubation period is 5-6 days, full range up to 14 days
- Need to track all contacts from previous two weeks

Example Case Study: Canadian Classification System

<table>
<thead>
<tr>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Close contact</strong></td>
<td><strong>Non-close contact</strong></td>
<td><strong>Transient interactions</strong></td>
</tr>
<tr>
<td>• Provided direct care without PPE</td>
<td>• Provided direct care with PPE</td>
<td>• Walking by the case</td>
</tr>
<tr>
<td>• <strong>Lived with</strong> infected person (e.g., family)</td>
<td>• Prolonged contact but not within 6 feet of person</td>
<td>• Briefly in same room</td>
</tr>
<tr>
<td>• Prolonged contact within 6 feet of person</td>
<td>• Direct contact (e.g., sneezed on)</td>
<td>• Exposure for less than 15 minutes</td>
</tr>
</tbody>
</table>

Need to isolate and test family members, those in contact >15 minutes closer than 6 feet

Sources: Annals of Internal Medicine: "The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Publicly Reported Confirmed Cases: Estimation and Application", Stephen A. Lauer, MS, PhD; Kyra H. Grantz, BA; Qifang Bi, MHS; Forrest K. Jones, MPH; Qulu Zheng, MHS; Hannah R. Meredith, PhD; Andrew S. Azman, PhD; Nicholas G. Reich, PhD; Justin Lessler, PhD; Government of Canada: Public health management of cases and contacts associated with coronavirus disease 2019 (COVID-19)
What Procedures Should Contacts Follow?

<table>
<thead>
<tr>
<th>Example Case Study: Canadian Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Risk</strong></td>
</tr>
<tr>
<td>Family Member</td>
</tr>
<tr>
<td>• Quarantine at home for 14 days after exposure</td>
</tr>
<tr>
<td>• Practice good hand hygiene and respiratory etiquette</td>
</tr>
<tr>
<td>• Self-monitor for symptoms such as fever or cough</td>
</tr>
<tr>
<td>• Record temperature daily</td>
</tr>
<tr>
<td><strong>Medium Risk</strong></td>
</tr>
<tr>
<td>Provided direct care while wearing PPE</td>
</tr>
<tr>
<td>• Self-monitor for symptoms such as fever or cough</td>
</tr>
<tr>
<td>• Avoid close contact with individuals at higher risk for severe illness</td>
</tr>
<tr>
<td>• Follow actions recommended for entire population</td>
</tr>
<tr>
<td><strong>Low Risk</strong></td>
</tr>
<tr>
<td>Walked by on street</td>
</tr>
<tr>
<td>• Follow actions recommended for entire population</td>
</tr>
</tbody>
</table>

Need to determine policies & procedures for contacts to follow based on risk level. Should only high risk contacts be self quarantined, or should medium risk contacts be quarantined as well?

Sources: Government of Canada Public health management of cases and contacts associated with coronavirus disease 2019
How Many Contacts Do You Need to Trace?

Impact of Tracing on Reproduction Rate ($R_n$)

<table>
<thead>
<tr>
<th>Legend</th>
<th>$R_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

Areas represent confidence intervals.

Key Considerations

- Tracing required varies depending on **basic reproduction number** ($R_0$) of COVID-19 without remediating efforts
- If $R_0$ is 2.5, need to trace 70% of contacts to control epidemic – studies estimate **20 people per case**
- If $R_0$ is 3.5, need to trace 90% of contacts to control epidemic – studies estimate **30 people per case**
- Additional measures taken to help lower $R_0$ will reduce burden on exactness in contact tracing

```
At initial $R_0 = 2.5-3.5$, need to trace 70-90% of contacts to get $R_n$ below 1
$R_n=1$. Below this, epidemic is controlled
```

Will likely need to trace and isolate 20-30 closest contacts of each positive case as fast as possible

How Many Investigators Do You Need?

Case-Based Manual Tracers Estimate

<table>
<thead>
<tr>
<th>Tracers Needed Per Case</th>
<th># of Tracers Needed to Clear One Case Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wuhan Success: 5</td>
</tr>
<tr>
<td></td>
<td>CMS Estimate: 12-15</td>
</tr>
</tbody>
</table>

Framing Equations

# of New Cases Per Day (x) # of Tracers to Clear One Case (=) Tracers Needed

MA Tracers Required

~1,000-2,000 (x) ~5 (=) ~5-10K Tracers

Scale of Manual Tracers Needed in MA

MA Today: 1,000
Johns Hopkins Plan: ~2,000
Case-Based Build: ~5,000-10,000

MA may need up to ~5-10K contact tracers

Sources: Tomas Pueyo, ProPublica, Johns Hopkins Bloomberg School of Public Health: A National Plan to Enable Comprehensive COVID-19 Case Finding and Contact Tracing in the US
How Do You Use Technology to Help?

Illustrative Contacts Identified through Manual Interview and Digital Tracing

Will be difficult to identify 70-90% of contacts with manual tracing alone. Digital tracing can help manual tracers identify far more contacts, particularly with opt-out Bluetooth apps.

Sources: Tomas Pueyo
# Range of Digital Tracing Options

<table>
<thead>
<tr>
<th>Description</th>
<th>Policy</th>
<th>Technology Used</th>
<th>Date Deployed</th>
<th>Success</th>
<th>Opt-In/Voluntary?</th>
<th>Information Disclosed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Google and Facebook</td>
<td>Europe</td>
<td>South Korea</td>
<td>China</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alerts users if they've been in contact with a positive case</td>
<td>App that uses central servers to alert contacts of positive cases</td>
<td>Government publishes detailed reports about confirmed cases</td>
<td>Traced residents who left Wuhan, involuntary quarantine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alerts users if they've been in contact with a positive case</td>
<td>Bluetooth, central servers, cell phone data</td>
<td>Cellphone data, credit-card transactions, security footage</td>
<td>Phone and location data, travel history, drones, security footage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In development</td>
<td>In development by consortium of institutions &amp; companies</td>
<td>Traced residents in February, gave access to local officials March 4th</td>
<td>Lockdown of Wuhan January 23rd, traced residents soon after</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NA</td>
<td>N/A</td>
<td>Average of 30 cases a day</td>
<td>0 reported new cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age and gender</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel history</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address &amp; location</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contacted persons</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Digital tracing can be highly effective, but privacy concerns a key issue.

Workplace Digital Tracing: Example Case Study

Exposure Heat Map – Locix App

Each dot represents a spot where two workers passed each other within 6ft

- Locix building a tool designed to track where people have been at work within a few centimeters
- Other proposed solutions (e.g., Microshare) may involve workers wearing badges, key rings or wristwatches embedded with inexpensive Bluetooth beacons to effectively trace populations without universal smartphone adoption

Example Solutions

<table>
<thead>
<tr>
<th>Devices Used</th>
<th>Technology Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone app</td>
<td>WiFi</td>
</tr>
<tr>
<td>Badges, key rings, and wristbands</td>
<td>Bluetooth</td>
</tr>
<tr>
<td>Smartphones, IoT sensors, asset trackers, appliances</td>
<td></td>
</tr>
</tbody>
</table>
Testing & Tracing: Summary

- Testing and tracing can have a large impact on reducing $R_0$ (up to ~2x more effective than self-isolating alone)

- In order to be effective, testing & tracing programs need to capture ~70% of contacts within 1-2 days. MA leading the way in the US on tracing (have already assembled a team of ~1000 tracers), but will likely need ~5-10x more tracers to accomplish this

- To accurately capture all cases & test contacts, will need ~100K tests/day. MA capacity slowly ramping (achieving ~10-15K / day currently). Need to rapidly explore avenues to performing ~100K tests / day, as ramping will likely take ~6-8 weeks post-contract

Although testing / tracing can have a significant impact on reducing $R_0$, that impact will be constrained by the time it takes to build up capacity, and the cost associated with large-scale efforts

Source: Bain Capital Partners Analysis
Legal Feasibility of New Workplace Norms

Key Legal Questions & Considerations

• How to make sure on-site temperature testing, symptom screening, and storing information are compliant with HIPAA and the ADA?

• Can compliance with health & safety guidelines be conditions of employment? How to deal with employees that refuse to comply?

• How to ensure a non-discriminatory implementation of policies and protocols?

• How to implement changes and protocols with a unionized workforce?

• How to deal with potential negligence & lawsuit risk related to new outbreaks and/or deaths?

Ropes & Gray Emerging Principles

• Afford employees a safe working environment by adopting and enforcing scientifically-based work rules & providing appropriate supplies & support

• Align work rules & practices with guidelines from the cognizant federal, state, and local authorities

• Comply with federal, state, and local laws and regulations

• Respect the special requirements of disability rights laws, including as they apply to comorbidity

• Cooperate with state and local public health departments

• To the greatest extent possible, keep private the health and social information of individual employees

Several legal considerations to implementing new workplace norms. Key questions are (1) what the state should mandate, (2) consistent implementation, and (3) how to provide legal guidance for SMBs

Source: Ropes & Gray. Does not constitute legal advice
Reducing $R_0$ Summary Thought Model

Impact of Low Cost, Highly Effective Policies

- Near-perfect implementation of low cost, highly effective policies such as universal mask wearing, distancing and self-diagnosis can reduce $R_0$ enough on their own.

Impact of High Cost, Highly Effective Policies

- Near-perfect implementation of a robust testing & tracing program (~100K tests/day, 5-10K tracers + digital tracing) can reduce $R_0$ enough on its own.

Each group of policies could theoretically reduce $R_0$ enough on their own to reopen the economy. A combination approach could keep the same level of reduction with less-than-perfect implementation.

Source: Bain Capital Partners analysis
The War on COVID-19

Timing & Hospital Capacity Constraint Model
Build a dynamic hospital capacity / demand model based on current infection rate and system readiness

Segmentation
Implement segmentation model, sequencing segments returning to work according to risk and ability to safeguard

Co-living
Develop guidelines for high risk segments living with segments returning to work

Enablers
Develop guidelines for back-to-school (including childcare) and transportation

Treatment
Identify and rapidly deploy effective therapeutic treatments and longer-term a vaccine

Therapeutics
While waiting for vaccine, implement effective treatments to curb hosp. rate

Vaccine
Accelerate vaccine development & prepare for deployment at-scale

Reduce R₀
Implement policies & procedures to reduce the rate of spread

Workplace Norms
Develop workplace norms to minimize reoccurrence

Testing & Tracing
Develop massive testing & tracing plan to be used to identify & contain virus spread

Source: Bain Capital Partners analysis
Appendix
Testing Companies and Organizations, References

- 3D Medicines
- Abbott
- Aculabs, Inc.
- Anaotomika Genewerks
- ARUP Laboratories
- ASTAR, Tan Tock Seng Hospital of Singapore
- Assure Tech
- Atlia BiOySystens
- AusDiagnostics
- Autobio Diagnostics
- Avalino Lab
- Bako Diagnostics
- Baptist Hospital Miami Pathology/Laboratory Medicine Lab
- Becton Dickinson
- Becton Dickinson, BioGx
- Beijing DeconBio Biotechnology
- Beijing Diagreat Biotechnology
- Beijing Xuewei Clinical Diagnostic Reagent
- Beijing O&D Biotech
- Beroni Group
- BGI
- Biodesix
- BioMedomics
- BioMérieux
- BioMérieux/BioFire Defense
- Biomere
- BioReference Laboratories
- Boston Children’s Hospital Infectious Diseases Diagnostic Laboratory (IDDL)
- BTNX
- Cellex
- Centers for Disease Control and Prevention
- Cepheid
- CerTest Biotec
- Chembio Diagnostics
- Children’s Hospital of Philadelphia Infectious Disease Diagnostics Laboratory
- CirrusDx Laboratories
- Co-Diagnostics
- Core Technology
- Credo Diagnostics Biomedical
- DiaCarta
- Diagnostic Solutions Laboratory
- DiaSorin Molecular
- Diatherix Eurofins
- Diatyme Laboratories
- Echop Biopharmaceuticals
- Euroimmun/PerkinElmer
- Exact Sciences
- Fosun Pharma USA
- Fulgent Genetics/MedScan Laboratory
- Genetic Signatures
- Genetron
- GenMark Diagnostics
- Genomica/PharmMar Group
- GenoSensor
- Genomeq
- Gold Standard Diagnostics
- Guangzhou Wondfo Biotech
- Hackensack University Medical Center (HUMC)
- Molecular Pathology Laboratory
- Molecular Diagnostics Laboratory
- Molecular Diagnostics Laboratory
- NeMoDx Molecular
- Nirmidas Biotech
- Northwestern Medicine Diagnostic Molecular Laboratory
- Novacay/Primerdesign
- NY State Department of Health (performed at Wadsworth Center and New York City Department of Health and Mental Hygiene, Public Health Laboratories)
- Origin
- Ortho Clinical Diagnostics
- Osang Healthcare
- PathoFinder
- PCL
- PerkinElmer
- Phamatech
- Promedical
- Qiagen
- Quest Diagnostics
- Quidel
- Rendu Biotechnology
- Roche
- Rutgers University Clinical Genomics Laboratory
- SciCell Research Laboratories
- SD Biosensor
- Seegene
- Sentinel Diagnostics
- Shanghai Fosun Long March Medical Science/Shanghai Fosun Pharmaceutical
- Shenzhen Landwind Medical
- Snibe Diagnostics
- Solgent
- Sonic Healthcare
- Specialty Diagnostic (SDI) Laboratories
- Stanford Health Care Clinical Virology Laboratory
- SureScreen Diagnostics
- Suzhou Kangheshun Medical Technology
- TIB Molbiol Synthesealabor
- United Biomedical
- University of North Carolina Medical Center
- Vela Diagnostics
- Viraco Eurofins
- Vision Medicals
- VivaChek Biotech (Hangzhou)
- Yale New Haven Hospital Clinical Virology Laboratory
- YD Diagnostics
- Zhejiang Orient Gene Biotech
- Zhengzhou Fortune Bioscience
- Zhongshan Bio-Tech
- Zhuhai Encode Medical Engineering
- Zhuhai Livzon Diagnostics

White House Return to Work Framework

### Gating Criteria

**Symptoms**
- Downward trajectory of flu and COVID-19 like illnesses reported within a 14-day period

**Cases**
- Downward trajectory of positive test rates or documented cases within a 14-day period

**Hospitals**
- All patients treated without crisis care
- Testing program for healthcare workers in place

### Phase One
- **Individuals**
  - Vulnerable individuals shelter in place
  - Others should **maximize distance** in public, avoid groups of >10 people, wear PPE in public
- **Employers**
  - Encourage telework
  - Close **common areas**
  - Minimize non-essential travel
  - Certain venues (bars, schools) should **remain closed**

### Phase Two
- **Individuals**
  - Vulnerable individuals shelter in place
  - Others should **maximize distance** in public, wear PPE
  - Can resume non-essential travel
- **Employers**
  - Encourage telework
  - Close **common areas**
  - Provide accommodations for vulnerable populations
  - Restricted venues (bars, schools) can reopen with limited capacity

### Phase Three
- **Individuals**
  - Vulnerable individuals can resume public interactions
  - Others should minimize time spent in crowded environments, wear PPE in public
- **Employers**
  - Visits to senior care facilities and hospitals can resume
  - Large venues can operate under limited distancing protocols
  - Bars may operate with increased occupancy

Source: whitehouse.gov
Intermittent Work Phasing Option

To reduce risk of second wave, could begin by phasing groups in cycles of 4 work days and 10 lockdown days

![Diagram showing intermittent work phasing option]

Potential Impact

cyclic lockdown with two staggered groups of households

Could explore alternative back-to-work phasing to help reduce healthcare burden while allowing groups to return part-time earlier, potentially before system fully ready

Source: Prof. Uri Alon, Prof. Ron Milo, Prof. Nadav Davidovich, Prof. Amos Zahavi, Dr. Hagit Ulanovsky; Intermittent Work: A feasible strategy for return to economic activity that can prevent a second wave of COVID-19; Weizman Institute Science
European countries are starting to ease, but containment strategies appear limited, risking acceleration of the virus. This may mean a return to lockdown.

Source: Tony Blair Institute for Global Change: A Sustainable Exit Strategy Managing Uncertainty Minimizing Harm
East Asia countries are strongly emphasizing containment (masks, testing and tracing), which has enabled most countries to avoid full lockdowns and keep infection spikes below western peers.

Source: Tony Blair Institute for Global Change: A Sustainable Exit Strategy Managing Uncertainty Minimizing Harm
Reimagining Support Services: Workforce Redeployment

**New Jersey State Platform Example**

**How it works**

Job posting platform, featuring postings by employers whose labor needs are spiking due to COVID-19, hosted by NJ Economic Development Authority

No matching service, purely ‘bulletin board’ style.

**Outcomes so far**

Job posts: 540+ employers posted 46,000+ jobs on the site as of 2 April

Visitors and clicks: Site had ~340K unique visits in its first 10 days, with ~20K aggregate clicks on “Apply Now” buttons

**New Jersey has set up a ‘bulletin-board’ style platform to help match unemployed with new labor needs**

**Sources:** New Jersey Covid-19 Jobs Portal