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

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.

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

COVID-19 has a high spread & high rate of hospitalization / death – to return to work, need to adopt policies & procedures to reduce spread ($R_0$)

- Fundamental issue: COVID-19 has a high fatality rate and a high $R_0$ (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 $R_0$

*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

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

MA Unemployment approaching 2x+ ’09 levels

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<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>
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MA Job Vulnerability by Income Band

- Jobs at risk
- Jobs not at risk

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<tbody>
<tr>
<td>$20-25K</td>
<td>0.7</td>
<td>0.5</td>
<td>0.7</td>
<td>1.0</td>
<td>18%</td>
<td>0.9</td>
<td>2%</td>
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<tr>
<td>$25-30K</td>
<td>76%</td>
<td>54%</td>
<td>41%</td>
<td>82%</td>
<td>98%</td>
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<tr>
<td>$30-40K</td>
<td>24%</td>
<td>46%</td>
<td>59%</td>
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<td>$40-70K</td>
<td></td>
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<tr>
<td>&gt;$70K</td>
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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
Massachusetts COVID-19 Cases

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

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

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
MA Hospitalization Rate & Capacity Data

**MA Case Counts as of 4/27**

- **Not positive**: 244,887
- **Positive**: 56,462
- **ICU**

<table>
<thead>
<tr>
<th>%</th>
<th>23%</th>
<th>9%</th>
<th>28%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests Performed</td>
<td>Positive Tests</td>
<td>Currently Hospitalized Cases</td>
<td></td>
</tr>
</tbody>
</table>

Approximately ~9% of positive cases in MA hospitalized

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

~5,236 hospitalizations

- **1,089 in ICU**

% of Staffed Hospital Beds Filled by County

- **Plymouth**: 36%
- **Essex**: 27%
- **Suffolk**: 26%
- **Middlesex**: 20%
- **Worcester**: 20%
- **Bristol**: 19%
- **Hampden**: 17%
- **Norfolk**: 13%
- **Narborough**: 8%
- **Berkshire**: 6%
- **Dukes**: 4%

Total 21%

% of Staffed ICU Beds Filled by County

- **Essex**: 74%
- **Plymouth**: 65%
- **Suffolk**: 60%
- **Middlesex**: 57%
- **Worcester**: 49%
- **Narborough**: 45%
- **Bristol**: 44%
- **Hampden**: 39%
- **Narborough**: 36%
- **Berkshire**: 25%
- **Franklin**: 17%
- **Dukes**: 17%

Total 54%

*Hospitalization rate does not include patients previously hospitalized but since discharged, so likely higher than demonstrated by existing data. Source: Mass.gov*
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 R₀:** Implement policies & procedures to reduce the rate of spread

Source: Bain Capital Partners analysis
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.
The Industry Funnel

Ability to Work From Home

<table>
<thead>
<tr>
<th>Easier</th>
<th>Harder</th>
<th>Hardest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td></td>
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<tr>
<td>Utilities</td>
<td></td>
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<tr>
<td>Education</td>
<td></td>
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<tr>
<td>Social services &amp; healthcare</td>
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</tr>
<tr>
<td>Retail (food, grocery, pharmacy)</td>
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<td></td>
</tr>
<tr>
<td>Transportation (public)</td>
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</tbody>
</table>

Typically considered critical by states

<table>
<thead>
<tr>
<th>High</th>
</tr>
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<tbody>
<tr>
<td>Information</td>
</tr>
<tr>
<td>Finance, Real estate</td>
</tr>
<tr>
<td>Professional services</td>
</tr>
<tr>
<td>Management</td>
</tr>
<tr>
<td>Wholesale</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
</tr>
<tr>
<td>Mining</td>
</tr>
<tr>
<td>Construction</td>
</tr>
<tr>
<td>Manufacturing</td>
</tr>
<tr>
<td>Administrative</td>
</tr>
<tr>
<td>Recreation</td>
</tr>
<tr>
<td>Food &amp; accommodation</td>
</tr>
<tr>
<td>Retail (discretionary)</td>
</tr>
<tr>
<td>Transportation (private)</td>
</tr>
</tbody>
</table>

% of US GDP and % of US employment

- 41% of US GDP
- 19% of US employment
- 36% of US GDP
- 39% of US employment
- 20% of US GDP
- 37% of US employment

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
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.

**MA 65+ Population Living Situation**

- Lives w/ Younger Non Relatives
- Lives w/ Younger Relatives
- Lives w/ Parent
- Lives w/ Spouse
- Lives Alone

**1,098**

- All living with younger relatives
- Est. ~20% could be living w/ younger children
- Lower risk

**Strategies for At-Risk Individuals with Family Members Returning to Work**

- Encourage workers living with at-risk individuals to strictly adhere to all policies and procedures
- **In hot spots**, could consider setting up alternative housing for at-risk individuals

Source: 2018 American Community Survey Living Arrangements of Adults 18 Years and Over By Age
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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drug Candidates</strong></td>
<td>Acute remediation</td>
<td>Prevent and treat</td>
<td>Long-term cure</td>
</tr>
<tr>
<td></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>
</tr>
<tr>
<td></td>
<td>• Favipiravir</td>
<td>• New compounds targeting</td>
<td>• RNA-based vaccines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>essential viral proteins</td>
<td>– Moderna, CureVac, BioNTech</td>
</tr>
<tr>
<td><strong>Challenges</strong></td>
<td>• Dose likely higher than existing</td>
<td>• FDA approval timelines</td>
<td>• Unknown if vaccines will need to</td>
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<tr>
<td></td>
<td>use cases, <strong>supply</strong> limited</td>
<td>are usually 30 days for testing, 3-6 months for approval</td>
<td>be seasonal (like influenza) or</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>durable long-term (like measles)</td>
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</tbody>
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**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

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

Example Early Candidates Progress

<table>
<thead>
<tr>
<th>Compound</th>
<th>Monoclonal antibodies</th>
<th>Polyclonal antibodies</th>
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<tbody>
<tr>
<td>Developers</td>
<td>VIR, Biogen, Regeneron</td>
<td>Takeda, Celltrion</td>
</tr>
<tr>
<td>Description</td>
<td>Isolated antibodies from SARS survivors, GE mice</td>
<td>Hyperimmune globulin isolated from survivor plasma</td>
</tr>
<tr>
<td>Target Trial Start Date</td>
<td>June-August 2020</td>
<td>September 2020</td>
</tr>
<tr>
<td>Additional Research</td>
<td>Can prevent short-term and treat COVID-19 patients</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>Stage</th>
<th>Duration</th>
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<tbody>
<tr>
<td>Preclinical Animal Studies</td>
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<tr>
<td>Phase I/II Clinical Trials</td>
<td>18-24 Months</td>
</tr>
<tr>
<td>Additional Clinical Trials</td>
<td>24+ Months</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>
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<tbody>
<tr>
<td>RNA</td>
<td>moderna, biontech</td>
<td>USA, DE</td>
<td>Preclinical - Clinical Ph I</td>
<td>March 2020 – June 2021</td>
</tr>
<tr>
<td>DNA/Viral</td>
<td>inovio, jenner institute</td>
<td>USA, UK, CN</td>
<td>Preclinical - Clinical Ph II</td>
<td>April 2020 – November 2020</td>
</tr>
</tbody>
</table>

Vaccine likely to take 18+ months to develop

**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>
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<tbody>
<tr>
<td>University of Oxford</td>
<td>ChAdOx1 nCoV-1</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>
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<td>Inovio</td>
<td>DNA</td>
<td>NCT04336410</td>
<td>Recruiting</td>
<td>Phase I</td>
</tr>
</tbody>
</table>

*For query:

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

<table>
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<tr>
<th>Rapid FDA Approval</th>
<th>Government Funding</th>
<th>Scale Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investigational New Drug Review</strong></td>
<td><strong>New Drug Application (NDA)</strong></td>
<td><strong>Commentary</strong></td>
</tr>
<tr>
<td>• <em>Issue:</em> Companies must wait 30 days after submission to implement trials</td>
<td>• <em>Issue:</em> FDA review of an NDA typically takes 3-6 months</td>
<td>Government action can turbocharge vaccine and therapeutic development &amp; deployment</td>
</tr>
<tr>
<td>• <em>Solution:</em> FDA should ask relevant questions before receiving IND, allow trial initiation immediately</td>
<td>• <em>Solution:</em> FDA communicate daily with relevant companies, complete NDA review within 1 week</td>
<td></td>
</tr>
<tr>
<td><strong>Purchase Guarantees</strong></td>
<td><strong>Test and Trace Funding</strong></td>
<td><strong>What we can do to help:</strong></td>
</tr>
<tr>
<td>• <em>Issue:</em> Insufficient PPE including gloves, gowns, masks, and N95s</td>
<td>• <em>Issue:</em> Hospitals, others lack supplies to conduct fastest tests</td>
<td>• Encourage frequent communication between FDA &amp; companies &amp; push for rapid FDA approval</td>
</tr>
<tr>
<td>• <em>Solution:</em> Provide companies financial guarantees above market prices, regulatory relief</td>
<td>• <em>Solution:</em> Provide funding guarantees for viral testing and serological test to detect antibodies</td>
<td>• Provide financial stability to companies scaling production</td>
</tr>
<tr>
<td><strong>Scaling Existing Production</strong></td>
<td><strong>Free Up U.S. Plant Capacity</strong></td>
<td>• Help U.S. plants be ready and able to produce therapeutic candidates</td>
</tr>
<tr>
<td>• <em>Issue:</em> Individual companies cannot produce enough of emerging therapies</td>
<td>• <em>Issue:</em> Need capacity to scale treatments prior to approval</td>
<td></td>
</tr>
<tr>
<td>• <em>Solution:</em> Facilitate manuf. of promising candidates by other U.S. drug cos</td>
<td>• <em>Solution:</em> FDA should approve new plants for the production of other medicines</td>
<td></td>
</tr>
</tbody>
</table>

New therapies and vaccines months to years off, but targeted government action can accelerate development

Source: Scientists to Stop COVID-19
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>500K</td>
<td>500K</td>
<td>500K</td>
</tr>
<tr>
<td>400K</td>
<td>400K</td>
<td>400K</td>
</tr>
<tr>
<td>300K</td>
<td>300K</td>
<td>300K</td>
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<tr>
<td>200K</td>
<td>200K</td>
<td>200K</td>
</tr>
<tr>
<td>100K</td>
<td>100K</td>
<td>100K</td>
</tr>
<tr>
<td>0K</td>
<td>0K</td>
<td>0K</td>
</tr>
</tbody>
</table>

Visualizing $R_0$

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

$R_0 = 2.4$ $R_0 = 1.0$ $R_0 = 0.8$
Potential Policies to Reduce R\textsubscript{0}

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PPE / Masks</strong></td>
<td>Mandated mask &amp; PPE use</td>
</tr>
<tr>
<td><strong>Personal Hygiene</strong></td>
<td>Frequent hand washing or sanitizing. Avoid touching eyes, nose and mouth. Good respiratory hygiene</td>
</tr>
<tr>
<td><strong>Self-Diagnosis</strong></td>
<td>Comprehensive check-list of symptoms each worker considers before leaving home</td>
</tr>
<tr>
<td><strong>Distancing / No Large Groups</strong></td>
<td>Social distancing at work where possible. Staggered shifts and lunch times</td>
</tr>
<tr>
<td><strong>Workspace Cleaning</strong></td>
<td>Frequent workplace deep cleaning. Hygiene zones with mandatory sanitization checkpoints in between</td>
</tr>
<tr>
<td><strong>Employer Screening</strong></td>
<td>Temperature measurement and symptom screening upon entry</td>
</tr>
<tr>
<td><strong>Re-designing Workspace</strong></td>
<td>Re-modeling of workspace to ensure greater spacing between employees. Improved air filtration and ventilation. Touch-free handles and interfaces</td>
</tr>
<tr>
<td><strong>Telework</strong></td>
<td>Encourage telework where possible</td>
</tr>
<tr>
<td><strong>Travel limitations</strong></td>
<td>Discourage travel unless absolutely necessary. Before traveling, ensure virus levels low at home &amp; destination</td>
</tr>
<tr>
<td><strong>Smaller Transport Methods</strong></td>
<td>Limit use of mass transit when possible. Encourage carpooling or deploy corporate vans where hygiene easier</td>
</tr>
<tr>
<td><strong>Tracing</strong></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>
<tr>
<td><strong>Testing</strong></td>
<td>6-10 centralized testing centers in MA performing 100K tests a day</td>
</tr>
</tbody>
</table>

Large variety of possible strategies to help reduce R\textsubscript{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)
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 $R_0$

![Diagram showing theoretical mask use impact on $R_0$.]

Key Considerations

- **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>

Mean 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 Gir, George Kafatos, 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 effective in lowering R<sub>0</sub>**.

---

Source: Scientists to Stop COVID-19

---

Reduce $R_0$
Temperature checks and other employer screening are useful tools when used in combination with other policies.
Potential Policies to Reduce $R_0$

- **Group A**: Masks, Self-Diagnosis and Employer Screening
- **Group B**: Testing & Tracing
Combined Testing & Tracing Program Effectiveness

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%

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.

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
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 $R_0$

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 Feretti, 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>MA Today</th>
<th>Bare Bones</th>
<th>Minimal</th>
<th>Moderate</th>
<th>Goal</th>
<th>Expansive</th>
<th>Universal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Tested</td>
<td>Those with strong symptoms, other causes ruled out in hot spots</td>
<td>Those with strong symptoms</td>
<td>Those with mild symptoms</td>
<td>Everyone every week</td>
<td></td>
<td></td>
</tr>
<tr>
<td># Tests Required / day in MA</td>
<td>~10K / day Current testing capacity</td>
<td>~20K / day</td>
<td>~50K / day</td>
<td>~100K / day</td>
<td>~1M / day</td>
<td></td>
</tr>
<tr>
<td>Cost¹</td>
<td>~$6M / month</td>
<td>~$12M / month</td>
<td>~$30M / month</td>
<td>~$60M / month</td>
<td>~$600M / month</td>
<td></td>
</tr>
<tr>
<td>% Pop. Tested</td>
<td>~50%</td>
<td></td>
<td></td>
<td></td>
<td>~7M residents × 7 days a week</td>
<td></td>
</tr>
</tbody>
</table>

**Example Countries**

- **Bare Bones**: Those with strong symptoms, other causes ruled out in hot spots.
- **Minimal**: Those with strong symptoms.
- **Moderate**: Those with mild symptoms.
- **Goal**: Expansive, Those with mild symptoms + contacts traced.
- **Expansive**: Everyone every week.

---

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

### Pros
- Detects current infection
- High throughput
- Inexpensive
- Can collect at home

### Cons
- Slow results
- Requires many swabs, limited reagents
- High throughput machines require trained technicians

### Testing Companies & Capacity

**Key Companies**
- Abbott Molecular
- BD
- BioGX
- Cepheid
- DiaSorin Molecular
- Hologic
- LabCorp
- NeuMoDx
- PerkinElmer
- Quest Diagnostics
- Quidel Corporation
- Roche Molecular Systems
- Thermo Fisher Scientific

**Full List in Appendix**

**Sample High Throughput Machines / Products**

<table>
<thead>
<tr>
<th>Company</th>
<th>Machine / Product</th>
<th>Daily Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott</td>
<td>m2000</td>
<td>470</td>
</tr>
<tr>
<td>BD / BioGX</td>
<td>BDMax Infinity</td>
<td>&gt;2,000</td>
</tr>
<tr>
<td>Cepheid</td>
<td>Panther Fusion</td>
<td>1,150</td>
</tr>
<tr>
<td>Hologic</td>
<td>288 Molecular</td>
<td>864</td>
</tr>
<tr>
<td>NeuMoDx</td>
<td>COBAS 8800</td>
<td>4,128</td>
</tr>
<tr>
<td>Roche Fisher</td>
<td>TaqPath Labs incl. Quest, LabCorp, etc.</td>
<td></td>
</tr>
<tr>
<td>Thermo Fisher</td>
<td></td>
<td>752</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

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Can identify previous infections</td>
<td>• Antibodies slow to develop</td>
</tr>
<tr>
<td>• Takes seconds to test</td>
<td>• Unclear how protected those with antibodies are</td>
</tr>
<tr>
<td>• Doesn’t require swabs</td>
<td>• Program based on antibody testing could encourage ppl to catch virus</td>
</tr>
<tr>
<td>• Can detect previous asymptomatic cases</td>
<td>• False positives</td>
</tr>
</tbody>
</table>

**Testing Companies & Accuracy**

<table>
<thead>
<tr>
<th>Companies</th>
<th>Biotechnology</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Abbott</td>
<td>• DeepBlue Medical</td>
</tr>
<tr>
<td>• BioMedomics Inc</td>
<td>• Innovita</td>
</tr>
<tr>
<td>• Bioperfectus Technologies</td>
<td>• Premier Biotech</td>
</tr>
<tr>
<td>• Cellex</td>
<td>• Sure Biotech</td>
</tr>
<tr>
<td>• Decombio</td>
<td>• UCP biosciences</td>
</tr>
</tbody>
</table>

**Sample Test Specificity**

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

<table>
<thead>
<tr>
<th>Specificity</th>
<th>BioMedomics</th>
<th>Bioperfectus</th>
<th>DecomBio</th>
<th>DeepBlue</th>
<th>Innovita</th>
</tr>
</thead>
<tbody>
<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**

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

<table>
<thead>
<tr>
<th>Nasal or Throat Swabs</th>
<th>Saliva Tests</th>
<th>Other Emerging Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Currently most broadly administered test</td>
<td>• Recently received FDA emergency use authorization</td>
<td>• DNA test that can deliver results in 40 minutes using CRISPR</td>
</tr>
<tr>
<td>• Recommended by the CDC</td>
<td>• Minimally invasive (simply spit into vial)</td>
<td>• Take-home test – FDA recently authorized the first take-home kit; receive kit with doctor approval and mail back</td>
</tr>
<tr>
<td>• Invasive (involves a long Q-tip-like swab stuck up the nose or into the back of the throat)</td>
<td>• Can be reliably self-administered</td>
<td></td>
</tr>
<tr>
<td>• Can take 1-5 hours to run the test</td>
<td>• Requires less PPE and personnel to administer</td>
<td></td>
</tr>
<tr>
<td>• Requires a trained professional to administer</td>
<td>• Not enough information to determine accuracy, but recent studies estimate ~90% to ~95% as effective as nasal or throat swabs</td>
<td></td>
</tr>
<tr>
<td>• Can have a false-negative rate of ~30%+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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](https://covidtracking.com/data/us-daily), Mass.gov
Given shortage of testing capacity, Massachusetts should rapidly explore avenues to secure capacity.
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>Close contact</th>
<th>Non-close contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Provided direct care without PPE</td>
<td>• Provided direct care with PPE</td>
</tr>
<tr>
<td>• Lived with infected person (e.g., family)</td>
<td>• Prolonged contact but not within 6 feet of person</td>
</tr>
<tr>
<td>• Prolonged contact within 6 feet of person</td>
<td></td>
</tr>
<tr>
<td>• Direct contact (e.g. sneezed on)</td>
<td></td>
</tr>
</tbody>
</table>

• Should trace & group contacts into high, medium, and low risk buckets

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>Procedures:</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>Procedures:</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>Procedures:</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 ($R_n$)

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

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

<table>
<thead>
<tr>
<th></th>
<th>MA Today</th>
<th>Johns Hopkins Plan</th>
<th>Case-Based Build</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracers Needed</td>
<td>1,000</td>
<td>~2,000</td>
<td>~5,000-10,000</td>
</tr>
</tbody>
</table>

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

**Decentralized**

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

**Centralized**

<table>
<thead>
<tr>
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<tr>
<td>Europe</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
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<td></td>
</tr>
<tr>
<td>China</td>
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**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>WiFi</td>
</tr>
</tbody>
</table>

Companies are building surveillance tools to monitor spread of coronavirus inside offices

Sources: Financial Times, company websites
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

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

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

**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

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

**Vaccine**
Accelerate vaccine development & prepare for deployment at-scale

**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
- Acurals, Inc.
- Anatolia Geneworks
- ARUP Laboratories
- A*STAR, Tan Tock Seng Hospital of Singapore
- Assure Tech
- Atla BioSystems
- AusDiagnostics
- AutoBio Diagnostics
- Avalino Lab
- Bako Diagnostics
- Baptist Hospital Miami Pathology/Laboratory Medicine Lab
- Bector Dickinson
- Bector Dickinson, BioGx
- Beijing Deconomy Biotechnology
- Beijing Diagreat Biotechnology
- Beijing Kewei Clinical Diagnostic Reagent
- Beijing O&D Biotech
- Beroni Group
- BGI
- Biodexis
- BioMedomics
- BioMérieux
- BioMérieux/BioFire Defense
- Bioneer
- BioReference Laboratories
- Boston Children’s Hospital Infectious Diseases Diagnostic Laboratory (IDDL)
- BTNX
- Cellx
- Centers for Disease Control and Prevention
- Cepheid
- CεrTeΧ 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
- Diayme Laboratories
- Eachy Biopharmaceuticals
- Euroimmun/PerkinElmer
- Exact Sciences
- Fosun Pharma USA
- Fulgent Genomics/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
- NeumoDx Molecular
- Nirimidas Biotech
- Northwestern Medicine Diagnostic Molecular Laboratory
- Novacyt/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
- Rendi 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
- Sol Gent
- Sonic Healthcare
- Specialty Diagnostic (SDI) Laboratories
- Stanford Health Care Clinical Virology Laboratory
- SureScreen Diagnostics
- Sushou Kangsheshun Medical Technology
- TIB Molbiol Syntheselabor
- United Biomedical
- University of North Carolina Medical Center
- Vela Diagnostics
- Viraco Eurofins
- Vision Medicals
- VivaChex 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 Livanon Diagnostics

### 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

Those infected at work reach peak infectiousness during lockdown days

<table>
<thead>
<tr>
<th>day 1</th>
<th>day 2</th>
<th>day 3</th>
<th>day 4</th>
<th>day 5</th>
<th>day 6</th>
<th>day 7</th>
<th>day 13</th>
<th>day 14</th>
<th>day 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>work</td>
<td>work</td>
<td>work</td>
<td>work</td>
<td>lockdown</td>
<td>lockdown</td>
<td>lockdown</td>
<td>lockdown</td>
<td>lockdown</td>
<td>work</td>
</tr>
<tr>
<td>infected</td>
<td>latent</td>
<td>latent</td>
<td>becoming infectious</td>
<td>infectious</td>
<td>infectious</td>
<td>infectious</td>
<td>not infectious</td>
<td>not infectious</td>
<td></td>
</tr>
</tbody>
</table>

Infection on first day

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

Potential Impact

cyclic lockdown with two staggered groups of households

Staggered 4-10 cycle

Increases robustness if lockdown strictly adhered

Group A work

Group B work

Number of cases

Weeks

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 Science
European countries are starting to ease, but containment strategies appear limited, risking acceleration of the virus. This may mean a return to lockdown.
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
New Jersey has set up a ‘bulletin-board’ style platform to help match unemployed with new labor needs.

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

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

Sources: New Jersey Covid-19 Jobs Portal