The War on COVID-19

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Have assembled a team of experts to help operationalize the White House “Opening America” framework

The War on COVID-19 Roadmap

Necessary Steps to Maintain Hospital Balance and to Safely Reopen the Economy

- Prevent Hospital Overload
- Mitigate Virus Transmission

Segmentation
Implement segmentation model, sequencing segments returning to work

- **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 R_T
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*

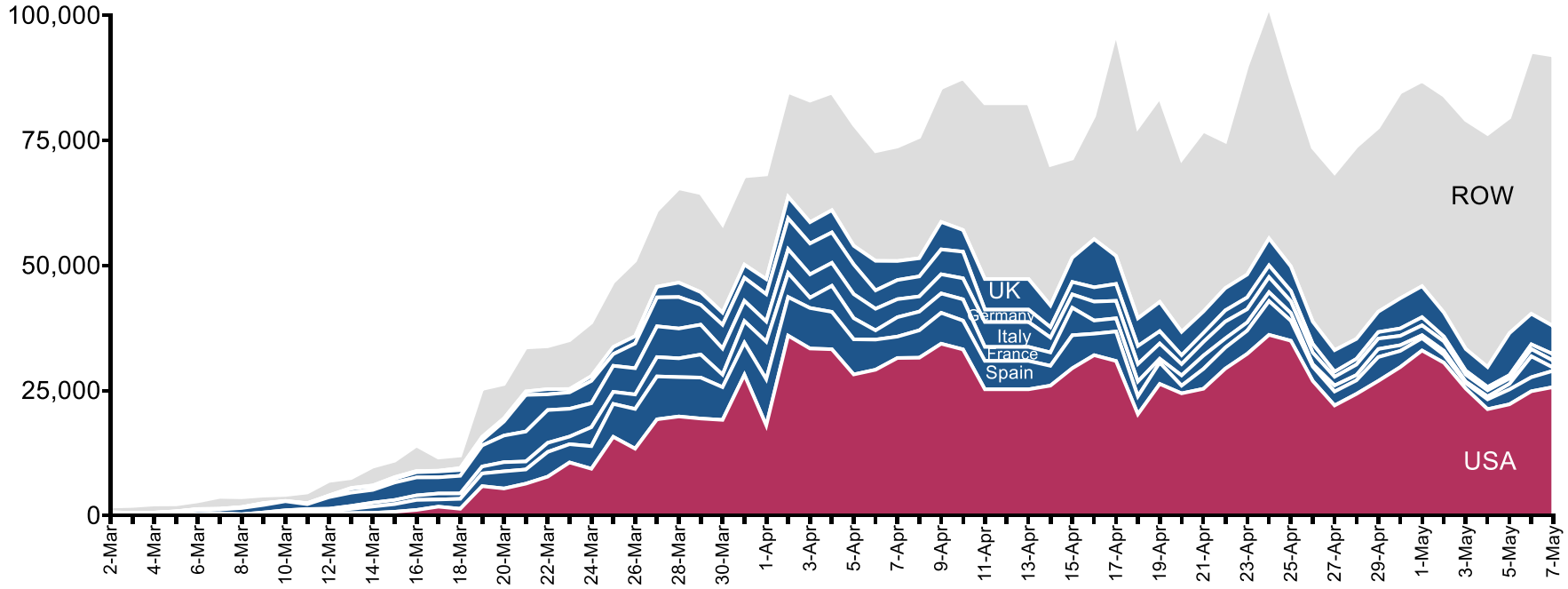
Effective implementation of (1) segmentation, (2) treatment options and (3) a strategy to reduce R_T are necessary to dampen a second major reoccurrence until a universal vaccine is available

Source: Bain Capital Partners analysis

Contents

Global COVID-19 Cases Update

Daily *New* Cases (Area of Chart = Total Cases) as of 5/7/20



3,871,718
global cases

270,279
global deaths

1,256,972
US cases

75,670
US deaths

73,721
MA cases

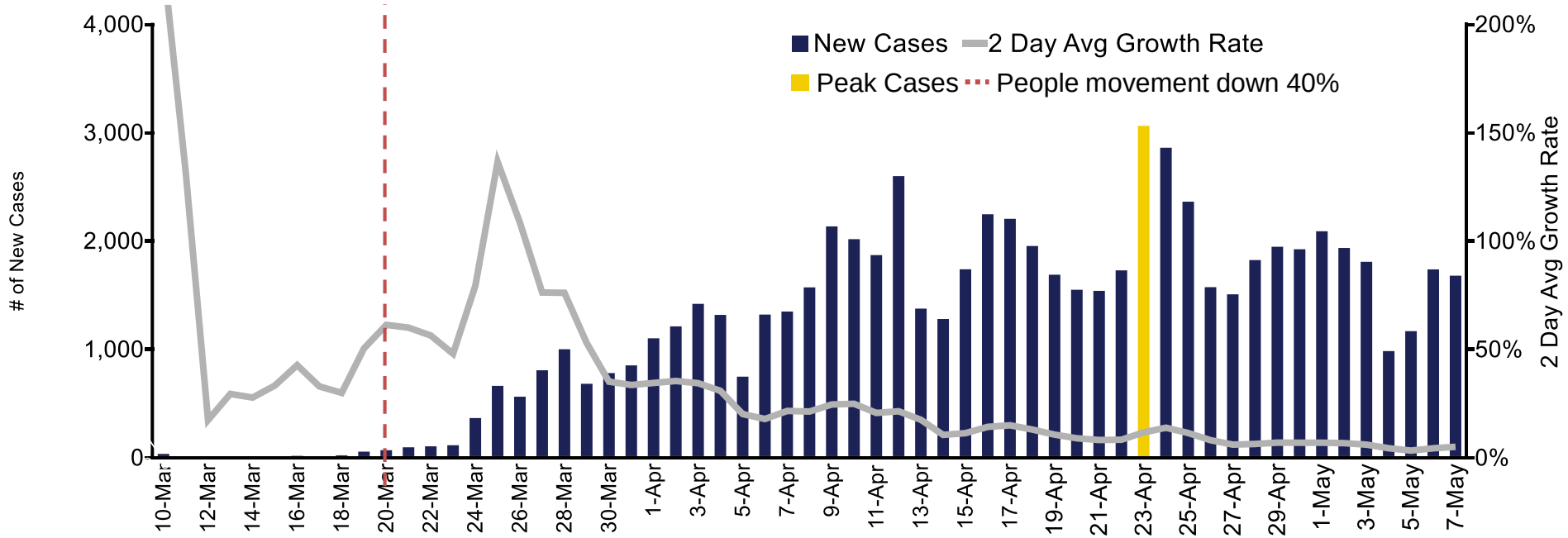
4,552
MA deaths

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

Sources: WHO situation reports, Johns Hopkins University, press search, McKinsey

Massachusetts COVID-19 Cases

# of new cases showing signs of flattening; growth rate has slowed since people movement slowed



69,087 total cases

3,446 in hospital

852 in ICU

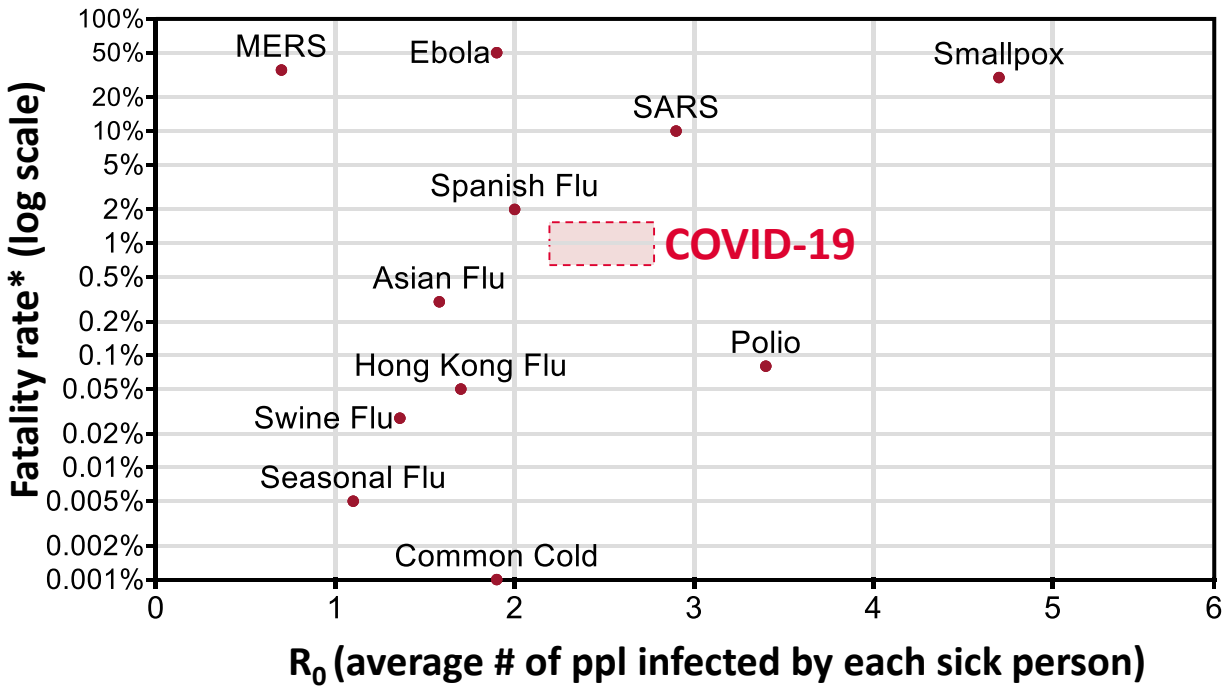
4,552 total deaths

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

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 5/7/20

Why is COVID-19 so serious?

Fatality Rate v. R_0



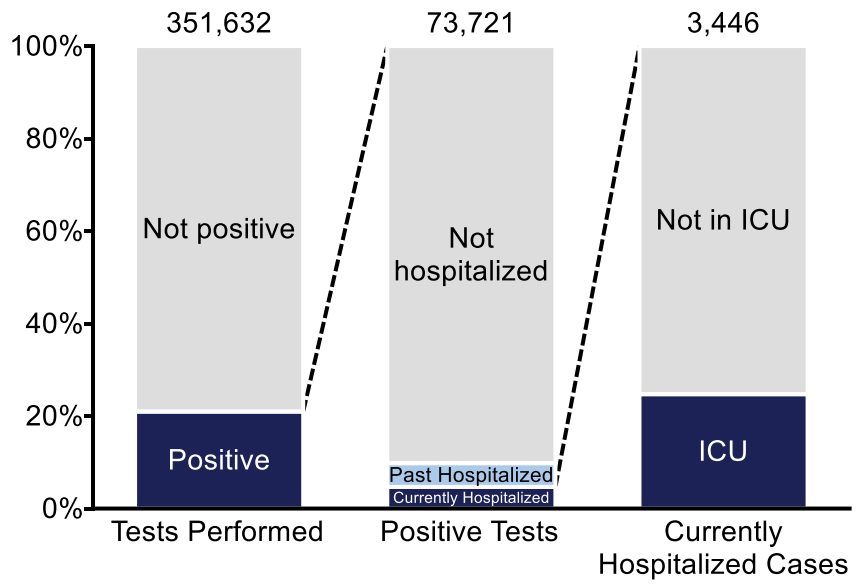
- Fundamental issue: COVID-19 has a **high fatality rate** and a **high R_0** (high rate of infection)
- Additionally, COVID-19 has a **high rate of hospitalization** (~10%+), which combined with high rate of spread creates **large tax on hospital capacity**
- Finally, COVID-19 is **indiscriminate**, causing serious long term health consequences in all ages
- In order to return to work, need to adopt policies & procedures to **reduce R_T**

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

*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

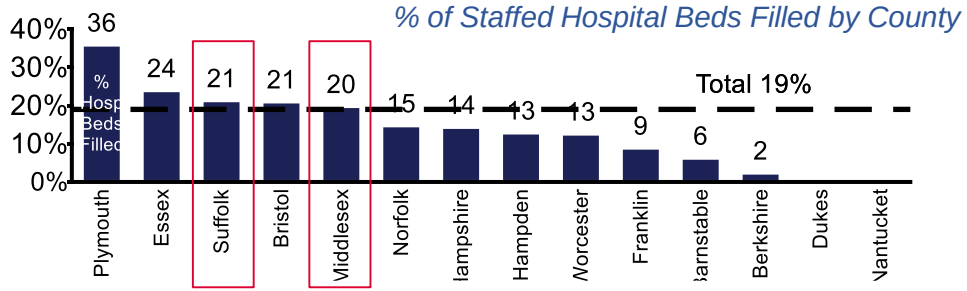
MA Hospitalization Rate & Capacity Data

MA Case Counts as of 5/7*

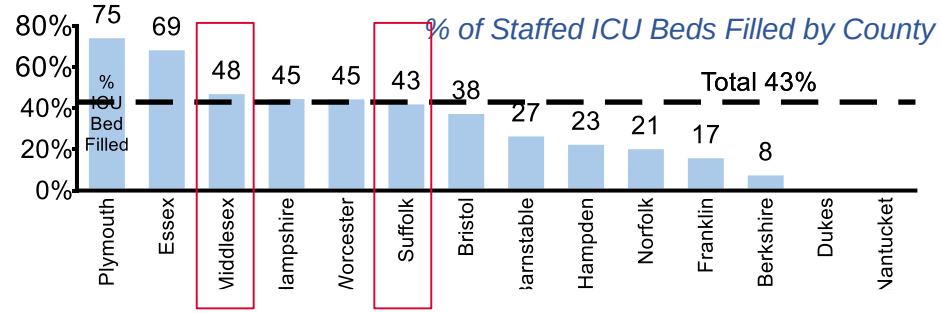


~19% of hospital beds and ~50% of ICU beds occupied with COVID-19 patients

3,539 in hospital



908 in ICU



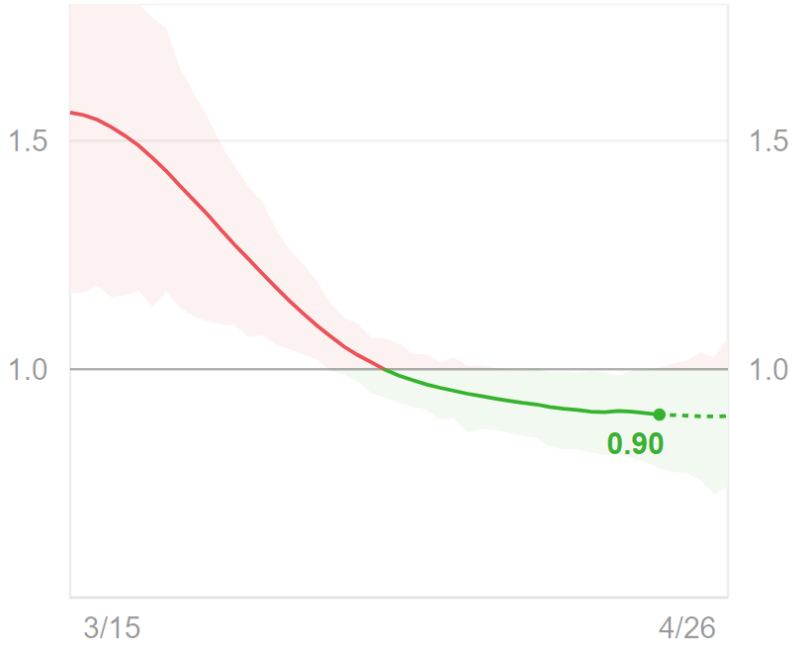
Approximately ~10% of positive cases in MA hospitalized

~19% of hospital beds and ~43% 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
Source: Mass.gov

R_T Today

Massachusetts Estimated R_T Overtime



- Social distancing & **mitigation efforts have successfully brought R_T down below 1**, controlling the outbreak
- However, these efforts are having a **significant impact on the economy**
- Goal of a "back-to-work" program to put policies & procedures in place to **keep R_T below 1** without as significant an impact on the economy

Today, MA's R_T has fallen below 1.0 – the virus is being contained. However, mitigation efforts are having a dramatic impact on the economy and thus are unsustainable

Sources: rt.live, Kevin Systrom, Thomas Vladeck, Mike Krieger, Ryan O'Rourke, Robby Stein, Thomas Dimson, Frank Dellaert, Adam Lerer. Data last updated 4/30

Economic Impact of Shutdowns

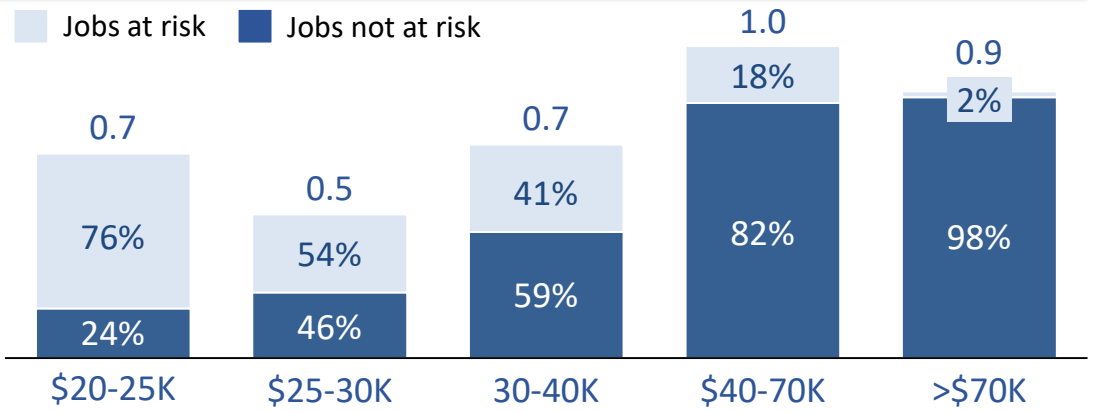
JP Morgan projecting US GDP to be down 40% QoQ in Q2; EU GDP to be down 45-55% QoQ

	Real GDP % over a year ago			Real GDP % over previous period, saar					
	2019	2020	2021	4Q19	1Q20	2Q20	3Q20	4Q20	1Q21
United States	2.3	-7.7	6.2	2.1	-10.0	-40.0	23.0	13.0	12.0
Canada	1.6	-6.9 ↓	1.9 ↓	0.3	-10.0 ↓	-30.0 ↓	12.0 ↑	5.0	4.0
Latin America	0.6	-4.5 ↓	2.4 ↑	-0.6	-5.0 ↓	-24.4 ↓	12.0	4.2 ↑	3.0 ↑
Western Europe	1.3	-7.1 ↓	6.9 ↑	0.4	-14.1 ↓	-46.6 ↓	81.3 ↑	7.8 ↑	4.4 ↑
Euro area	1.2	-7.1 ↓	6.7 ↑	0.5	-15.0	-45.0 ↓	75.0 ↑	7.0 ↑	4.5 ↑
Germany	0.6	-6.6 ↓	6.8 ↑	0.1	-12.0 ↑	-45.0 ↓	75.0 ↑	6.0 ↑	5.0 ↑
France	1.3	-8.9 ↓	7.0 ↑	-0.2	-15.0	-55.0 ↓	100.0 ↑	8.5 ↑	4.0 ↑
Italy	0.3	-8.8 ↓	5.5 ↑	-1.2	-20.0	-40.0 ↓	55.0 ↑	8.0 ↑	4.0 ↑
Spain	2.0	-8.1 ↓	5.5 ↑	1.7	-15.0	-45.0 ↓	55.0 ↑	9.0 ↑	5.0 ↑
Norway	2.4	-4.4 ↓	6.6 ↑	0.7	-16.5 ↓	-33.2 ↓	68.1 ↑	5.3 ↑	3.3 ↑
Sweden	1.3	-4.0	5.5 ↑	0.6	-9.2 ↑	-33.2 ↓	50.8 ↑	5.1 ↑	5.6 ↑
United Kingdom	1.4	-8.0 ↓	8.0 ↑	0.1	-10.5 ↓	-59.3 ↓	119.9 ↑	12.6 ↑	3.6 ↑

MA Unemployment approaching 2x+ '09 levels

'09 Peak	2/29/2020	3/7/2020	3/14/2020	3/21/2020	3/28/2020	4/4/2020	4/11/2020
5.7%	2.3%	2.1%	2.1%	2.3%	5.2%	8.7%	10.1%

MA Job Vulnerability by Income Band

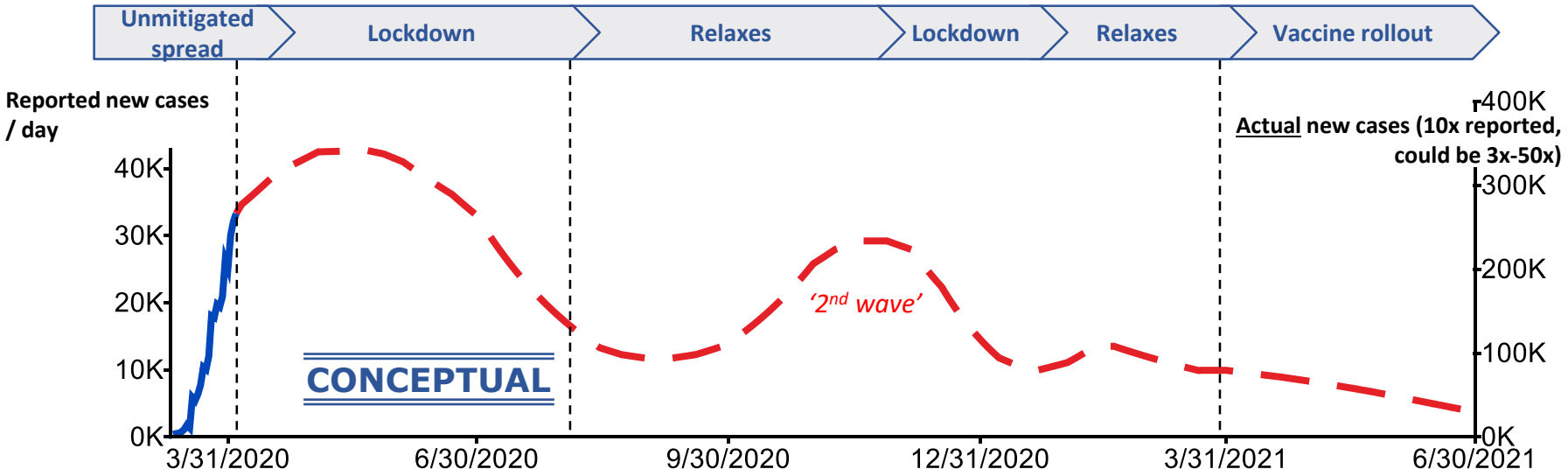


Mitigation efforts are having a significant impact on the economy, and impact is most severe in low income workers

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)

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

COVID-19 History & Economic Impact: Summary

- Global **cases and deaths continue to rise**, but the US & Massachusetts are seeing **evidence of "flattening"**
- 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. MA managing hospital capacity well so far, with **ICU beds only ~43% filled** and **total hospital patients declining** the past week
- 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**
- Need to reopen the economy, but critical to "avoid the W"

Mitigation efforts are working, but are also having a significant impact on the economy, and impact is most severe in low income workers. Need to focus on developing policies and protocols to enable a return to work while minimizing the risk of another lockdown

Source: Bain Capital Partners Analysis

Contents

The Key 3 Steps to Achieve Hospital Balance & Worker Safety

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

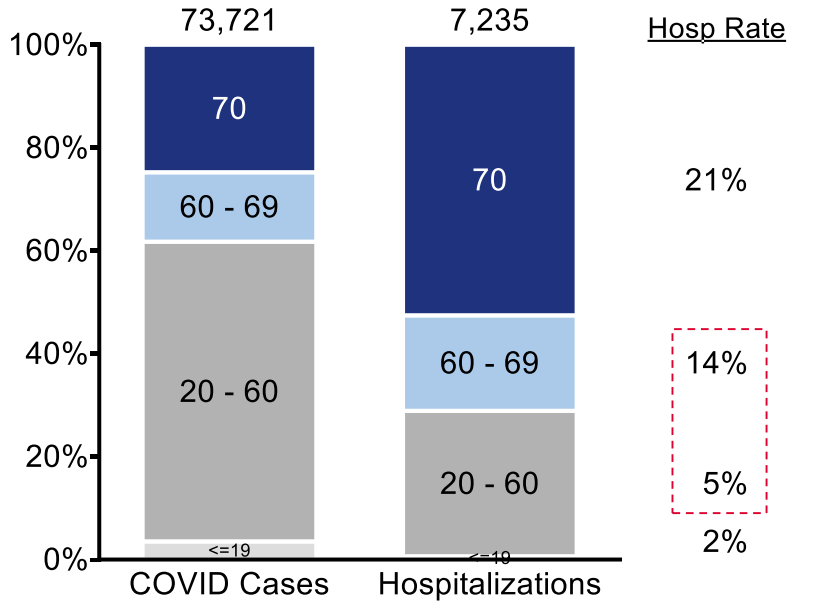
Effective Therapeutics: While waiting for vaccine, implement effective treatments to curb hospitalization rate & fatality rate

Reduce R_T: Implement policies & procedures to reduce the rate of spread

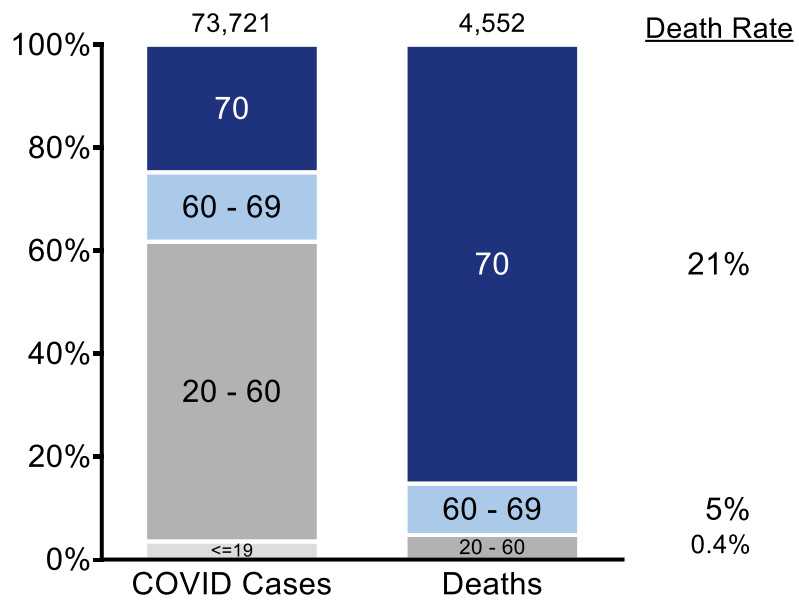
Source: Bain Capital Partners analysis

Age Segmentation

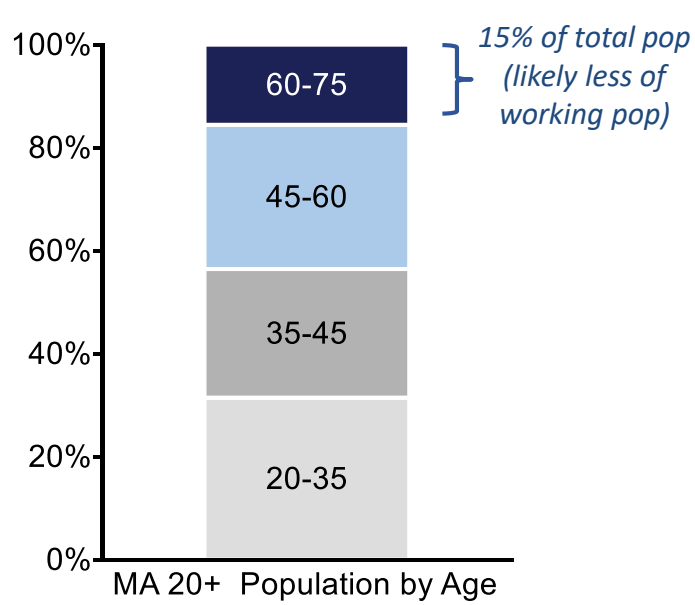
MA Hospitalization Rate by Age



MA Death Rate by Age



MA Pop. by Age



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 5/7/20

Industry Segmentation

Ability to Work From Home

Typically considered critical by states	Easier	Harder	Hardest
High		Government (2) Utilities Education	Social services & healthcare (1) Retail (food, grocery, pharmacy) Transportation (public)
Low	Information (5) Finance, Real estate Professional services Management Wholesale	Agriculture Mining Construction (3) Manufacturing Administrative	Recreation Food & accommodation Retail (discretionary) Transportation (private)
% of US GDP[1]	**41%**	**36%**	**20%**
% of US employment[1]	**19%**	**39%**	**37%**

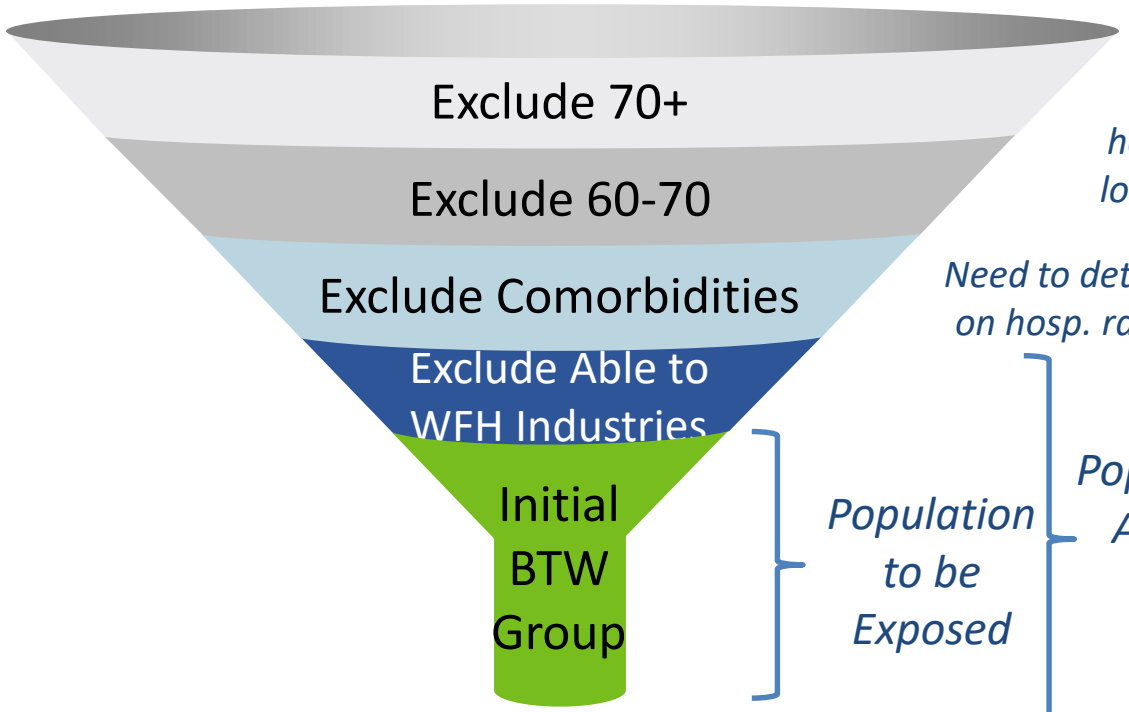
Need to Determine How To Group & Sequence Sector Reopening

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
Source: McKinsey, U.S. Bureau of Labor Statistics (CES, QCEW), Moody's Analytics

Comprehensive "Funnel Framework"



Large impact on hospitalization rate, low # of ppl excluded

Need to determine impact on hosp. rate & % of pop

Other Considerations

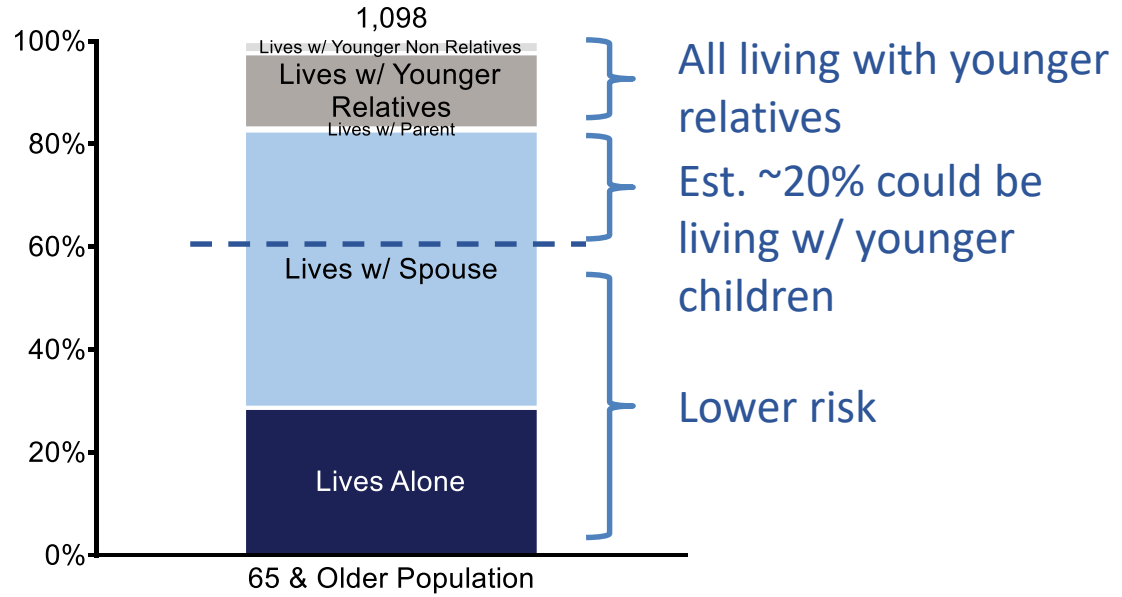
- **Returning population's exposure to excluded population:** how many excluded ppl will still be exposed by household members returning to work?
- **Nursing Homes:** how to deal with isolated high-risk populations interacting with workers?
- **Workforce enablers:** (**childcare *I* education**) – need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

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

Source: Bain Capital Partners analysis

Other Considerations: Families with At-Risk Relatives

MA 65+ Population Living Situation



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**

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

Earliest to Open → ***Latest to Open***

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

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**
- Transportation 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)

Sources: WSJ (https://www.wsj.com/articles/where-schools-reopen-distancing-and-disinfectant-are-the-new-coronavirus-routine-11586971911), CNN, NY Times, Danish ministry of education guidelines

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_T: Implement policies & procedures to reduce the rate of spread

Source: Bain Capital Partners analysis

Types of Solutions & Timeline

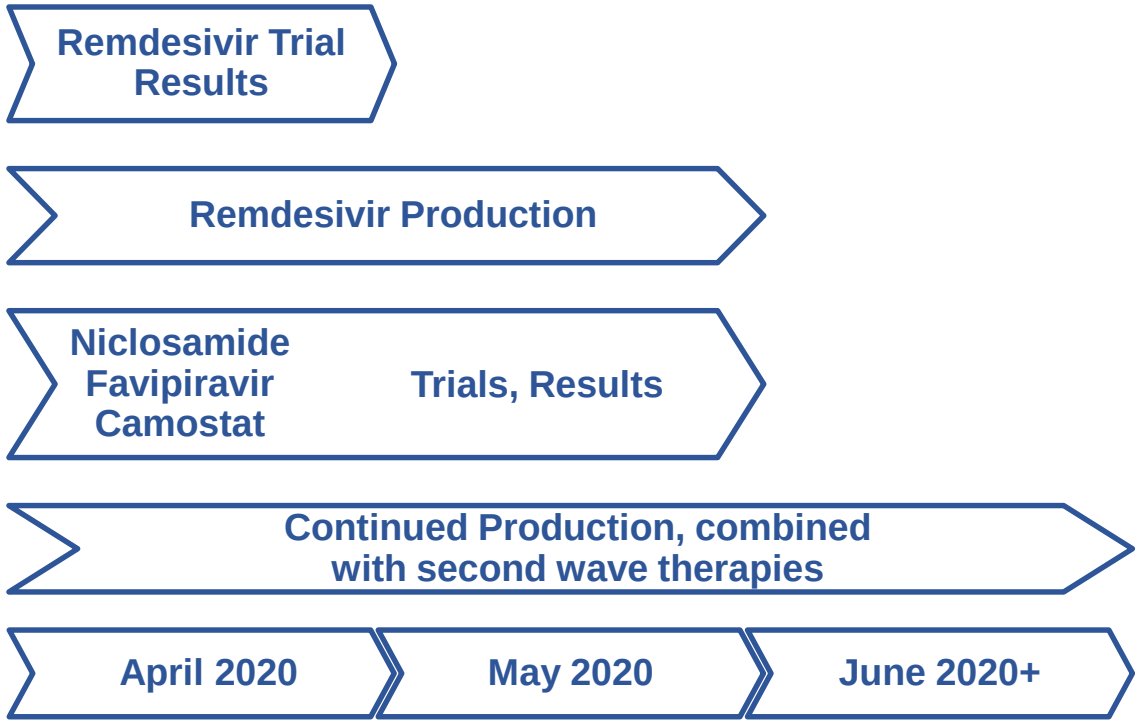
	First Wave "Repurposed" Therapeutics	Second Wave New Therapeutics	Third Wave Vaccines
Use Case	**Acute remediation**	**Prevent and treat**	**Long-term prevention**
Drug Candidates	• **Remdesivir** • Niclosamide • Favipiravir	• Human antibodies – Monoclonal and polyclonal • New compounds targeting essential viral proteins	• Inactivated virus particles • Live-hybrid viruses • RNA-based vaccines – Moderna, CureVac, BioNTech
Challenges	• **Dose** likely higher than existing use cases, **supply** limited	• **FDA approval timelines** are usually 30 days for testing, 3-6 months for approval	• **Unknown** if vaccines will need to be seasonal (like influenza) or durable long-term (like measles)
	April-June 2020	**July-September 2020**	**April 2021-April 2022+**

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



Example Early Candidates Progress

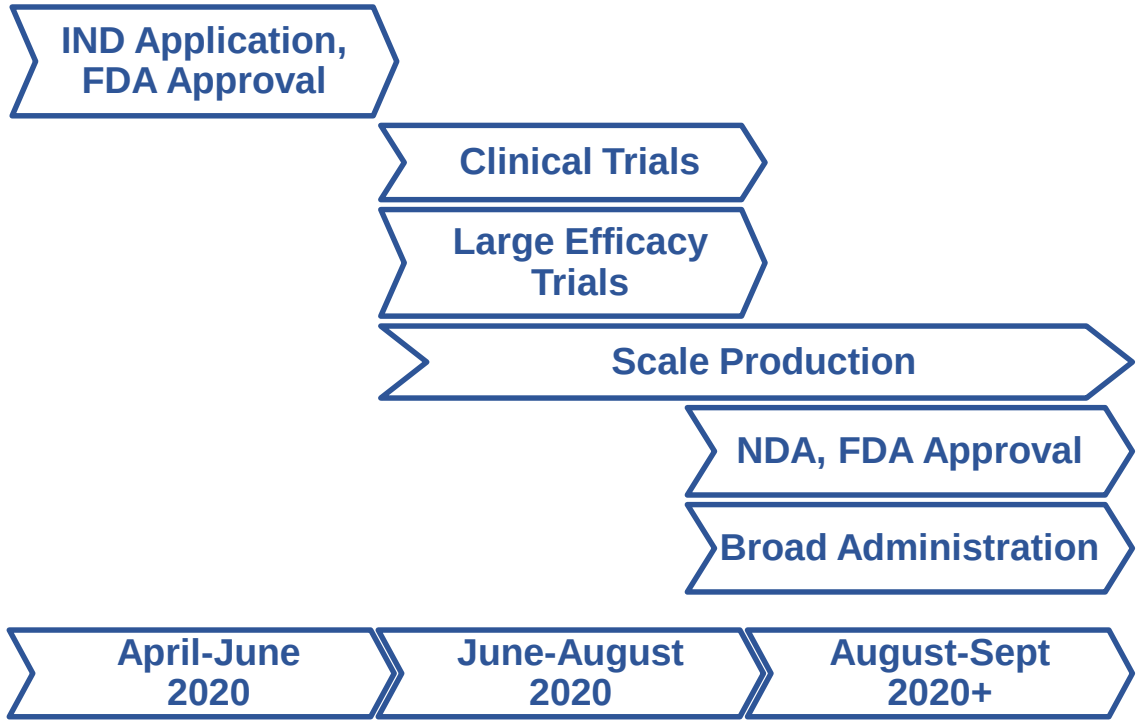
	GILEAD	FUJIFILM
US Status	**Under development** (Ebola, SARS)	**Investigational** (influenza) *approved in Japan
Use Case	Treatment	Treatment
Earliest Trial End Date	**May 2020**	**March 2020**
Initial Clinical Evidence	Positive outcomes on clinical improvement in global program	Positive results on viral load and clinical recovery in Chinese trials

With rapid FDA approval and ramped production will be available in next six to nine weeks, but limited to acute remediation

Source: Scientists to Stop COVID-19, Newpath Partners, Wang et al. Cell Research 2020, Holshue et al., New England Journal of Medicine 2020, Engineering Journal, Bain Capital Partners analysis

Second Wave – New Therapeutics

New Therapeutic Development Timeline



Example Early Candidates Progress

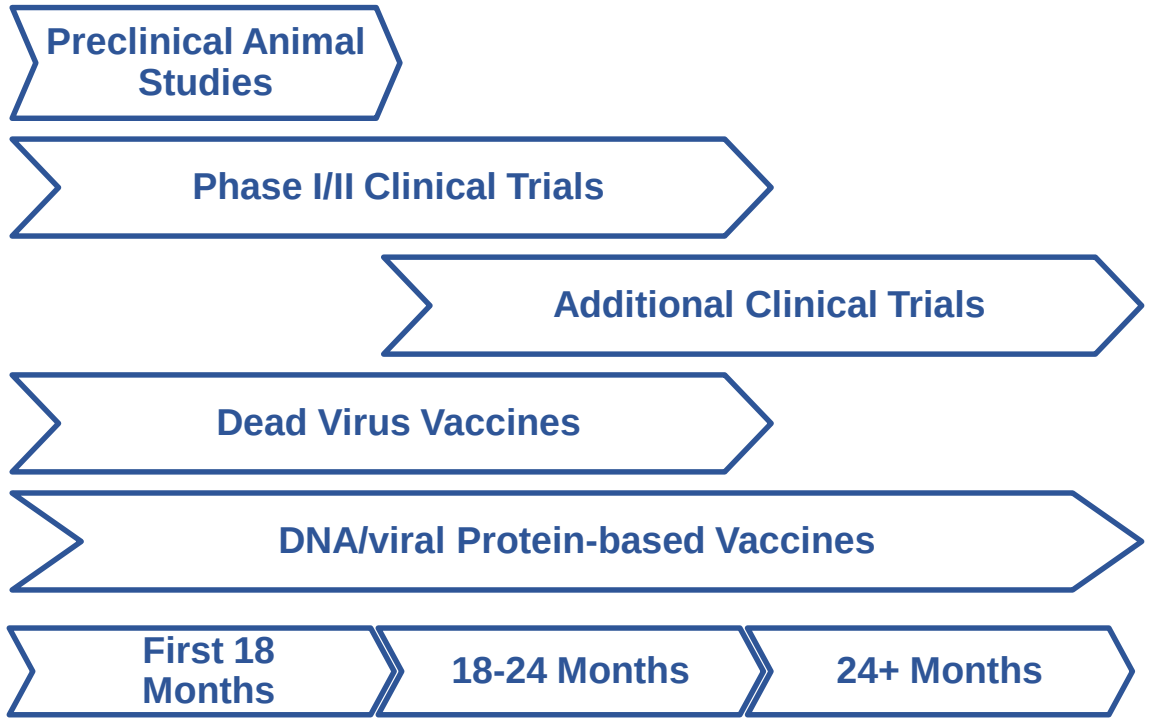
	Monoclonal antibodies	Polyclonal antibodies
Compound	**Monoclonal antibodies**	**Polyclonal antibodies**
Developers	VIR, Biogen, REGENERON	Takeda, CELLTRION
Description	Isolated antibodies from SARS survivors, GE mice	Hyperimmune globulin isolated from survivor plasma
Target Trial Start Date	**June-August 2020**	**September 2020**
Additional Research	Can prevent short-term and treat COVID-19 patients	9 candidates profiled already

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



Example Early Candidates Progress

Type	RNA	DNA/Viral
Developers	moderna messenger therapeutics; BIONTECH; StemRNA	inovio; THE JENNER INSTITUTE DEVELOPING INNOVATIVE VACCINES; CanSinoBIO
Country		
Development Phase	Preclinical - Clinical Ph I	Preclinical - Clinical Ph II
Clinical Trial Dates	March 2020 – June 2021	April 2020 – November 2020

Vaccine likely to take 18+ months to develop

Source: Scientists to Stop COVID-19, Newpath Partners, Milken Institute, BioCentury, WHO, Nature, Bain Capital Partners analysis

VACCINES

Vasudev Bailey, PhD @vasudevbailey
Zoe Guttendorf @zoeguttendorf

Vaccine	Company	Platform	Stage	Description	Location
1. mRNA-1273	Moderna	RNA	Phase I-First Patient Dosed	First to dose a human in the US. Vaccine consists of a synthetic strand of mRNA designed to elicit an immune response to produce antibodies against SARS-CoV-2	
2. Ad5-nCoV	CanSino Bio	Non-Replicating Viral Vector	Phase I	Benefits from previous success in the Ebola virus (time to market -3 years). The vaccine being developed is based on viral vectors (adenoviruses) to deliver antigens to express the SARS-CoV-2 spike protein	
3. ChAdOx1 nCoV-19	University of Oxford	Non-Replicating Viral Vector	Phase I/II	Enrolling 500+ inviduals to test its vaccine candidate, which uses a non-replicating virus to deliver RNA into cells.	
4. LV-SMENP-DC	Shenzhen Geno-Immune Medical Institute	Lentiviral	Phase I/II	Begun early testing of its vaccine candidate. The vaccine uses a lentiviral vector to deliver Covid-19 minigenes to modify dendritic cells and activate T cells.	
5. BCG Vaccine	Research Group, Netherlands	Live Attenuated Virus (LAV)	Phase II/III	Repurposing the BCG vaccine, orginally for TB, to fight SARS-CoV-2 in healthcare workers at high risk of infection. 1,000 individuals will be enrolled across 8 hospitals to receive the vaccine or placebo.	
6. BCG Vaccine	Murdoch Children's Research Institute	Live Attenuated Virus (LAV)	Phase II/III	The BRACE trial will conduct a randomized, multi-center study of the TB vaccine in 4,000 healthcare workers across Australia.	

*Trial sponsor

Source: FDA, WHO, company websites, news. Available upon request.

Vaccine Candidates

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Currently in early development (preclinical)

SARS-CoV-2 vaccines currently in clinical trials

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

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

How to Accelerate Therapeutic Development

Rapid FDA Approval

Investigational New Drug Review

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

New Drug Application (NDA)

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

Government Funding

Purchase Guarantees

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

Test and Trace Funding

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

Scale Production

Scaling Existing Production

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

Free Up U.S. Plant Capacity

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

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

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

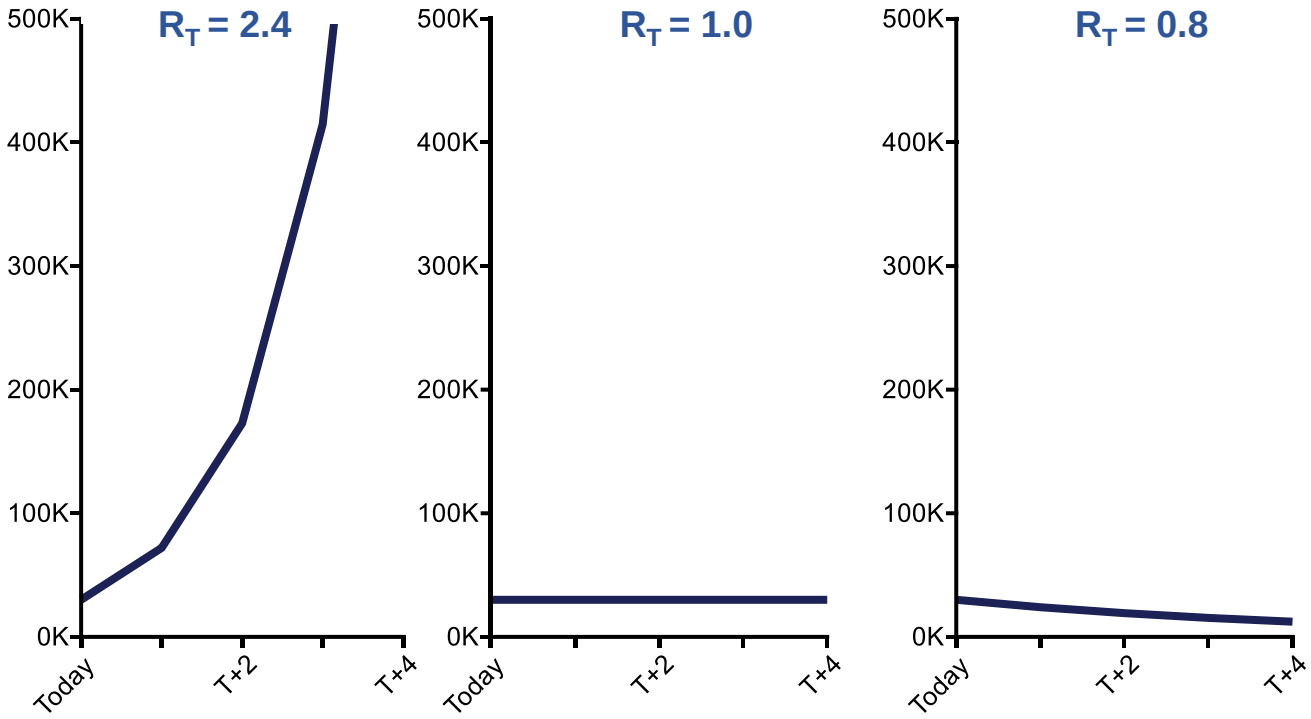
Effective Therapeutics: While waiting for vaccine, implement effective treatments to curb hospitalization rate & fatality rate

Reduce R_T: Implement policies & procedures to reduce the rate of spread

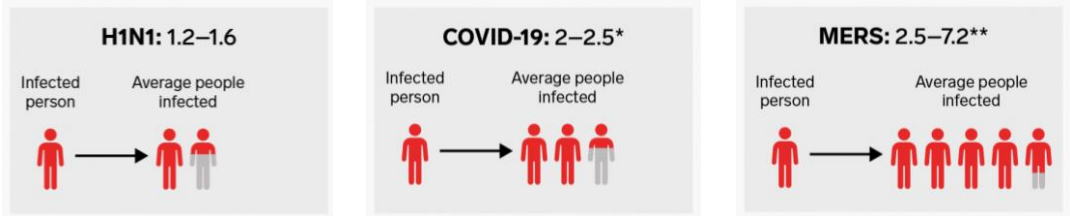
Source: Bain Capital Partners analysis

Reducing R_T: Why It Matters

MA New Cases Under Different R_T



Visualizing R_T



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_T

Less Expensive ↕ More Expensive

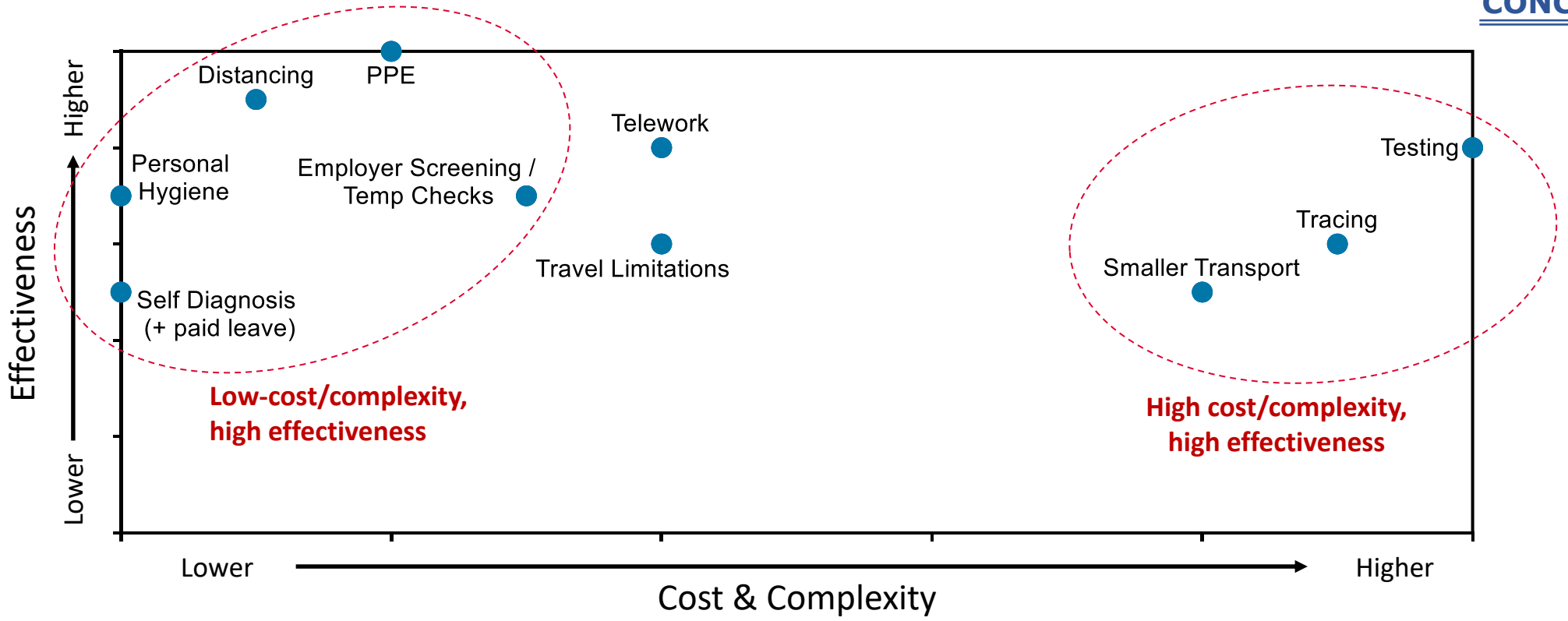
Group A	**PPE / Masks**	Mandated mask & PPE use
	Personal Hygiene	Frequent hand washing or sanitizing. Avoid touching eyes, nose and mouth. Good respiratory hygiene
	Self-Diagnosis	Comprehensive check-list of symptoms each worker considers before leaving home
	Distancing / No Large Groups	Social distancing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

Large variety of possible strategies to help reduce R_T – 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

Framework for Possible Workplace Norm Policies

CONCEPTUAL



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

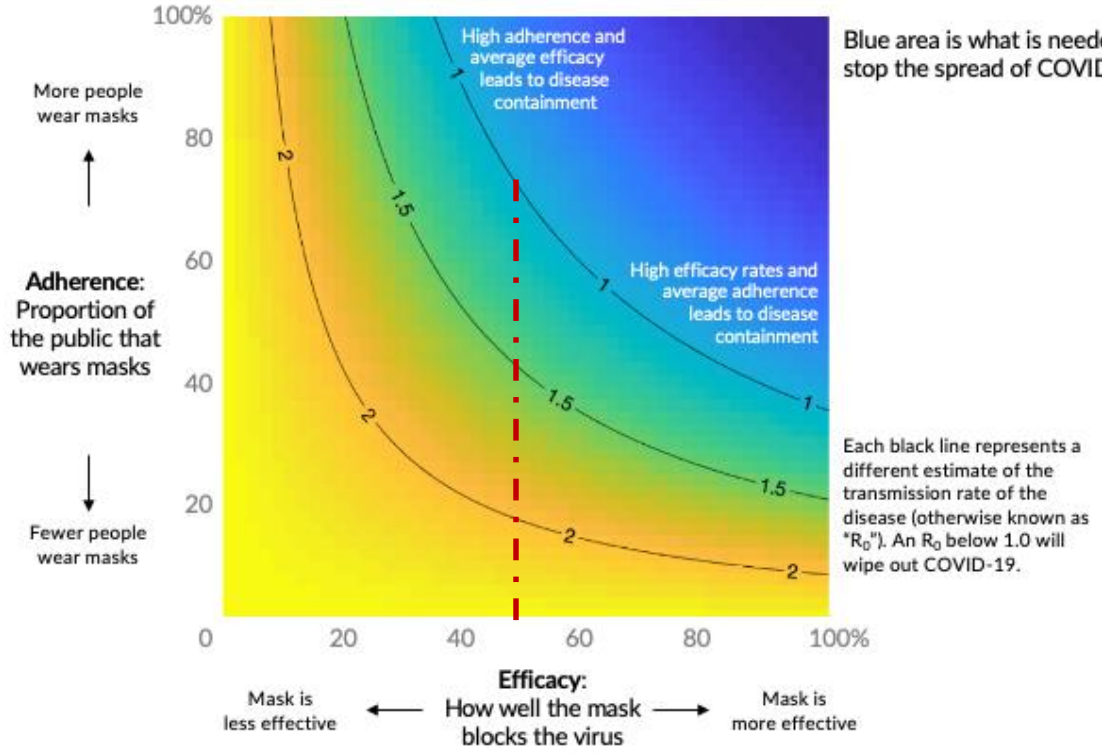
Source: Bain Capital Partners Analysis

Potential Policies to Reduce R_T

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

Theoretical Effectiveness of Masks & PPE

Theoretical Mask Use Impact on R_T



Key Considerations

- **Adherence:** Higher adherence, even with less effective masks, can greatly reduce R_T. 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

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

Scarf	100% Cotton Masks	Tea Towel	Surgical Masks	N95
49%	51%	72%	89%	95%+

Widespread use of masks, even lower quality cloth masks, can have a significant impact on R_T

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 Kafatos, Jimmy Walker, Allan Bennett

Self-Diagnosis

Daily Symptom Checklist

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

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_T**

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

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_T 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_T

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

Testing & Tracing: Summary

- Testing and tracing can have a **large impact on reducing R_T** (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

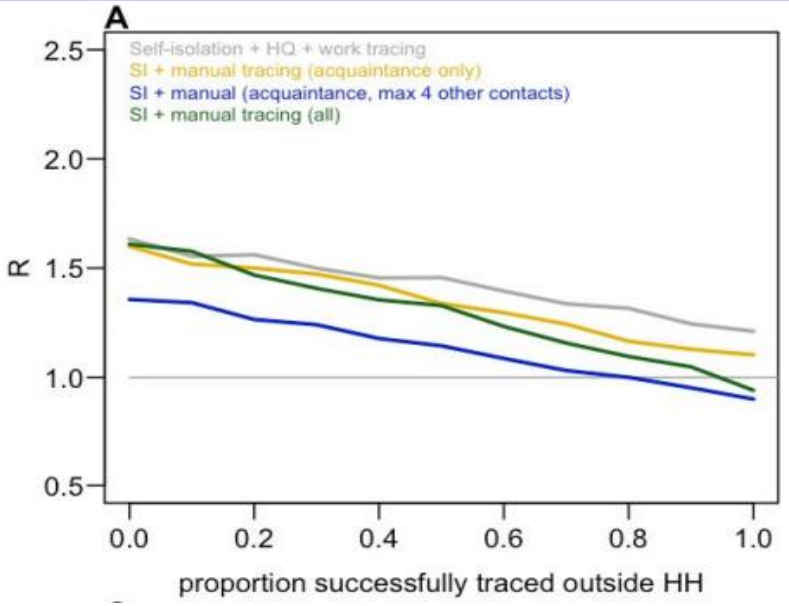
- To accurately capture all cases & test contacts, will need **~100K tests/day**. MA capacity slowly ramping (achieving ~10-15K / day currently). Need to **rapidly explore avenues** to performing ~100K tests / day, as **ramping will likely take ~6-8 weeks post-contract**

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

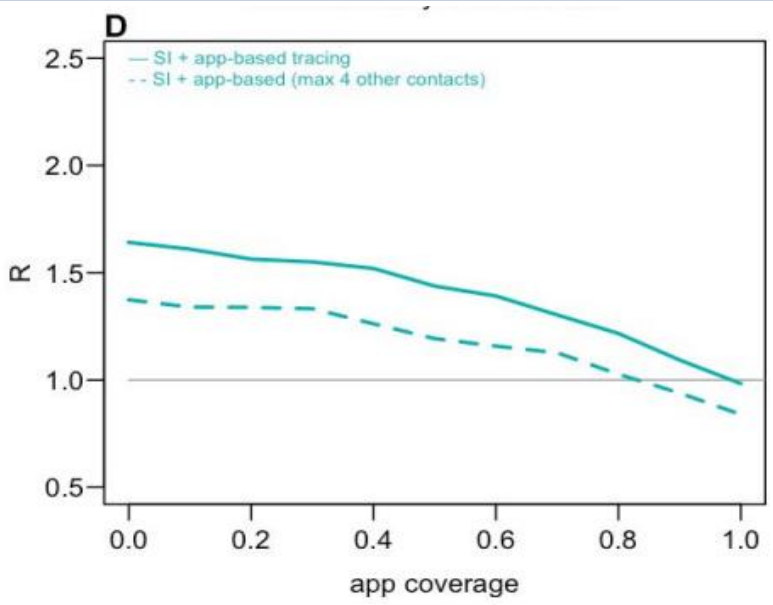
Source: Bain Capital Partners Analysis

Combined Testing & Tracing Program Effectiveness

Impact of Testing & Manual Tracing



Impact of Testing & App-Based Tracing



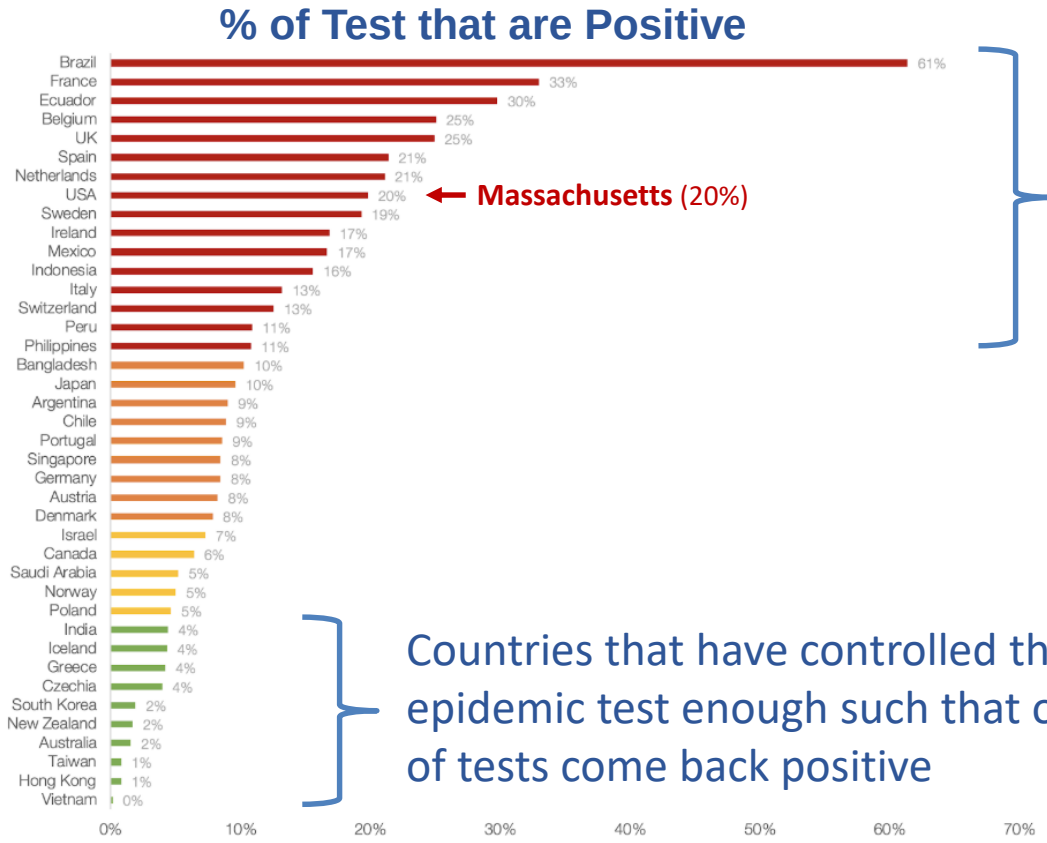
Study Conclusions

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

Testing and tracing strategies can *more than double* the impact on R_T 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



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

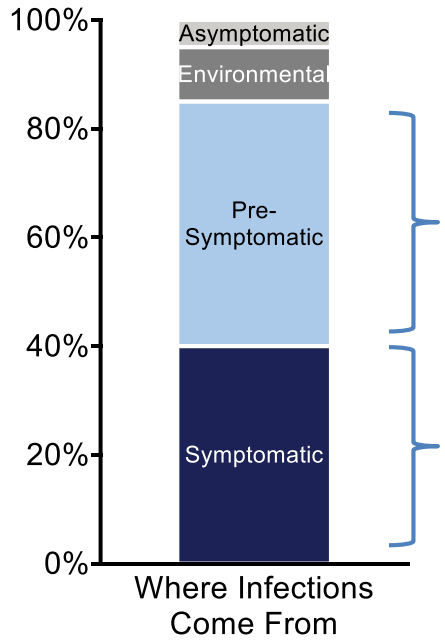
Countries that have controlled the epidemic test enough such that only ~3% of tests come back positive

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



45% of infections come from **pre-symptomatic** carriers

Only **40%** of infections come from **symptomatic** carriers

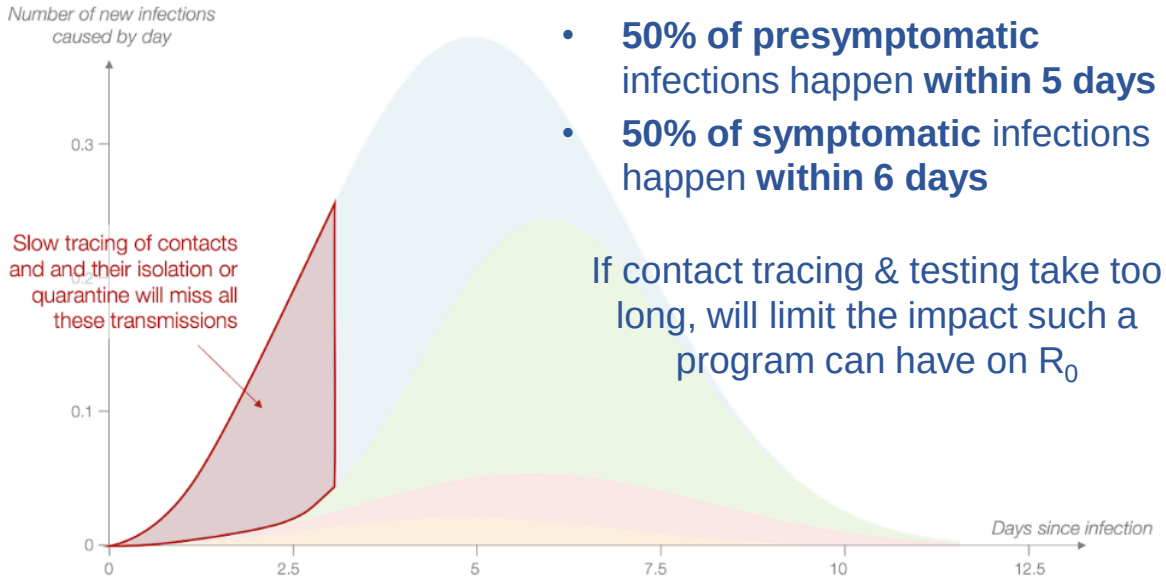
- If we **only test and isolate people with symptoms**, we can reduce R_T by **40% at most** – this will not be effective enough on its own
- If we also **trace contacts and test them**, possible to also catch the pre-symptomatics, **reducing R_T by up to 85%**

Recent research suggests ~45% of infections are caught from pre-symptomatic carriers
If only test symptomatic individuals, can only reduce R_T by 40%. But a combined testing & tracing program that catches asymptomatic carriers can reduce R_T 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 Univeristy, Tomas Pueyo

The Importance of Speed

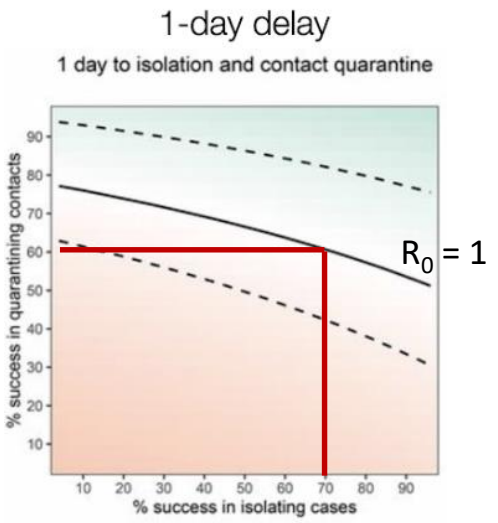
How Quickly Infections Happen



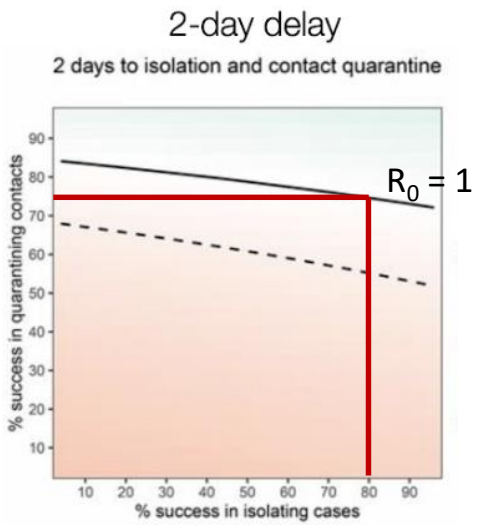
- **50% of presymptomatic** infections happen **within 5 days**
- **50% of symptomatic** infections happen **within 6 days**

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_T



If testing & tracing happens within 1 day, only need to successfully isolate **70% of cases & 60% of infected contacts to reduce R_T below 1**



But if takes 2 days to test & trace, will need to successfully isolate **80% of cases & 75% of infected contacts to reduce R_T below 1**

Speed is vital – the larger the delay between onset and successfully testing & tracing, the lower the impact on R_T. 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 Univeristy

Testing: Who to Test

Possible Testing Plans

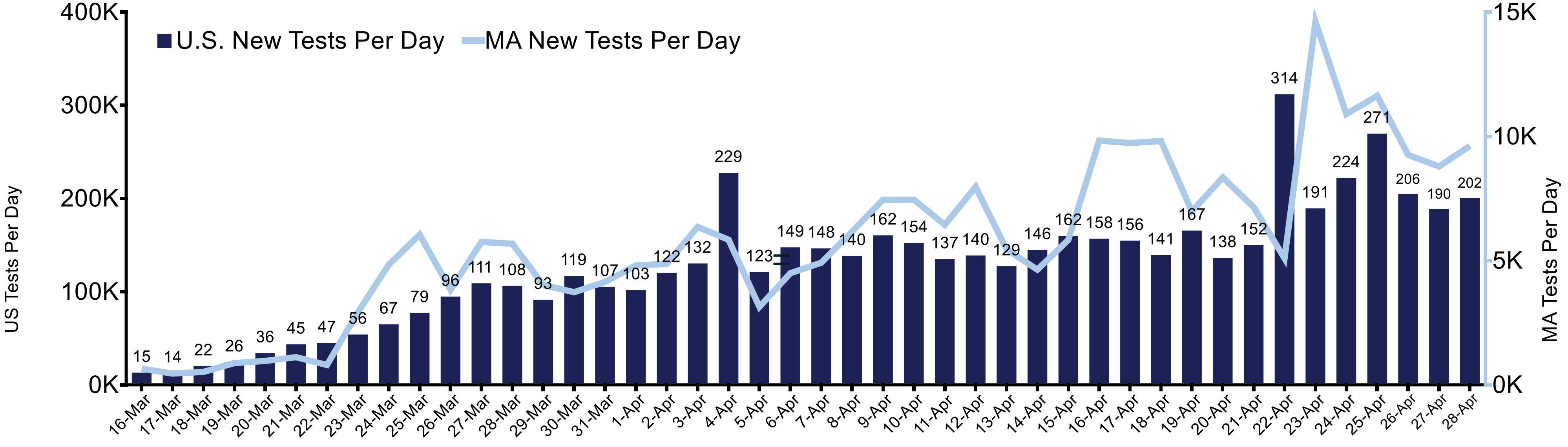
	MA Today	Bare Bones	Minimal	Moderate	Goal Expansive	Universal
Population Tested		Those with strong symptoms, other causes ruled out in hot spots	Those with strong symptoms	Those with mild symptoms	Those with mild symptoms + contacts traced	Everyone every week
# Tests Required / day in MA		**~10K / day** *Current testing capacity*	**~20K / day** *~1,500 positives @ 8% detection rate*	**~50K / day** *~1,500 positives @ 3% detection rate*	**~100K / day** *~1,500 positives @ 3% detection rate + 30 contacts/positive*	**~1M / day** *~7M residents ÷ 7 days a week*
Cost[1]		**~$6M / month**	**~$12M / month**	**~$30M / month**	**~$60M / month**	**~$600M / month**
% Pop. Tested						100% / 0%
Example Countries						

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

Current Testing Capacity

New Tests Per Day



Avg. US Tests/1K	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.6
Avg. MA Tests/1K	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.7	0.7	0.8	0.7	0.7	0.6	0.6	0.6	0.7	0.8	0.8	0.7	0.7	0.6	0.8	0.9	1.0	1.0	1.1	1.0	0.9	0.8	1.0	1.2	1.4	1.3	1.2	1.1	1.0	1.3	1.5	1.8	1.5	1.4	1.3

Per Capita Testing

Week of 4/25

1,485,717
US tests

64,714
MA tests

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

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**

Individual goes to local facility to get tested

Test sent to one of 6-10 centralized testing centers to take advantage of scale

Results delivered same-day or next-day

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 → Less expensive & easy

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

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 We Need to Trace?
Extensive tracing of 70-90% of contacts needed to slow spread

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

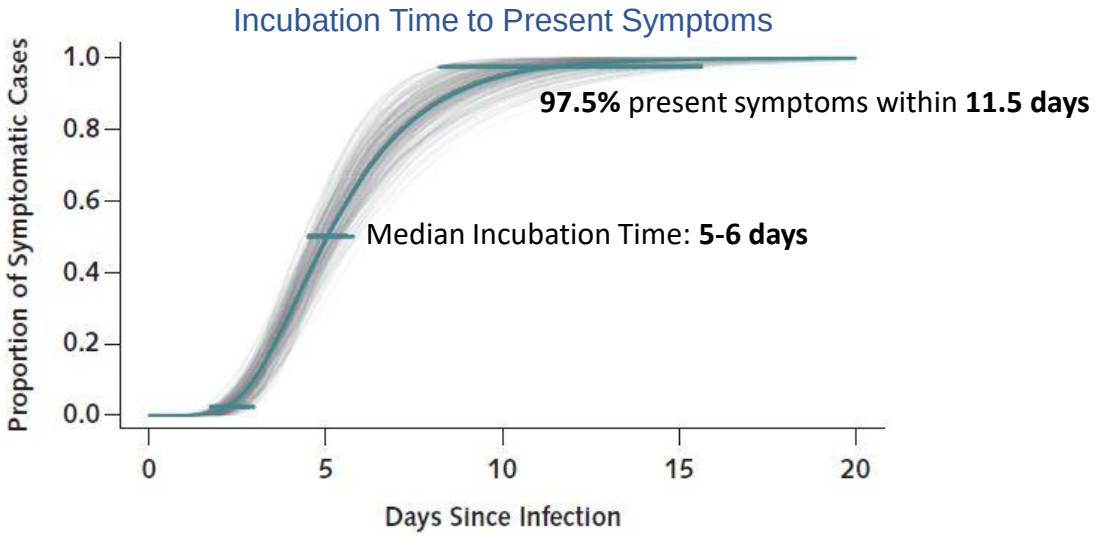
5. How Do We Use Technology to Help?
Digital tracing can increase efficacy considerably

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

High

Close contact

- Provided direct care **without PPE**
- **Lived with** infected person (e.g., family)
- Prolonged contact **within 6 feet of person**
- Direct contact (e.g. sneezed on)

Medium

Non-close contact

- Provided direct care **with** PPE
- Prolonged contact but **not within 6 feet of person**

Low

Transient interactions

- Walking by the case
- Briefly in same room
- Exposure for less than 15 minutes

- 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?

Example Case Study: Canadian Guidelines

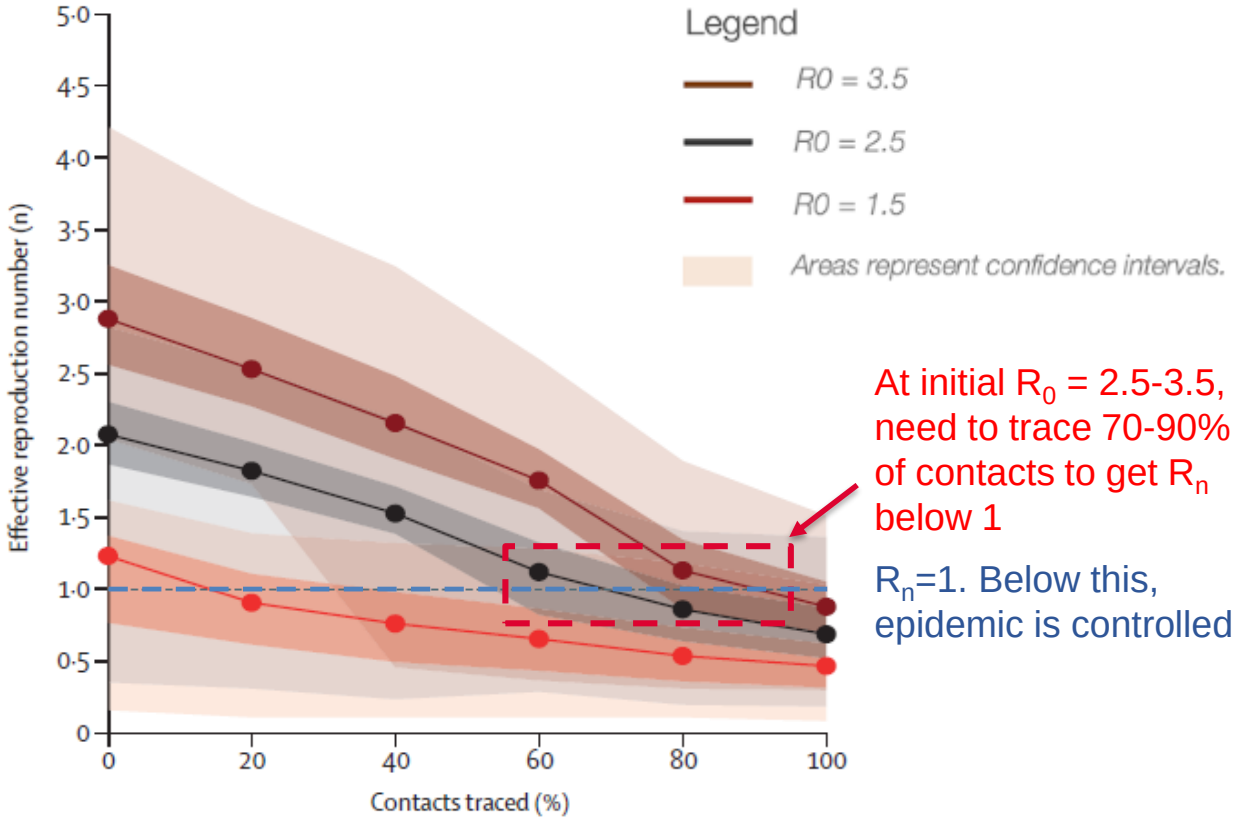
	High Risk	Medium Risk	Low Risk
Example	Family Member	Provided direct care while wearing PPE	Walked by on street
Procedures	• Quarantine at home for 14 days after exposure • Practice good hand hygiene and respiratory etiquette • Self-monitor for symptoms such as fever or cough • Record temperature daily	• Self-monitor for symptoms such as fever or cough • Avoid close contact with individuals at higher risk for severe illness • Follow actions recommended for entire population	• Follow actions recommended for entire population

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 We Need to Trace?

Impact of Tracing on Reproduction Rate (R_T)



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

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_T 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

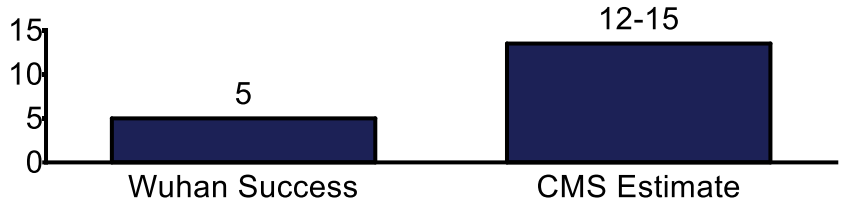
Sources: Tomas Pueyo, "Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts", Joel Hellewell, Sam Abbott, Amy Gimma, Nikos I Bosse, Christopher I Jarvis, Timothy W Russell, James D Munday, Adam J Kucharski, W John Edmunds, Centre for the Mathematical Modelling of Infectious Diseases COVID-19 Working Group, Sebastian Funk, Rosalind M Eggo

How Many Investigators Do We Need?

Case-Based Manual Tracers Estimate

Tracers Needed Per Case

# of tracers needed to clear one case per day

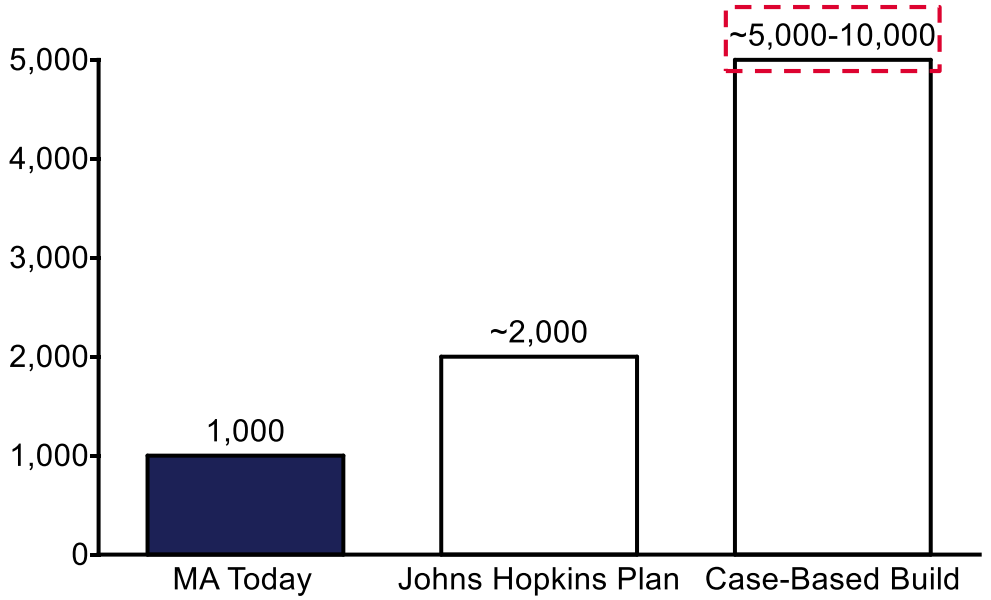


Framing Equations

# 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

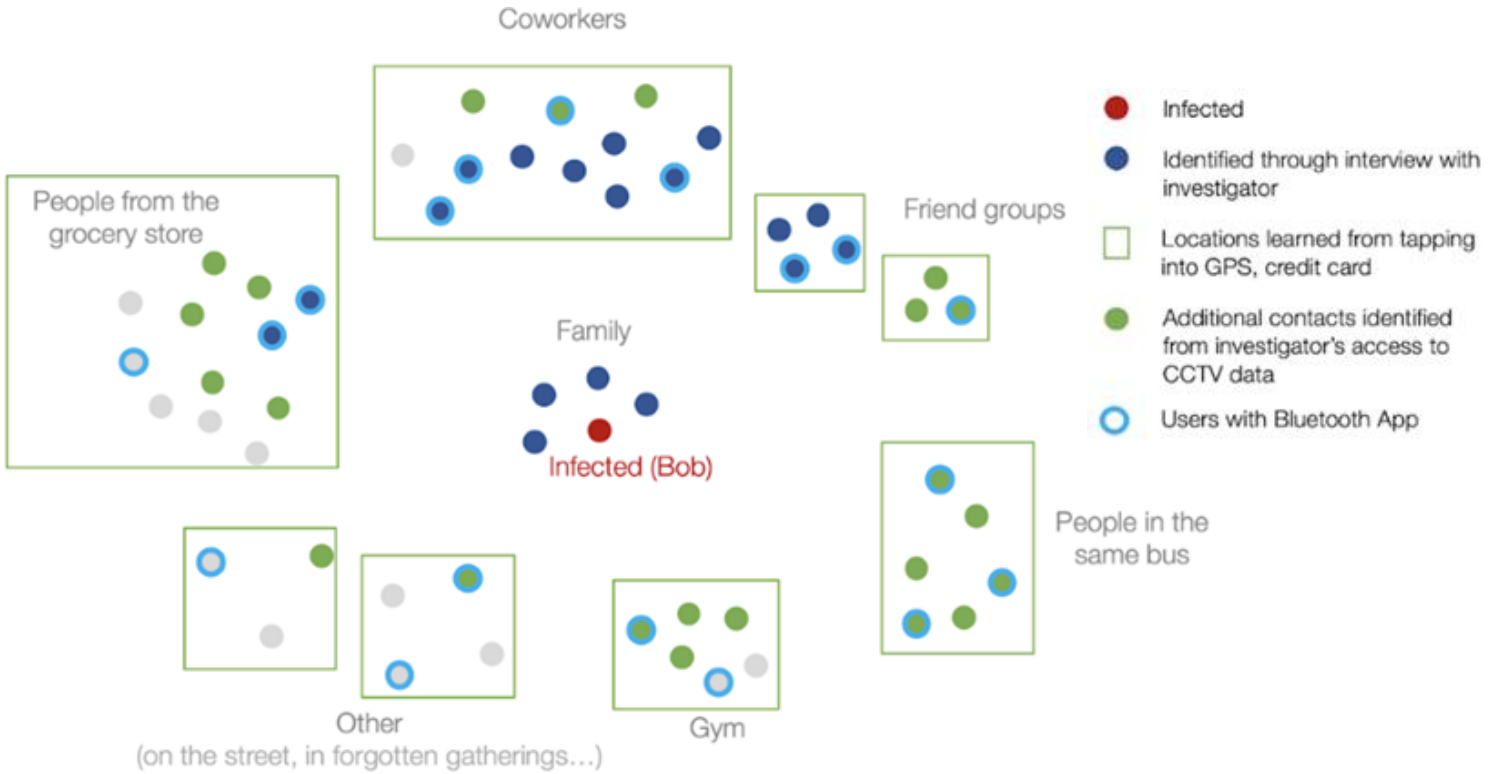


MA may need up to ~5-10K contact tracers

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

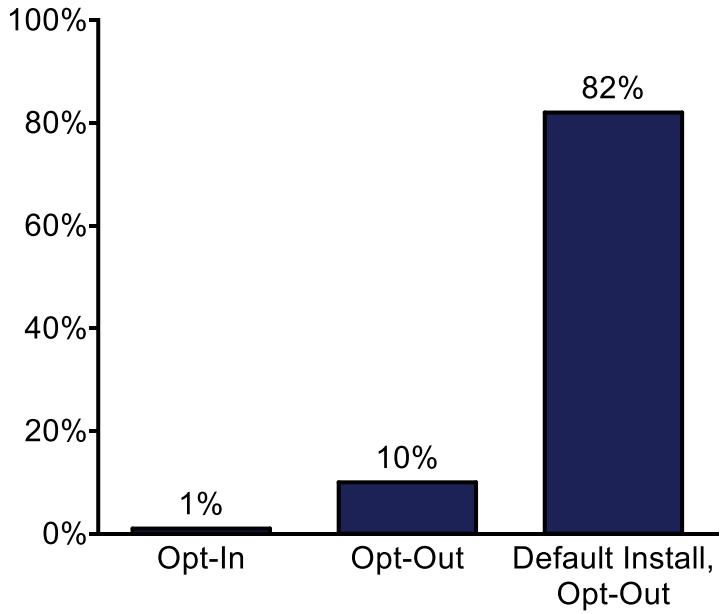
How Do We Use Technology to Help?

Illustrative Contacts Identified through Manual Interview and Digital Tracing



Opt-In vs. Opt-Out Bluetooth App

Share of contacts sent to investigators

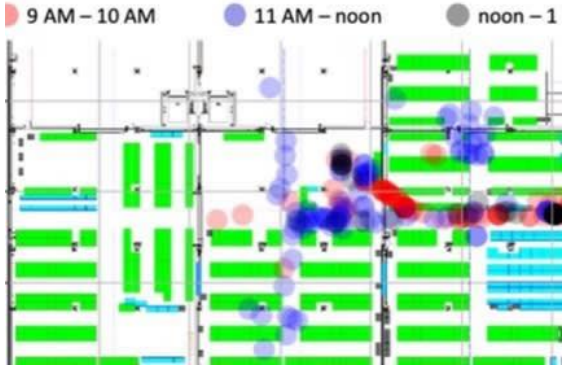


Will be difficult to identify 70-90% of contacts with manual tracing alone. Digital tracing can help manual tracers identify far more contacts, particularly with opt-out Bluetooth apps

Sources: Tomas Pueyo

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

	pwc	microshare	LOCIX
Devices Used	Smartphone app	Badges, key rings, and wristbands	Smartphones, IoT sensors, asset trackers, appliances
Technology Used			

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

Sources: Financial Times, company websites

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

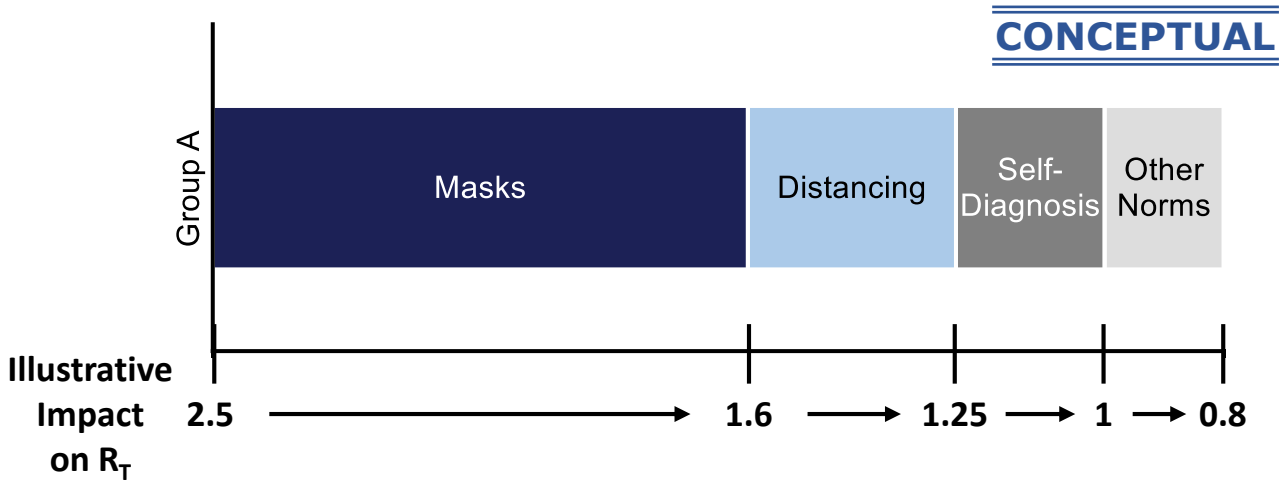
- Afford employees a **safe working environment** by adopting and enforcing scientifically-based work rules & providing appropriate supplies & support
- Align work rules & practices with **guidelines from the cognizant federal, state, and local authorities**
- Comply with federal, state, and local **laws 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

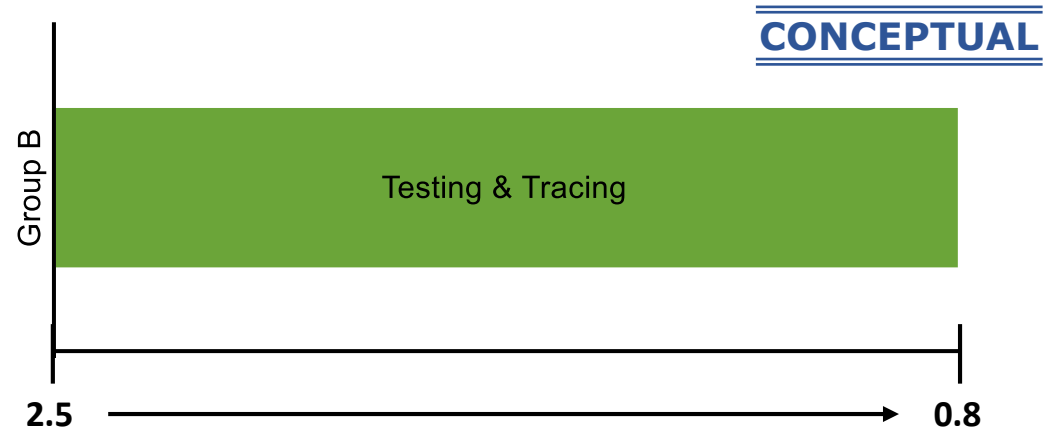
Reducing R_T Summary Thought Model

Impact of Workplace Norms



- Workplace norms such as universal mask wearing, distancing and self-diagnosis can significantly reduce R_T

Impact of Testing & Tracing



- A robust testing & tracing program (~100K tests/day, 5-10K tracers + digital tracing) can have a similar impact on reducing R_T as workplace norms

Source: Bain Capital Partners analysis

Contents

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 currently managing hospital capacity well, with **ICU beds only ~46% 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

Having policies and protocols in place not enough – need to also build a dynamic hospital capacity / demand model to ensure hospital capacity remains balanced with demand and minimize the risk of another lockdown

Source: Bain Capital Partners Analysis

Determining When to Reopen

Supply

- Availability of supply inputs: **beds, HC workers**
- Timeline & supply of **therapeutic options**
- System readiness for policies to reduce R_T (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**

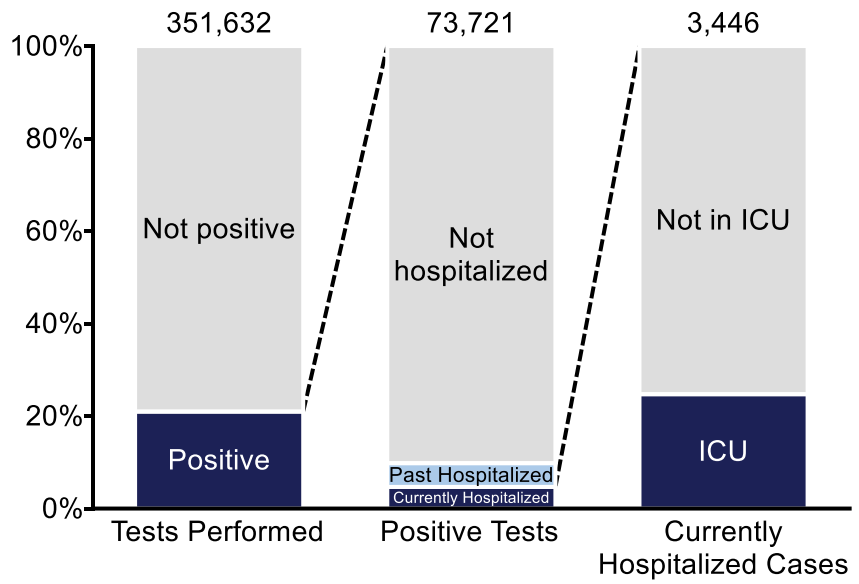
Need to model out supply and demand and reopen with a buffer on total capacity utilization

Source: Mass.gov (https://www.mass.gov/doc/hospital-bed-availability-april-17-2020/download), press search, CNN

MA Hospitalization Rate & Capacity Data

RECALL

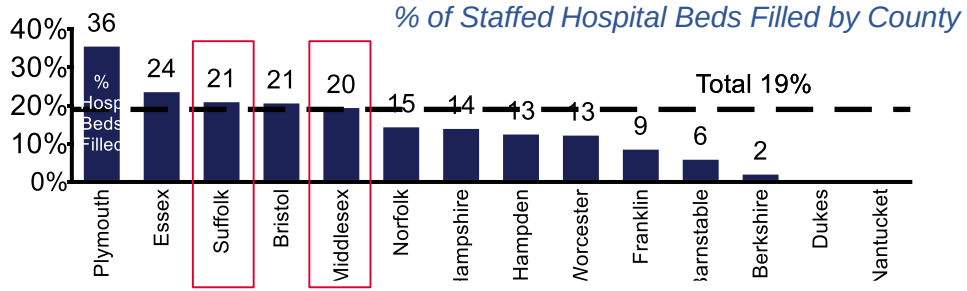
MA Case Counts as of 5/7*



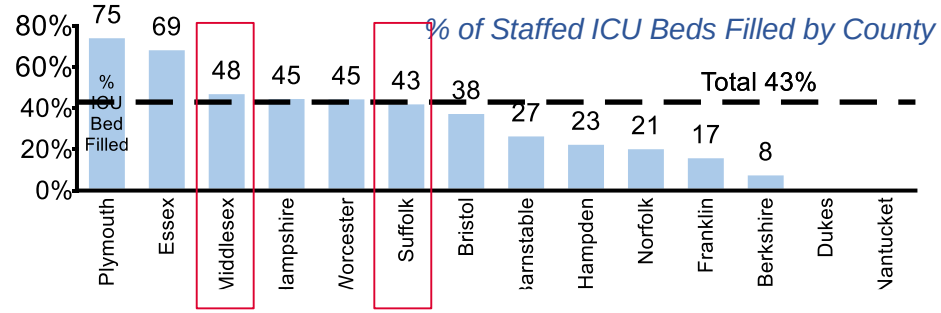
%	21%	10%	25%

~19% of hospital beds and ~50% of ICU beds occupied with COVID-19 patients

3,539 in hospital



908 in ICU



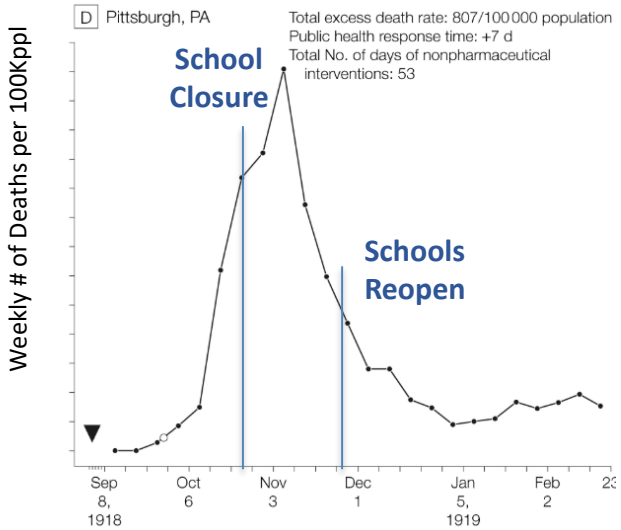
Approximately ~10% of positive cases in MA hospitalized

~19% of hospital beds and ~43% 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
Source: Mass.gov

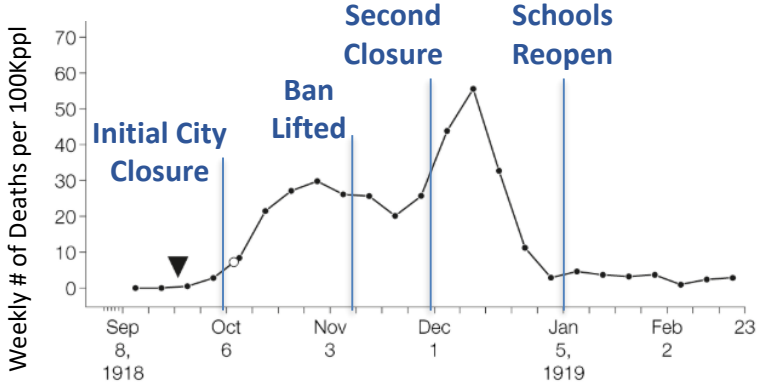
1918 Spanish Flu Precedent

Philadelphia – too late to shut, overwhelmed



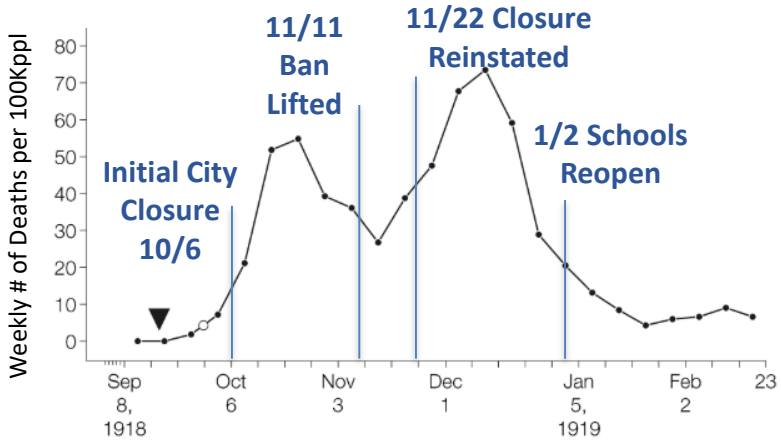
- Philadelphia **acted too late** to curb the death rate – after **waiting until after a massive parade** to close the city, the virus overwhelmed hospitals
- But because initial rate so high, **no second peak**

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

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 R_T
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

United we will win the war against COVID-19

Source: Bain Capital Partners analysis

Appendix

BACKUP

Testing Companies and Organizations, References

- 3D Medicines
- Abbott
- Aculabs, Inc.
- Anatolia Geneworks
- ARUP Laboratories
- A*STAR,Tan Tock Seng Hospital of Singapore
- Assure Tech
- Atila BioSystems
- AusDiagnostics
- Autobio Diagnostics
- Avellino Lab
- Bako Diagnostics
- Baptist Hospital Miami Pathology/Laboratory Medicine Lab
- Becton Dickinson
- Becton Dickinson, BioGx
- Beijing Decombio Biotechnology
- Beijing Diagreat Biotechnologies
- Beijing Kewei Clinical Diagnostic Reagent
- Beijing O&D Biotech
- Beroni Group
- BGI
- Biodesix
- BioMedomics
- BioMérieux
- BioMérieux/BioFire Defense
- Bioneer
- 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
- Diazyme Laboratories
- Eachy Biopharmaceuticals
- Euroimmun/PerkinElmer
- Exact Sciences
- Fosun Pharma USA
- Fulgent Genetics/MedScan Laboratory
- Genetic Signatures
- Genetron
- GenMark Diagnostics
- Genomica/PharmMar Group
- GenoSensor
- Gnomegen
- Gold Standard Diagnostics
- Guangzhou Wondfo Biotech
- Hackensack University Medical Center (HUMC) Molecular Pathology Laboratory
- Hangzhou AllTest Biotech
- Hangzhou Biotest Biotech
- Hangzhou Clongene Biotech
- Hangzhou Testsealabs Biotechnology
- Healgen Scientific
- Hologic`
- InBios International
- Innovita (Tangshan) Biological Technology
- Integrated DNA Technologies/Danaher
- Integrity Laboratories
- Ipsum Diagnostics
- Jiangsu Macro & Micro-Test Med-Tech
- JN Medsys
- Kogene Biotech
- KorvaLabs
- Laboratory Corporation of America
- LGC, Biosearch Technologies
- Lifeassay Diagnostics
- Luminex
- Maccura Biotechnology
- Massachusetts General Hospital
- Mayo Clinic Laboratories
- Medical Systems Biotechnology
- Mesa Biotech
- Mount Sinai Labs
- Nanjing Liming Bio-products
- NanoResearch
- Nantong Diagnos Biotechnology
- NeuMoDx Molecular
- Nirmidas 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)
- Orig3n
- Ortho Clinical Diagnostics
- Osang Healthcare
- PathoFinder
- PCL
- PerkinElmer
- Phamatech
- Promedical
- Qiagen
- Quest Diagnostics
- Quidel
- Rendu Biotechnology
- Roche
- Rutgers University Clinical Genomics Laboratory
- ScienCell 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
- Systaaq Diagnostic Products
- Telepoint Medical Services
- Thermo Fisher Scientific
- Tianjin Beroni Biotechnology
- TIB Molbiol Syntheselabor
- United Biomedical
- University of North Carolina Medical Center
- Vela Diagnostics
- Viracor 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

https://www.medtechdive.com/news/over-90-of-1m-abbott-coronavirus-tests-sitting-idle-white-house-official/575794/
https://www.bd.com/en-us/company/news-and-media/press-releases/bd-biogx-announce-fda-emergency-use-authorization-submissions-for-new-covid-19-diagnostics-for-use-in-us
https://www.cepheid.com/en_US/systems/GeneXpert-Family-of-Systems/GeneXpert-Infinity
https://investors.hologic.com/press-releases/press-release-details/2020/Hologics-Molecular-Test-for-the-Novel-Coronavirus-SARS-CoV-2-Receives-FDA-Emergency-Use-Authorization/default.aspx
https://www.neumodx.com/wp-content/uploads/2019/03/NeuMoDx_288_Spec_Sheet_R2.pdf
https://www.ibj.com/articles/roche-begins-shipping-emergency-approved-covid-19-tests-across-country
https://www.thermofisher.com/us/en/home/clinical/clinical-genomics/pathogen-detection-solutions/coronavirus-2019-ncov/genetic-analysis/taqpath-rt-pcr-covid-19-kit.html (94 specimens in 3 hours)

Source: 360dx.com, CDC, FDA, company websites

White House Return to Work Framework

BACKUP

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	Phase Two	Phase Three
Individuals	• **Vulnerable individuals** shelter in place • Others should **maximize distance** in public, avoid groups of >10 people, wear PPE in public	• **Vulnerable individuals** shelter in place • Others should **maximize distance** in public, wear PPE • Can resume non-essential travel	• **Vulnerable individuals** can resume public interactions • Others should minimize time spent in crowded environments, wear PPE in public
Employers	• **Encourage telework** • Close **common areas** • Minimize non-essential travel • Certain venues (bars, schools) should **remain closed**	• **Encourage telework** • Close **common areas** • Provide accommodations for vulnerable populations • Restricted venues (bars, schools) can **reopen** with limited capacity	• Visits to **senior care facilities and hospitals can resume** • Large venues can operate under limited distancing protocols • Bars may operate with increased occupancy

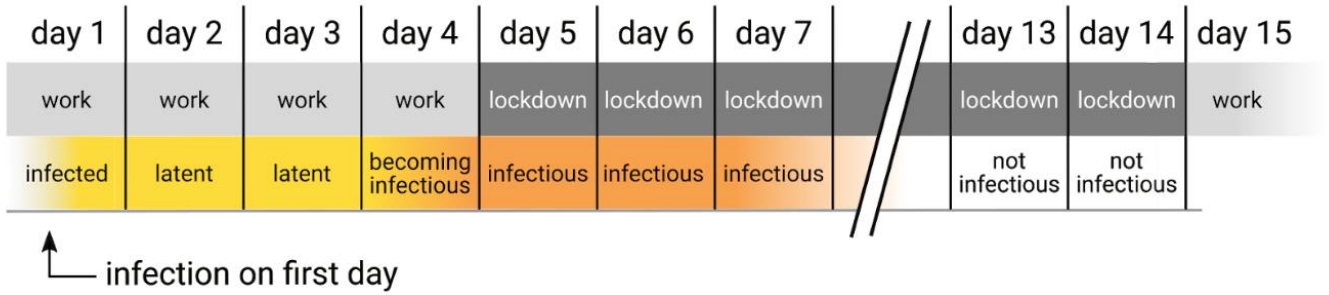
Source: whitehouse.gov

Intermittent Work Phasing Option

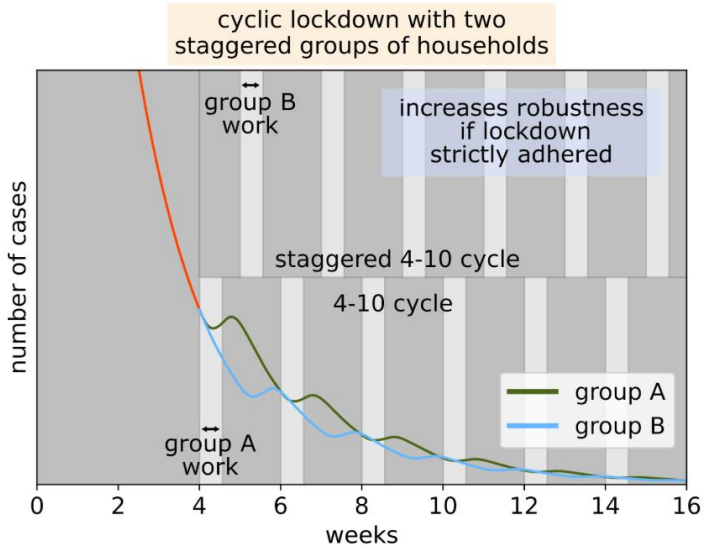
BACKUP

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



Potential Impact

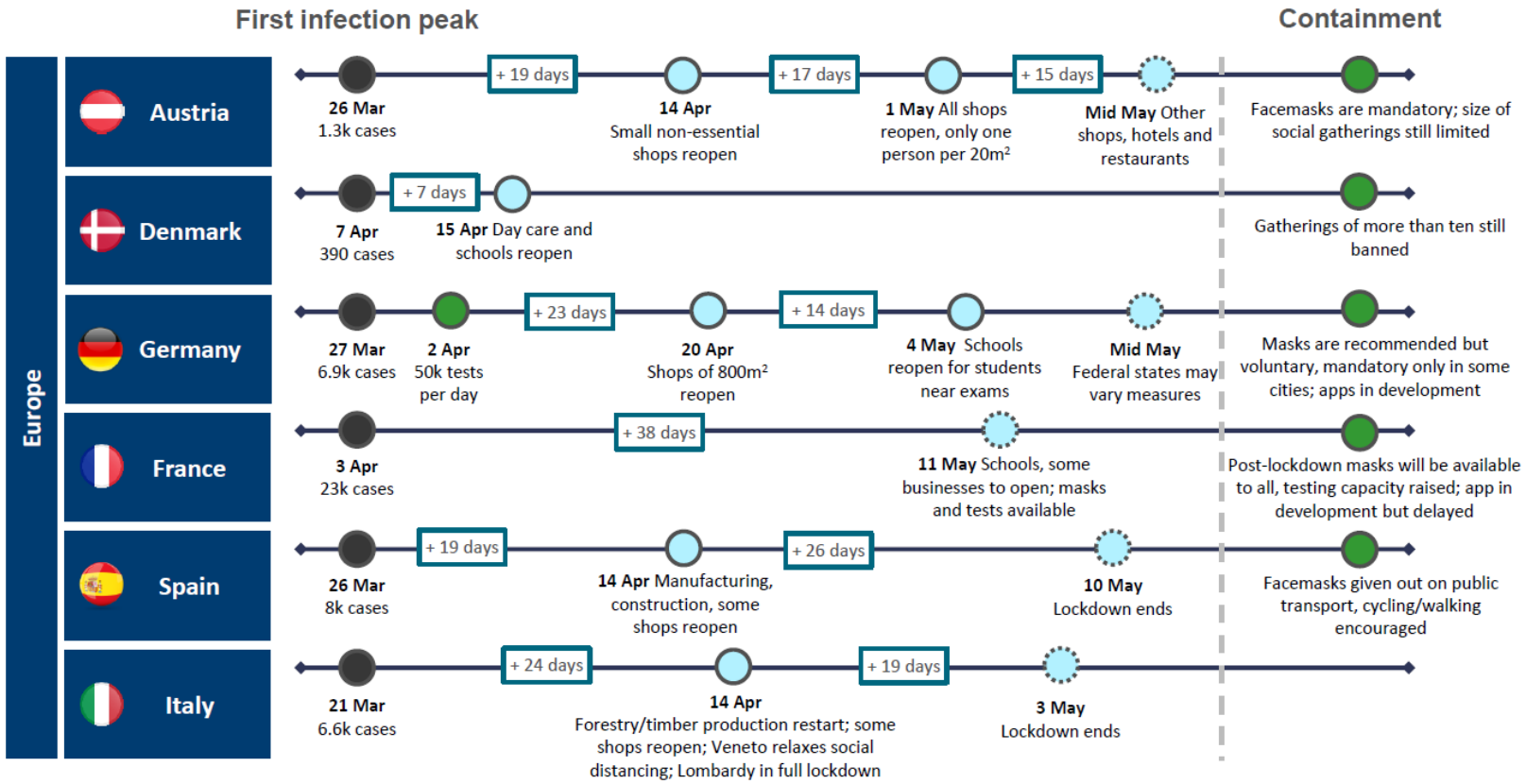


Could explore alterative back-to-work phasing to help reduce healthcare burden while allowing groups to return part-time earlier, potentially before system fully ready

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

European Timelines

BACKUP

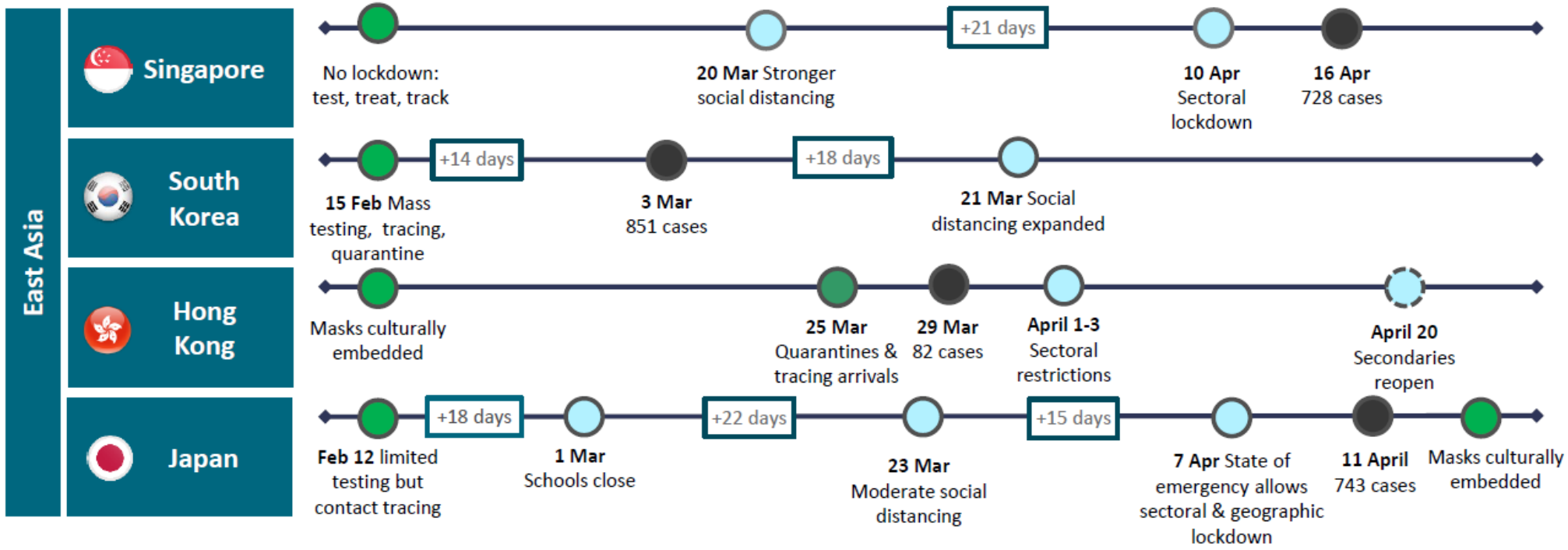


European countries are starting to ease, but containment strategies appear limited, risking acceleration of the virus. This may mean a return to lockdown

Source: Tony Blair Institute for Global Change: A Sustainable Exit Strategy Managing Uncertainty Minimizing Harm

East Asia Timelines

BACKUP



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

Testing: How to Test

BACKUP

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 ~10ppl/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 <u>within the first 2 days of exposure</u>

Source: NPR.org, Bain Capital Partners Analysis

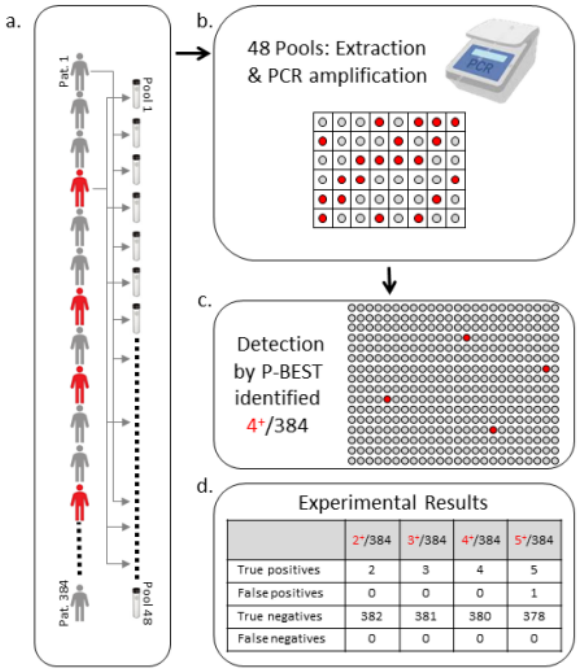
Making Testing More Efficient: Test Pooling Case Study

BACKUP

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



	2+/384	3+/384	4+/384	5+/384
True positives	2	3	4	5
False positives	0	0	0	1
True negatives	382	381	380	378
False negatives	0	0	0	0

- 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)

Source: med.Stanford.edu, "Efficient high throughput SARS-CoV-2 testing to detect asymptomatic carriers", Noam Shental, Shlomia Levy, Vered Wuvshet, Shosh Skorniakov, Yonat Shemer-Avni, Angel Porgador, Tomer Hertz

What Tests to Use: Viral Testing Overview

BACKUP

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

Full List in Appendix

Key Companies

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

Sample High Throughput Machines / Products

Company	Abbott	BD / BioGX	Cepheid	Hologic	NeuMoDx	Roche	Thermo Fisher	Labs incl. Quest, LabCorp, etc.
Machine / Product	m2000	BDMax	GeneXpert Infinity	Panther Fusion	288 Molecular	COBAS 8800	TaqPath	Lab Developed Tests
Daily Capacity	470	360	>2,000	1,150	864	4,128	>1,500	>200

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

BACKUP

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

Full List in Appendix

Companies

- Abbott
- BioMedomics Inc
- Bioperfectus Technologies
- Cellex
- Decombio
- Biotechnology
- DeepBlue Medical
- Innovita
- Premier Biotech
- Sure Biotech
- UCP biosciences
- VivaChek Biotech
- Wondfo Biotech
- SD Biosensor
- Biolidics Limited
- Biomedomics
- Epitope Diagnostics

Sample Test Specificity

Company	BioMedomics	Bioperfectus	DecomBio	DeepBlue	Innovita
Specificity	87%	95%	90%	84%	96%

Company	Premier	Sure	UCP	VivaChek	Wondfo	Epitope
Specificity	97%	100%	98%	95%	99%	90%

Note: FDA allowed self-validation for first kits without data validation. The above data is self-declared and may not be accurate

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

BACKUP

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

Range of Digital Tracing Options

BACKUP

Decentralized → *Centralized*

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

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

Source: Press search, WSJ (https://www.wsj.com/articles/coronavirus-paves-way-for-new-age-of-digital-surveillance-11586963028?mod=article_inline)

Reimagining Support Services: Workforce Redeployment

BACKUP

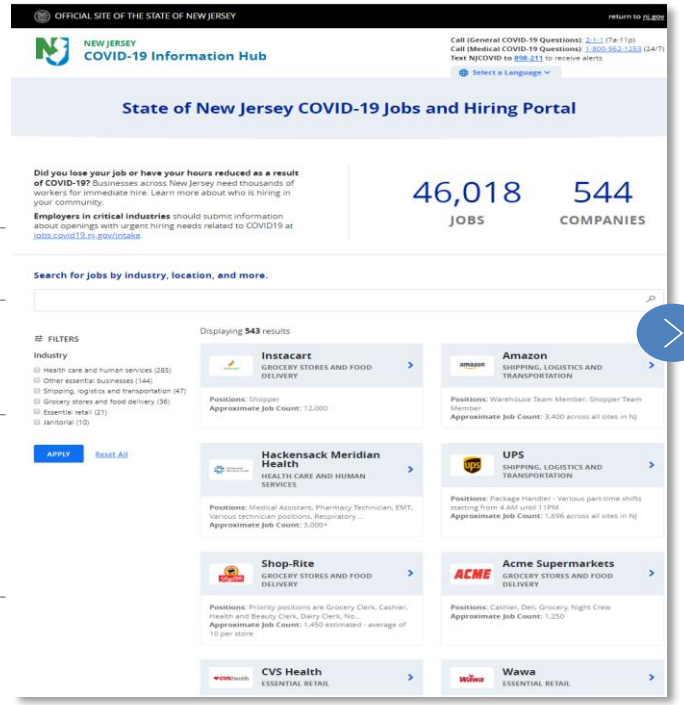
New Jersey State Platform Example

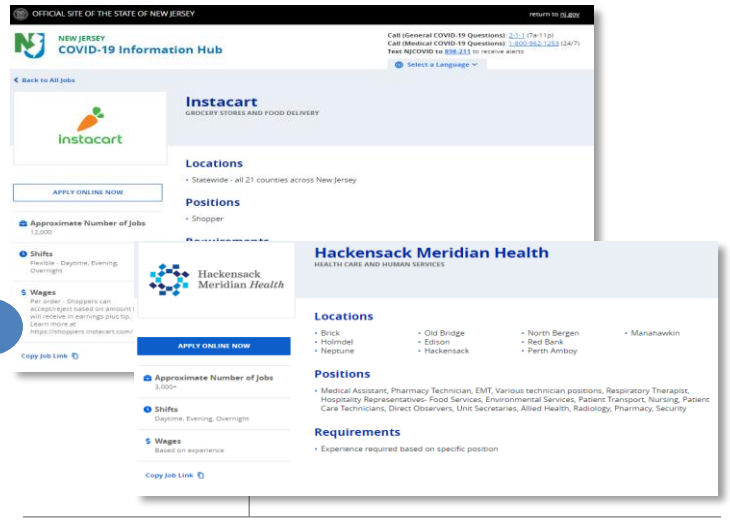
Employer intake form

Ability to search by industry, location, role

Ability to filter main site by industry

Compressed employer cards to allow for viewing more per page; employers still listed in order of total # of posts





Employer details pages

Clicking on employer card on main site takes users to details page; able to see overview of all postings per employer and navigate to employer's website (or send email)

Future releases may allow users to explore an employer's postings by role/location (in contrast to current site, where all of Hackensack's hospital postings are listed together, without specific wage data, # postings per role, locations per role, etc.)

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