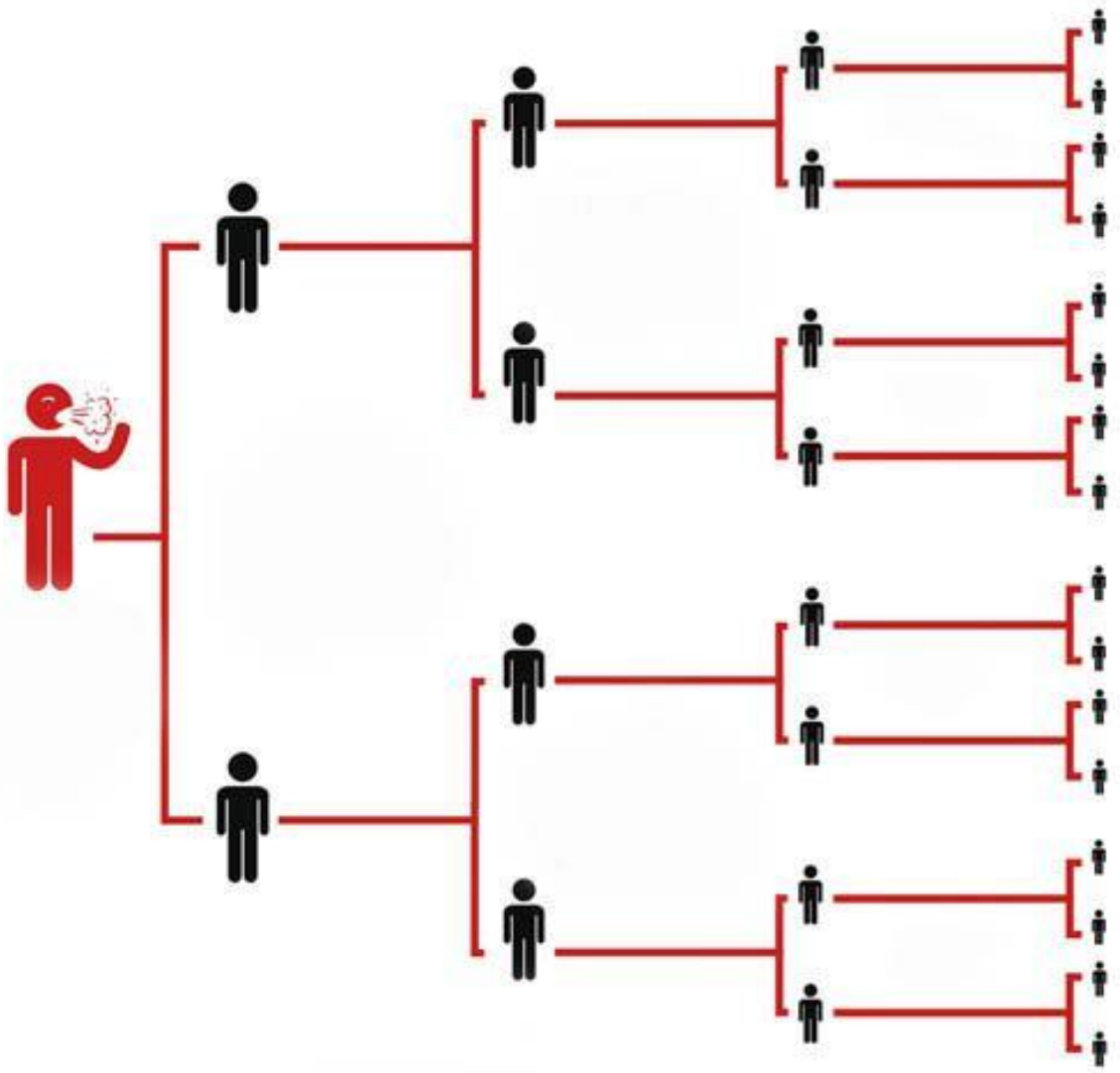
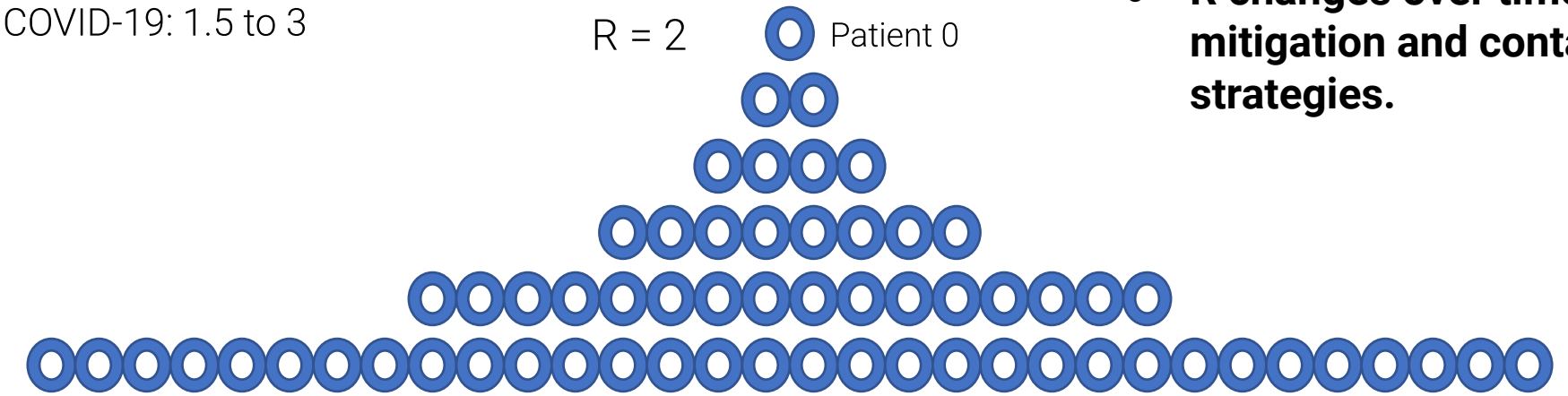
Coronavirus Simulation

“What if?”



Virus Replication – Simplified

- **Higher R (Socialization)**
  - Cruise Ship
  - Nursing Home
  - Rome, Barcelona, Manhattan
- **Lower R (Isolation)**
  - Ranch in Wyoming
- **R is “Figure of Merit”**
  - Based on data collection and regression
  - Varies widely based on calculation
    - Measles: 11 to 18
    - Flu: 2 to 3
    - COVID-19: 1.5 to 3



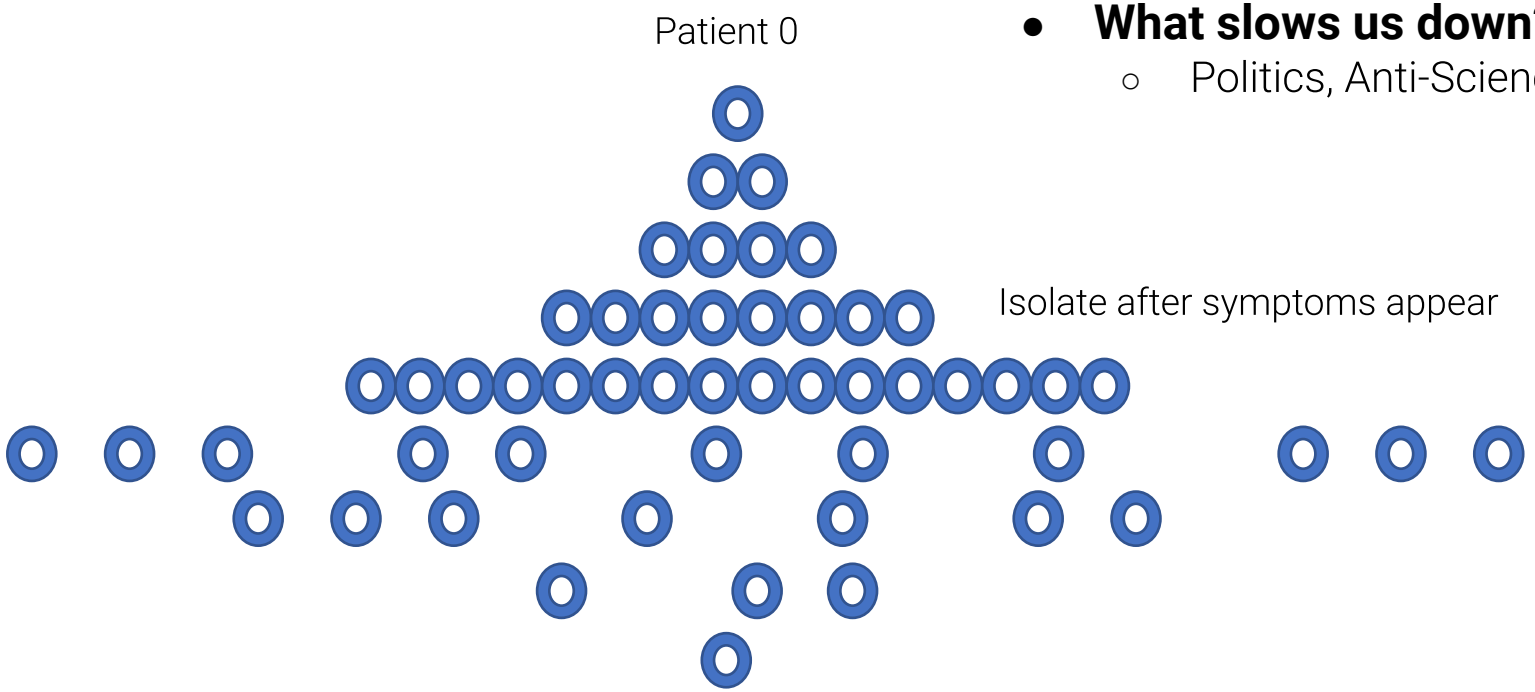
- **Simple Power Series for Cumulative Infections**
  - $N(i) = N(i - 1) + R^i$
- **Small Change in R Has Big Impact!**
  - 14 Days
  - R = 1.5, 290 cases
  - R = 2: 16384 cases
- **R needs to be lowered below 1.0 to stop the outbreak**
- **R changes over time based on mitigation and containment strategies.**

How to Control?

- **Many Factors to Consider**
  - Must isolate at factor of 1- 1/R infections!
  - How many are contagious with symptoms?
  - How long does it take to show symptoms?
  - How long does it take to get test result?
  - How long to vaccine?

- **Do we agree there is a problem?**
  - Determining severity is NOT difficult
  - Huge knowledge pool
  - Information Sharing
  - Centuries of experience

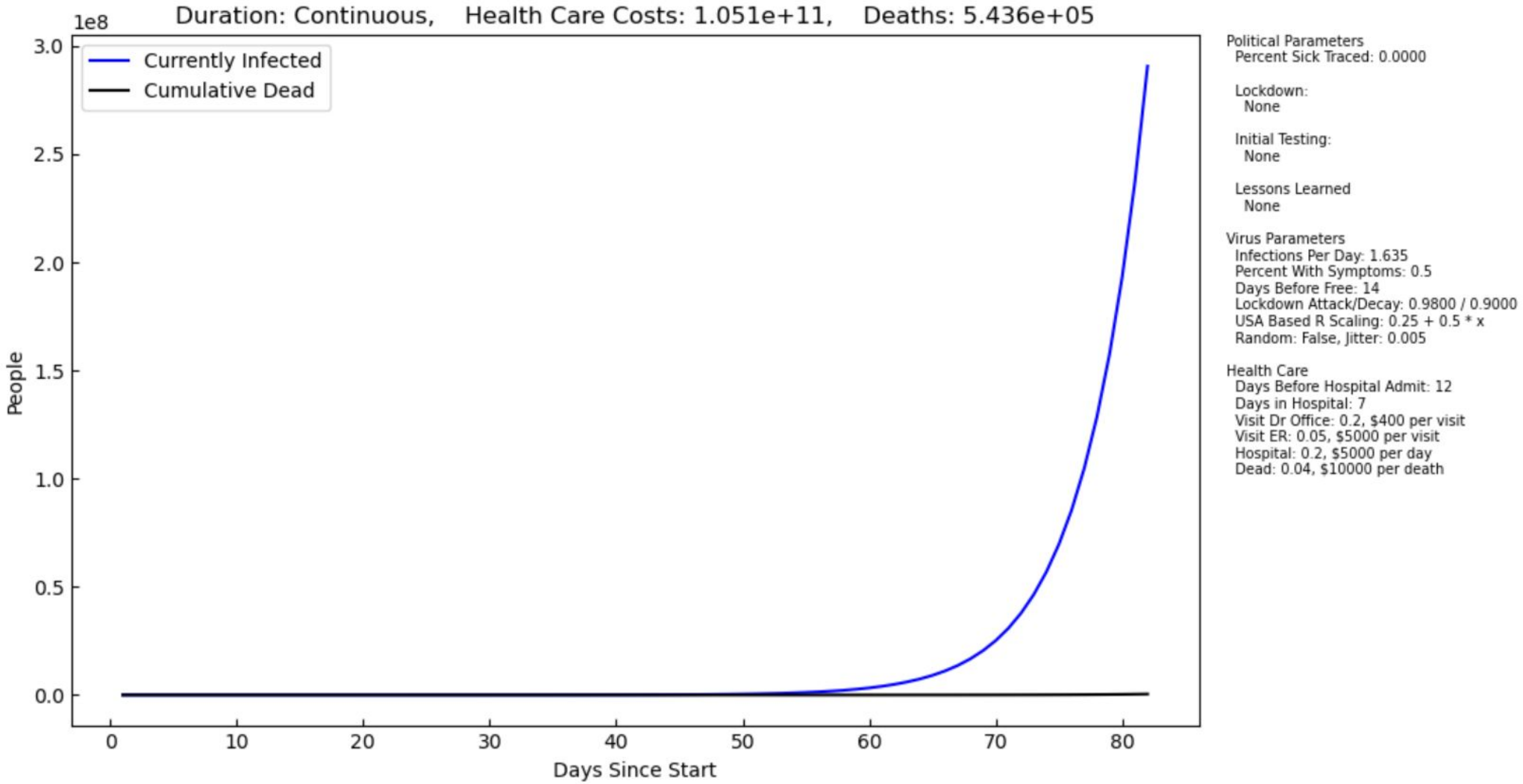
- **What slows us down?**
  - Politics, Anti-Science, Religion



Not the Time for Politics

- **Betting that national pride will beat a virus is a VERY bad bet.**
- **What if we said “No biggie…” ?**
  - In a few months, every person in US would have been infected
  - 500,000+ deaths (Similar to Civil War)
  - Many survivors will have irrecoverable injuries; heart, kidney, lungs, brain will be severely damaged.
  - Our response to routine health care emergencies would be crippled. Doctors, Nurses burned out, more will die due to lack of medical facilities and personnel.
  - Herd immunity or thinning the herd?
- **But the economy?**
  - 50+ population is being mischaracterized as economically unproductive and therefore sacrificial (old person’s disease)
  - Across the United States, about 38% of coronavirus patients sick enough to be hospitalized were ages 20 to 54, the CDC reported in April.
  - Sick employees at work are not productive and will infect other workers.
  - Sick customers do not buy goods and services and will infect workers and other customers.
  - Ultimately countries will restrict imports and travel, severely impacting the economy.

No Biggie? Wrong. 500,000 Dead in 3 Months



What if We Fight It? We Can Win. Really!

- **Lockdown**
  - How long do we wait?
  - How many people will observe the isolation?
  - How long does lockdown last?
    - Do we end it abruptly?
    - Do we wait until number of infections is sustained below a manageable threshold?

- **Testing**
  - When is it available to deploy?
  - Accuracy
  - Who gets tested?
    - Only sick people?
    - Random?
    - Hot Spots?
  - How long does it take to get results?
  - How many people can we trace based on positive result?
    - Reduced by time to get results (forgetting factor)

- **Lessons Learned - Behavior Change?**
  - Better testing methods and coverage?
  - More contact tracing?
  - Behavior change?
    - Lockdown earlier?
    - More isolation when sick?

We Decide These Things as a Nation!

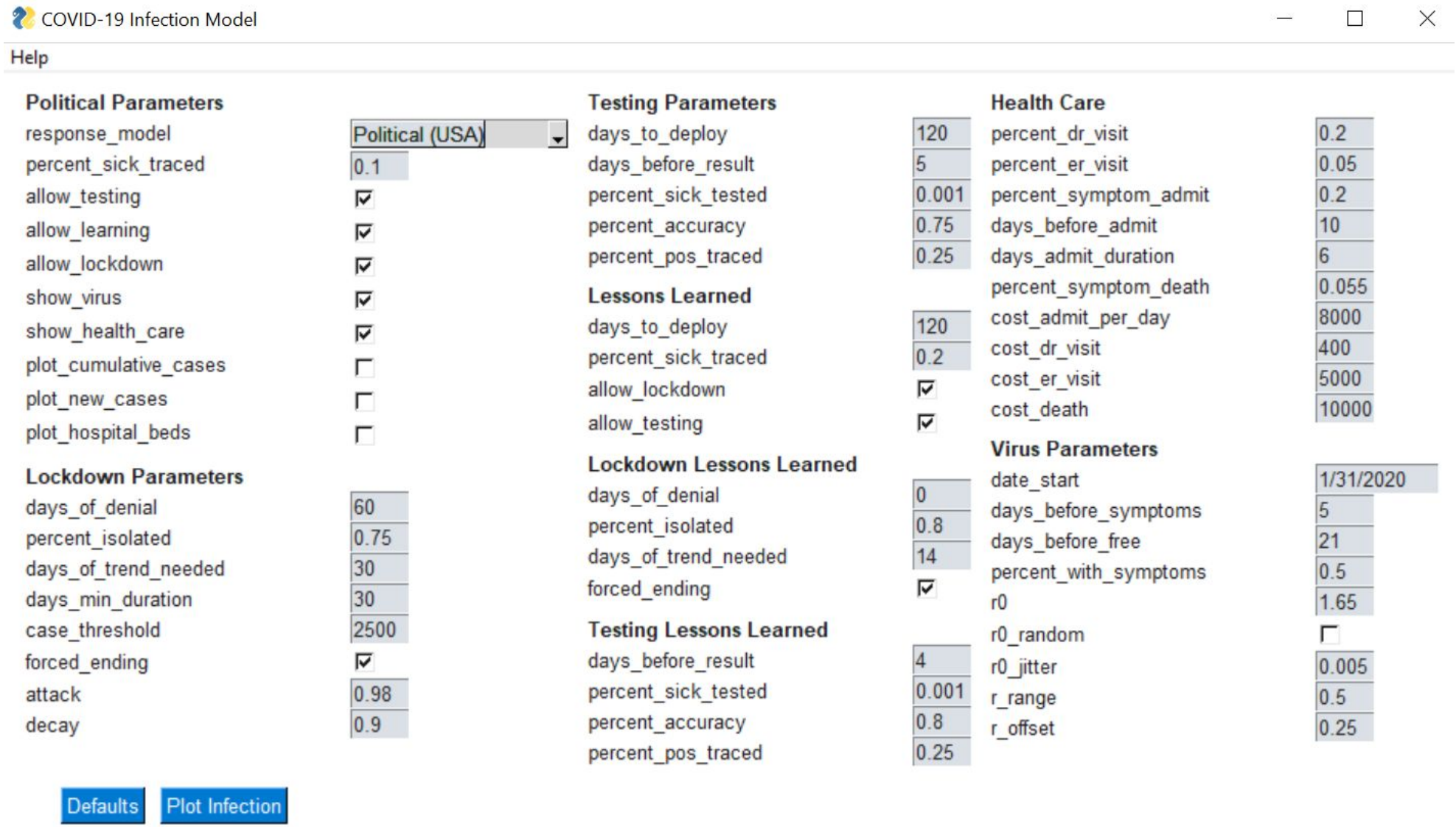
We can Simulate This to Guide a Response

- **Virus Replication is not a Complicated to Model**
  - Simple power series (exponential)
  - Scale it to meet the environment

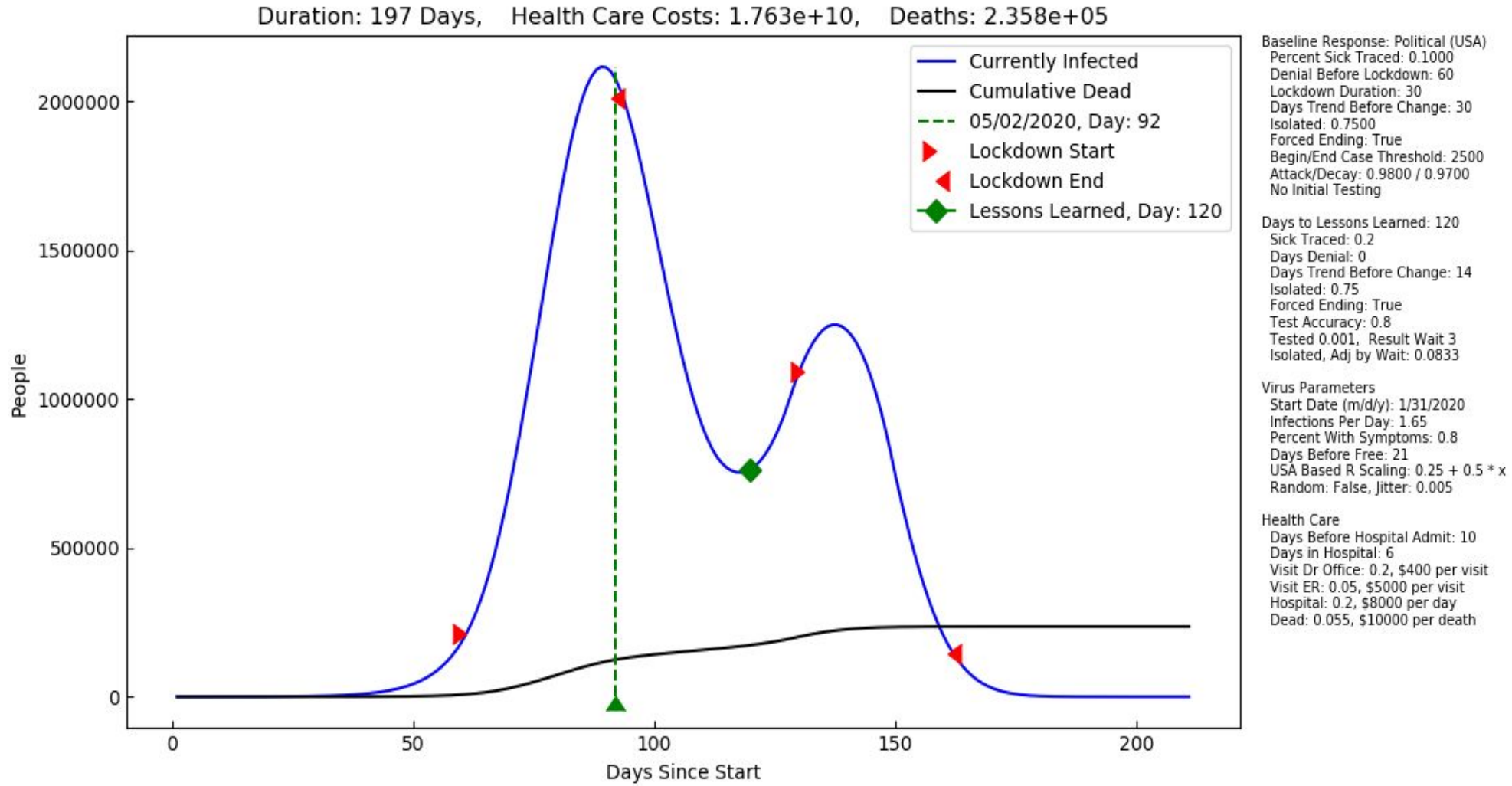
- **Human Behavior is a Complicated to Model**
  - How many people will “social distance”?
  - Will people “stay cool”?
  - What about political pressure?
  - When should we start and end lockdown?
  - Do we spend money on testing?
  - Will we learn things to improve?

- **We can Test Basic Assumptions**
  - What if we end lockdown early?
  - Herd immunity?
  - What if we test earlier?
  - What if we islote more?

COVID Simulator *"What if…?"*



USA: A Political Response (We Will Bounce)
Late to Lockdown, Late Testing, Too Early to Declare Victory



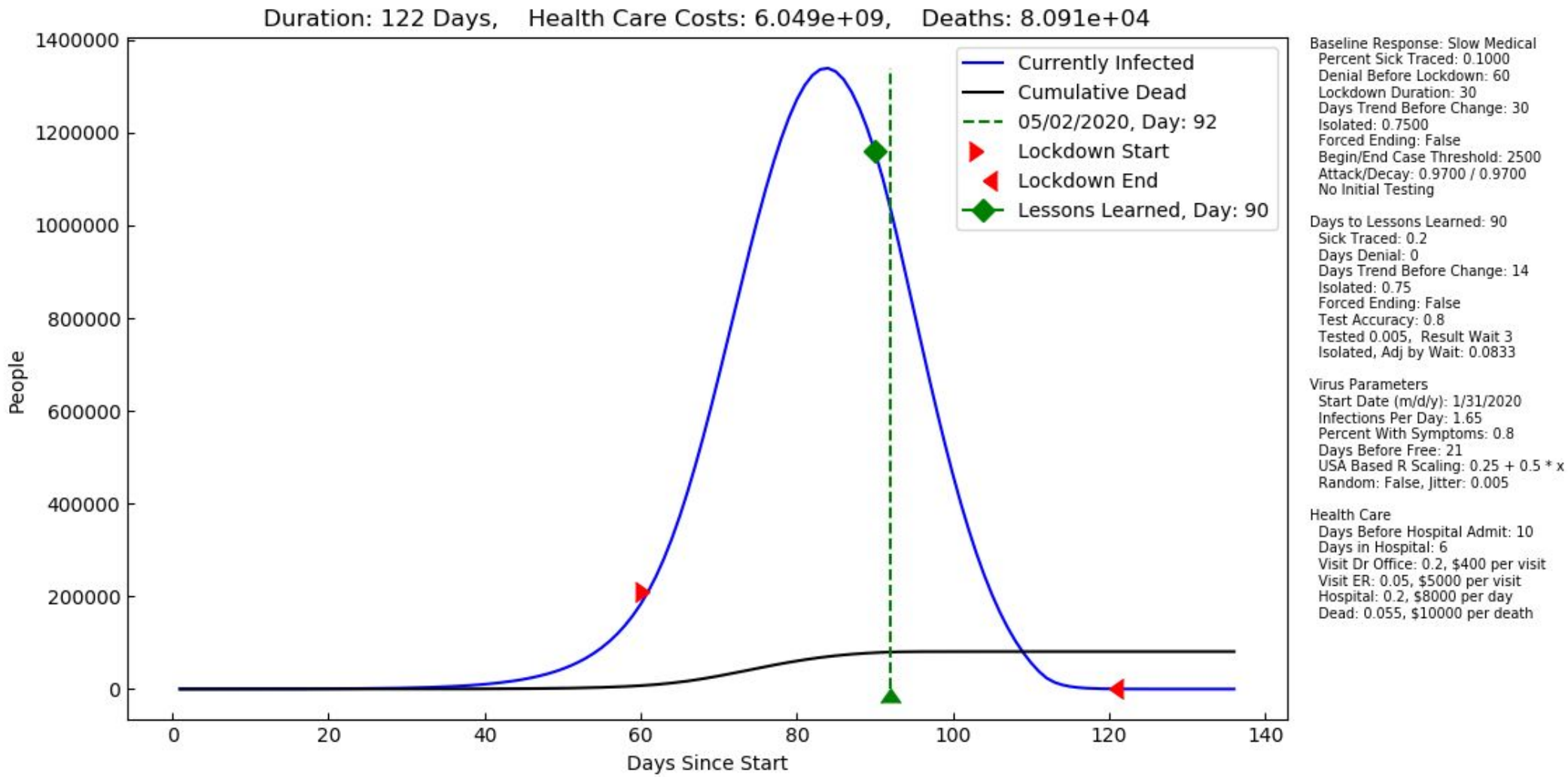
Baseline Response: Political (USA)
Percent Sick Traced: 0.1000
Denial Before Lockdown: 60
Lockdown Duration: 30
Days Trend Before Change: 30
Isolated: 0.7500
Forced Ending: True
Begin/End Case Threshold: 2500
Attack/Decay: 0.9800 / 0.9700
No Initial Testing

Days to Lessons Learned: 120
Sick Traced: 0.2
Days Denial: 0
Days Trend Before Change: 14
Isolated: 0.75
Forced Ending: True
Test Accuracy: 0.8
Tested 0.001, Result Wait 3
Isolated, Adj by Wait: 0.0833

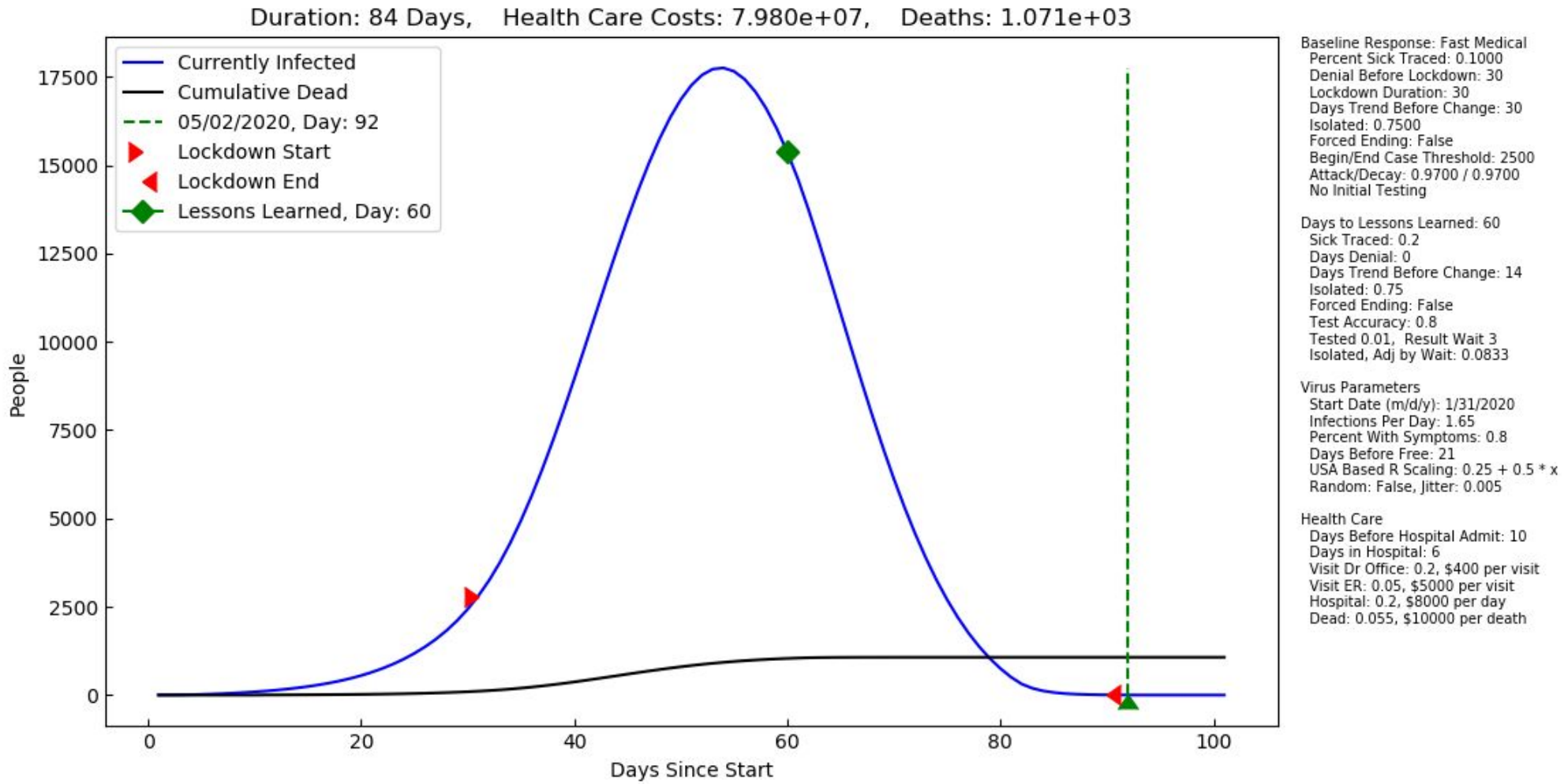
Virus Parameters
Start Date (m/d/y): 1/31/2020
Infections Per Day: 1.65
Percent With Symptoms: 0.8
Days Before Free: 21
USA Based R Scaling: 0.25 + 0.5 * x
Random: False, Jitter: 0.005

Health Care
Days Before Hospital Admit: 10
Days in Hospital: 6
Visit Dr Office: 0.2, $400 per visit
Visit ER: 0.05, $5000 per visit
Hospital: 0.2, $8000 per day
Dead: 0.055, $10000 per death

What if we deployed testing a bit earlier?

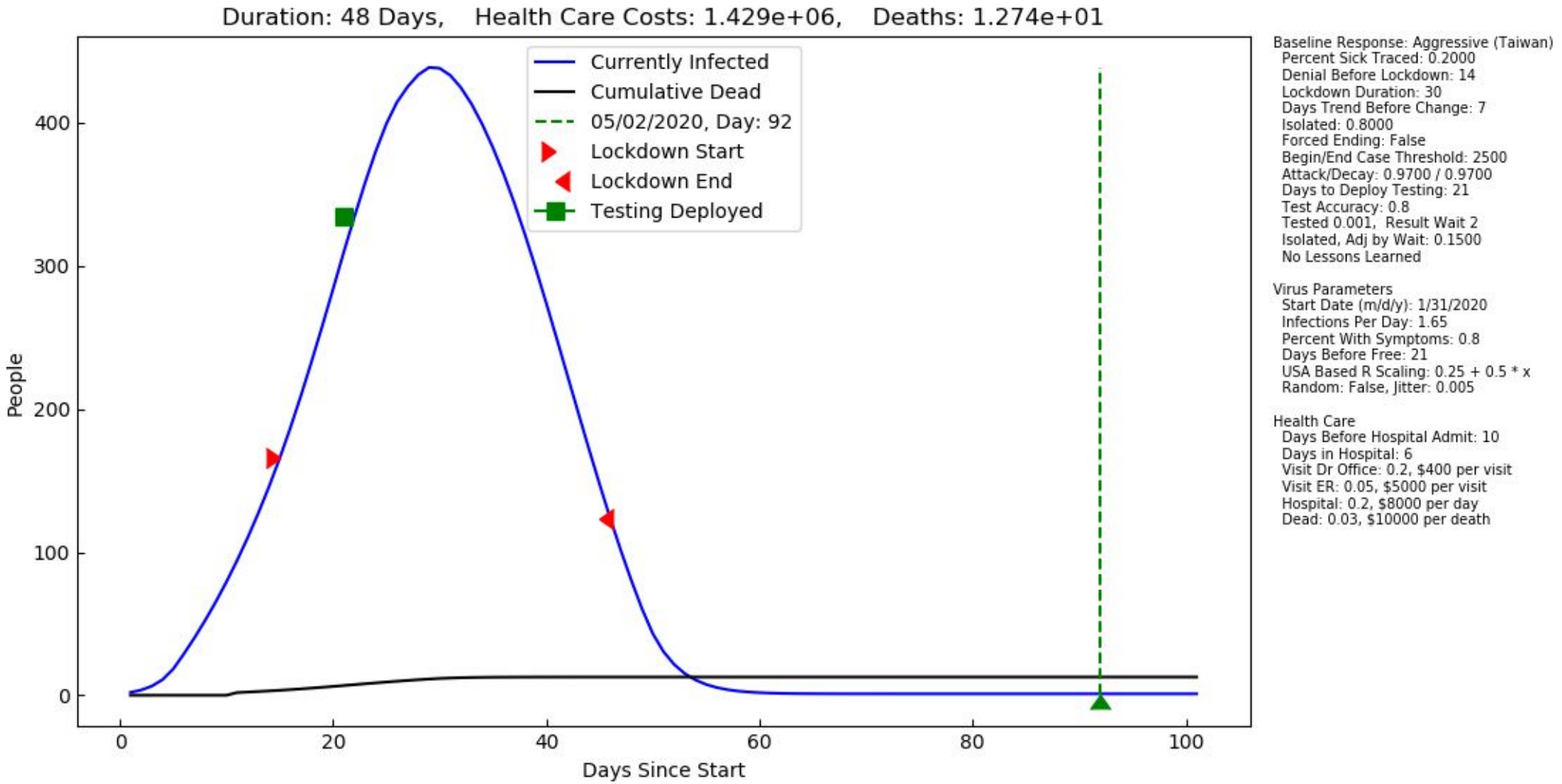


What if We Started 30 Days Earlier?



Taiwan Model – World Leader, 43M Population

Prioritized Aggresive Medical Response, Good Health Care System

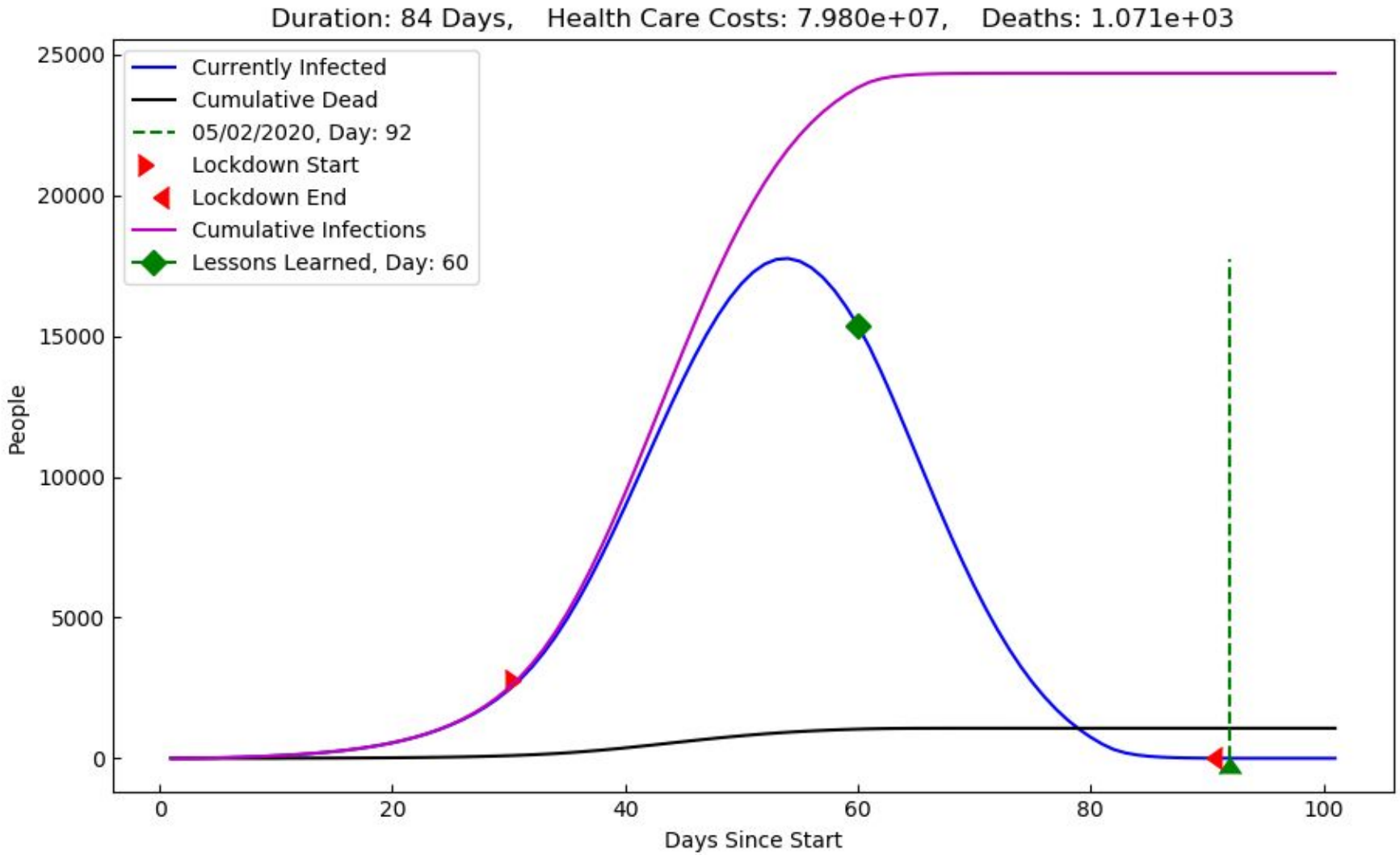


Baseline Response: Aggressive (Taiwan)
Percent Sick Traced: 0.2000
Denial Before Lockdown: 14
Lockdown Duration: 30
Days Trend Before Change: 7
Isolated: 0.8000
Forced Ending: False
Begin/End Case Threshold: 2500
Attack/Decay: 0.9700 / 0.9700
Days to Deploy Testing: 21
Test Accuracy: 0.8
Tested 0.001, Result Wait 2
Isolated, Adj by Wait: 0.1500
No Lessons Learned

Virus Parameters
Start Date (m/d/y): 1/31/2020
Infections Per Day: 1.65
Percent With Symptoms: 0.8
Days Before Free: 21
USA Based R Scaling: 0.25 + 0.5 * x
Random: False, Jitter: 0.005

Health Care
Days Before Hospital Admit: 10
Days in Hospital: 6
Visit Dr Office: 0.2, $400 per visit
Visit ER: 0.05, $5000 per visit
Hospital: 0.2, $8000 per day
Dead: 0.03, $10000 per death

Taiwan Flattens the Curve



Baseline Response: Fast Medical
Percent Sick Traced: 0.1000
Denial Before Lockdown: 30
Lockdown Duration: 30
Days Trend Before Change: 30
Isolated: 0.7500
Forced Ending: False
Begin/End Case Threshold: 2500
Attack/Decay: 0.9700 / 0.9700
No Initial Testing

Days to Lessons Learned: 60
Sick Traced: 0.2
Days Denial: 0
Days Trend Before Change: 14
Isolated: 0.75
Forced Ending: False
Test Accuracy: 0.8
Tested 0.01, Result Wait 3
Isolated, Adj by Wait: 0.0833

Virus Parameters
Start Date (m/d/y): 1/31/2020
Infections Per Day: 1.65
Percent With Symptoms: 0.8
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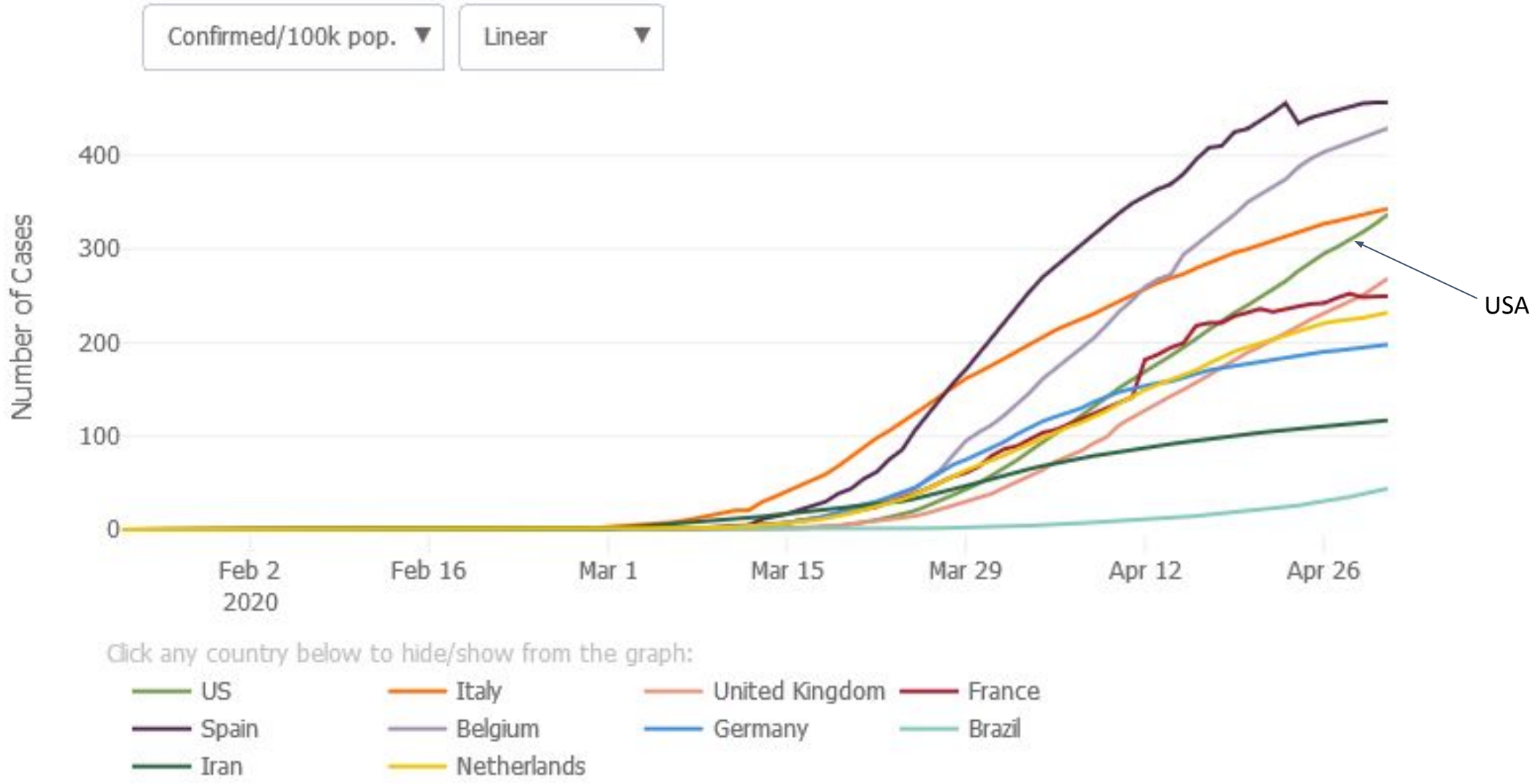
Health Care
Days Before Hospital Admit: 10
Days in Hospital: 6
Visit Dr Office: 0.2, $400 per visit
Visit ER: 0.05, $5000 per visit
Hospital: 0.2, $8000 per day
Dead: 0.055, $10000 per death

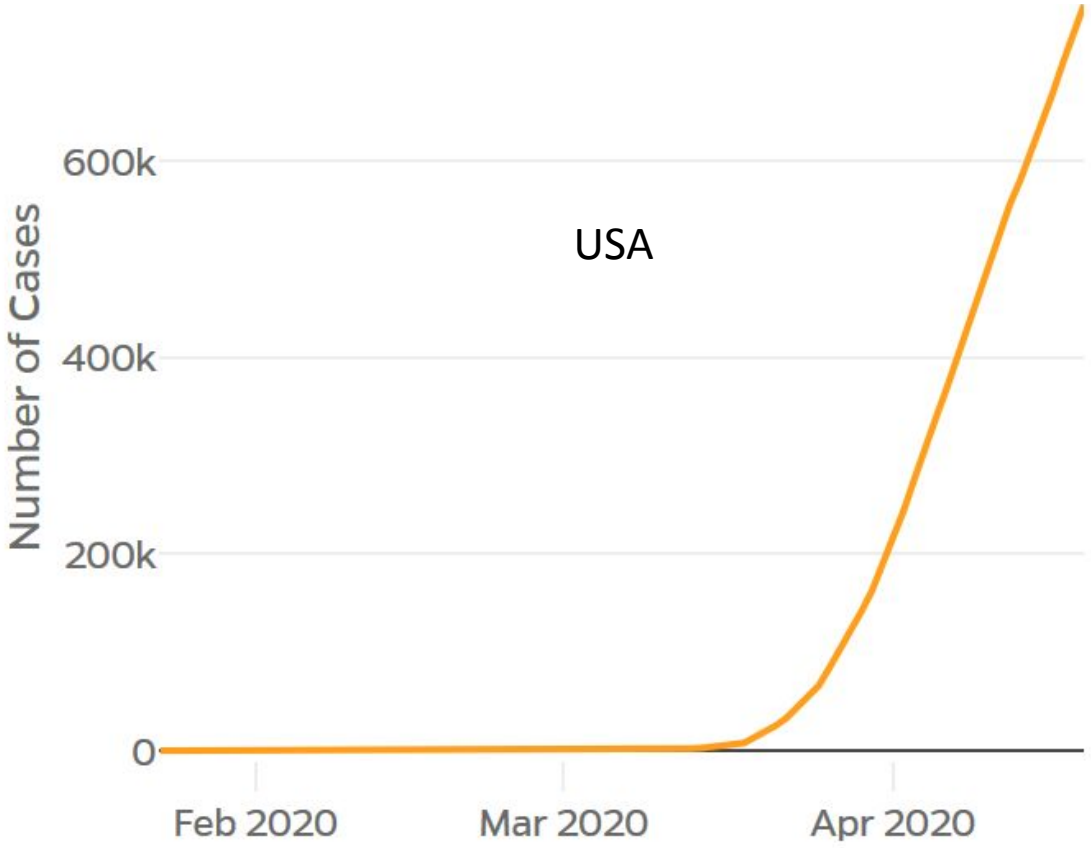
USA is not Flattening

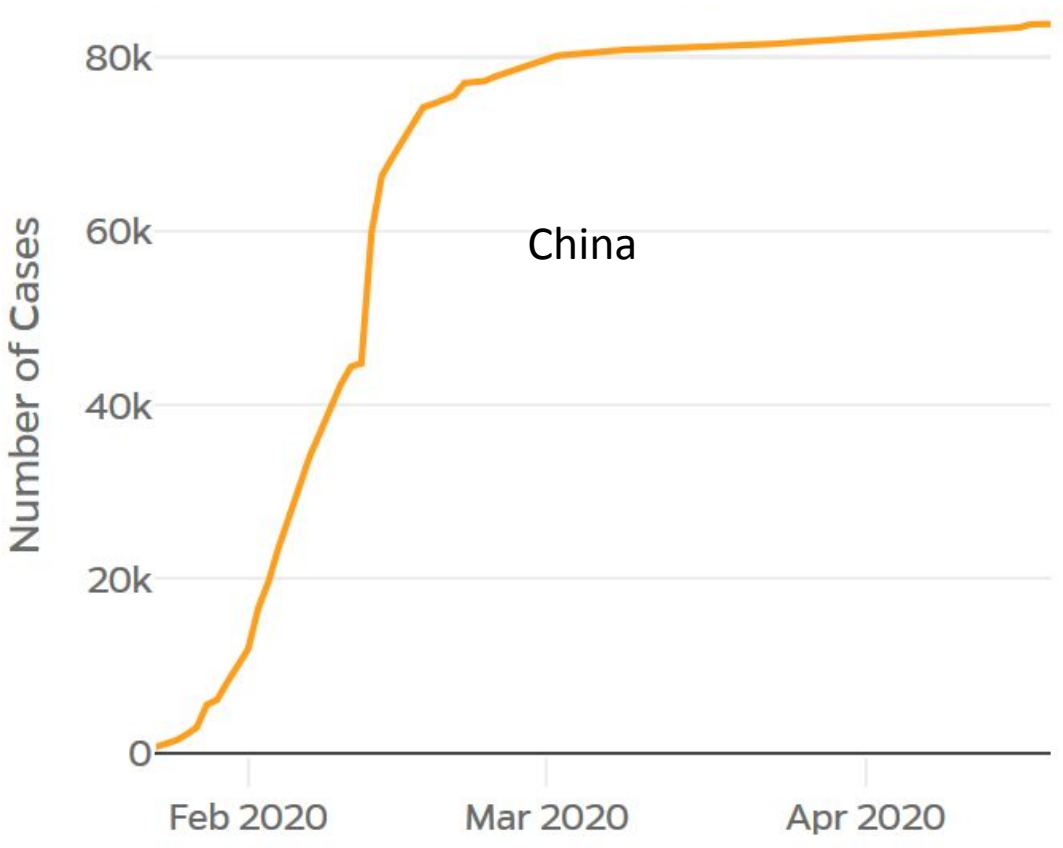
Hopkins Resource Center



Ready to Lift the Lockdown?

Hopkin's Corona Resource Center





Learn from Taiwan

- **Tactical**
  - Limit Entry and Quarantine Travelers ($35/day)
  - Contact Tracing
  - Location Tracking, Smart Checking
  - Supply Masks - Set Price, Apps to Track Stock
  - Prepare for Surge in Patients
  - Rent subsidies, transportation

- **Human Behavior**
  - Acknowledge the Facts Early
  - Distancing
  - Hand Washing/Hygiene
  - Trust

- **Strategic**
  - Learned from SARS
  - Investment in National Health System
    - 90% Satisfaction Rating
  - Vaccine and Testing

How We Could Have Avoided This

Lockdown

- Don’t delay! Denial costs thousands of lives, huge economic impact!
- Enforce compliance, don't end early (it will bounce back!)
- Provide Incentives - Stipend, Rent, Masks, Loans
- Quarantine travelers
- Have testing in place at end of lockdown.

Testing

- Don’t delay!
- Just a small percentage needed, contract tracing is critical
- Reduce time to results
  - Consider that time to symptoms + time to results = lots of infections
  - Delay causes forgetting factor for tracing contacts (who did I cough on 6 days ago?)
- Follow up with tracing and isolation
- A solid test that catches 50% to 80% of positive cases is better than 0%!
  - Don’t require perfect accuracy, it will delay implementation
  - Accuracy will improve over time.