NC STATE UNIVERSITY
EDWARD P. FITTS DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING
THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Georgia Tech Health & Humanitarian Systems Interdisciplinary Research Center
Georgia Tech Health Analytics Stewart School of Industrial & Systems Engineering

COVID-19 Simulation Integrated Model (CovSim) for State and Local Levels

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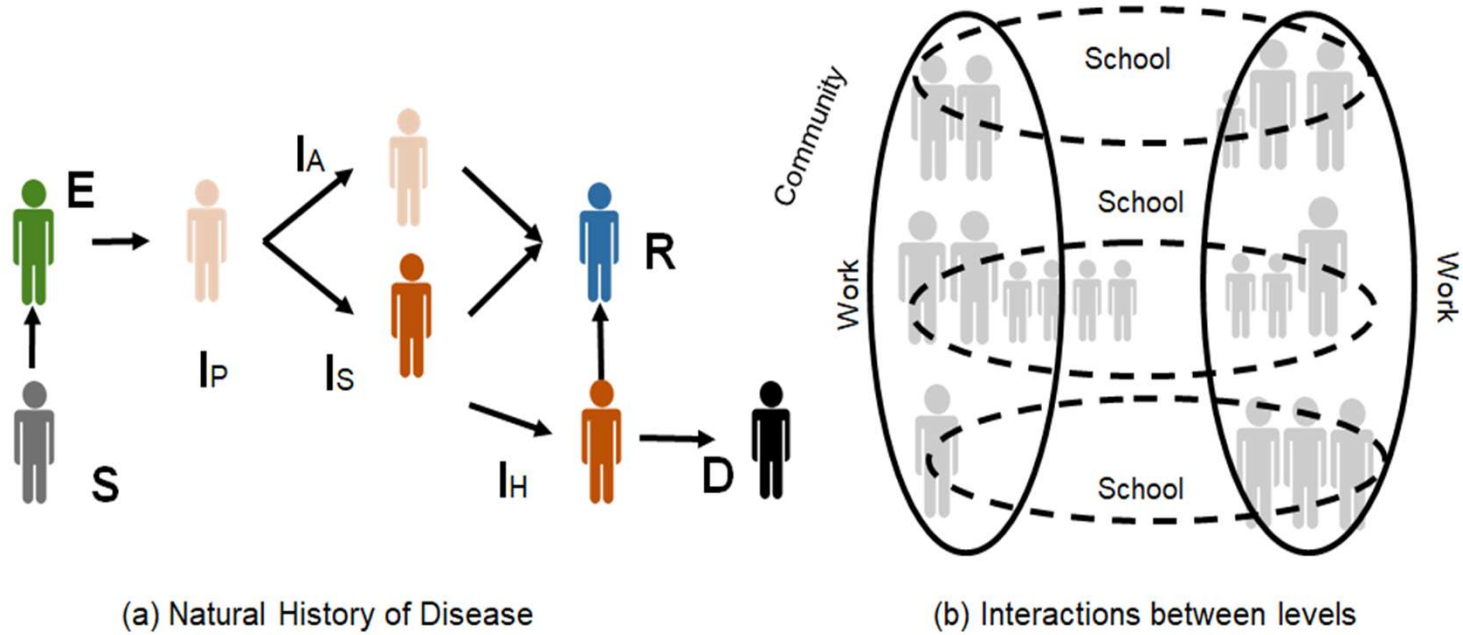
- NC State (NC Covid Model)
  - Faculty: Julie Ivy, Maria Mayorga, Julie Swann
  - Student Team: Nicole Colberg, Jessica Mele, Erik Rosenstrom, Yiwei Zhang
- UNC-Chapel Hill (Decision Maker Engagement and Communication)
  - Faculty: Paul Delamater, Mehul Patel, Kristen Hassmiller Lich, Mark Holmes
  - Raymond Smith (ECU)
  - Student Team: Karl Johnson, Caitlin Biddell, Joseph Konstanzer
- Georgia Tech (GA Covid Model)
  - Faculty: Pinar Keskinocak
  - Student Team: Buse Eylul Oruc, Akane Fujimoto Wakabayashi, Daniel Kim, April Yu
  - Previous students and collaborators

CovSim Initiative

- Project Focus
  - Modeling of interventions (e.g., masks, vaccine, school closures, etc.)
  - Communication and engagement with health departments
  - Currently: GA and NC
  - Website with interactive tableau results in development
- Today's results
  - Maintaining non-pharmaceutical interventions
  - Projecting potential impact of variants with or without NPIs
  - Materials developed in consultation with local health departments

Model Structure: Stochastic Agent Based Disease Model



(a) Natural History of Disease

(b) Interactions between levels

S=Susceptible; E=Exposed; I_P=Infected, pre-symptomatic; I_A=Infected, asymptomatic; I_S=Infected, symptomatic; I_H=Infected, hospitalized; R=Recovered; D=dead; Vaccination status is tracked (not illustrated)

Probabilistic nature of model induces variability in possible outcomes of simulation

A research article with state-level modeling results is currently in press to be published in *JAMA Network Open*

Model Inputs

Age Group	• 5 distinct age groups (US Census) • Disease progression varies by age
Enhanced Demographics	• Race and ethnicity, household size at census tract level • Independent data correlates directionally
High-Risk Comorbidities	• Diabetes assigned based on race and age • Increased risk of hospitalization (and age)
Workflow	• Agents can work in different census tract than residence • Creates connections between locations
Mobility	• Safegraph data to classify adult agents probabilistically to interact with peer groups or not • All agents interact in community
Masking	• Adherence and efficacy are input parameters
Voluntary Quarantine	• Agents with symptomatic household member with quarantine with dynamic probability

Validation (e.g., by hospitalizations or deaths)

INTERVENTION SCENARIOS WE CAN SIMULATE AND COMPARE

1. Non-pharmaceutical interventions (NPIs):

- Extended NPI scenario:
  - Mask usage and social distancing remain at pre-vaccination levels: 70% mask usage, 15% voluntary isolation and self-quarantine. Community and workplace interactions remain reduced.
- Removed NPIs scenario:
  - On March 27th, workplace and community interactions including schooling return to normal, individuals no longer isolate or quarantine when recommended to do so.
  - Face mask usage decreases at a rate proportional to the number of people vaccinated until the end of vaccine distribution.

2. Vaccine efficacy:

- High: 90% (roughly corresponding to estimates from clinical trials of mRNA vaccines after both doses)
- Low: 50% (single dose of mRNA vaccine, compromised efficacy due to variants, etc)

3. Vaccine rollout speed:

- Fast: Gradual rollout from Dec 27th to April 6th
- Slow: Gradual rollout from Dec 27th to June 25th

4. Vaccine coverage:

- Med: By April 6th (fast rollout) or June 25th (slow rollout), coverage reaches 50% of adults
- Low: By April 6th (fast rollout) or June 25th (slow rollout), coverage reaches 25% of adults

16 possible scenarios to compare, crossing ***2 NPI options, 2 vaccine efficacy levels, 2 vaccine rollout speeds,*** and ***2 vaccine coverage levels*** (16=2x2x2x2)

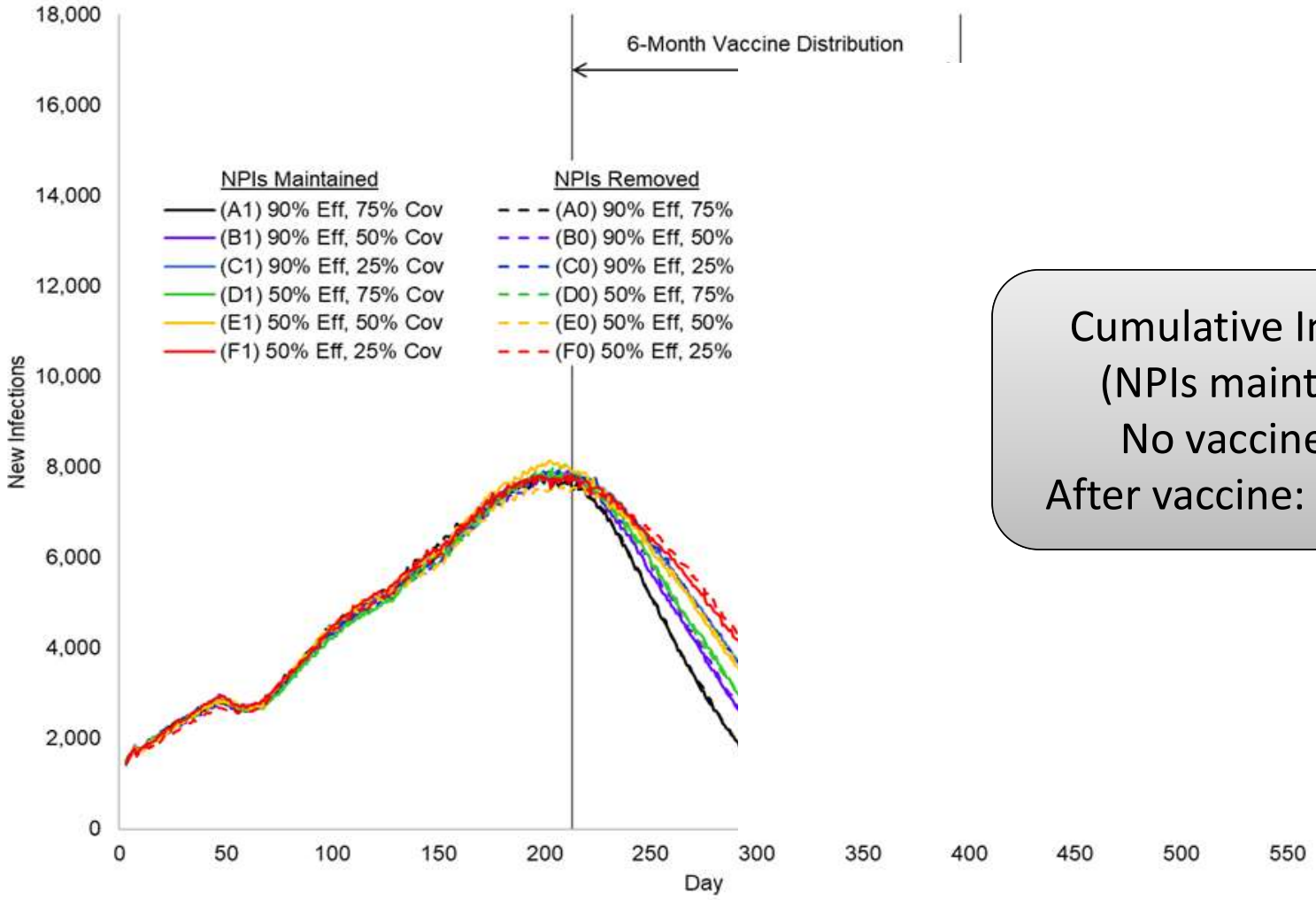
(a CDC-funded modeling collaboration with NC State, Georgia Tech, UNC Chapel Hill, and ECU)
Learn more at covsim.hosted-wordpress.oit.ncsu.edu

State-level results are provided for NC.

Example results are displayed alternating between Granville Vance District and Forsyth County. While specific estimates vary between counties (due to population demographics and size), overall patterns are consistent.

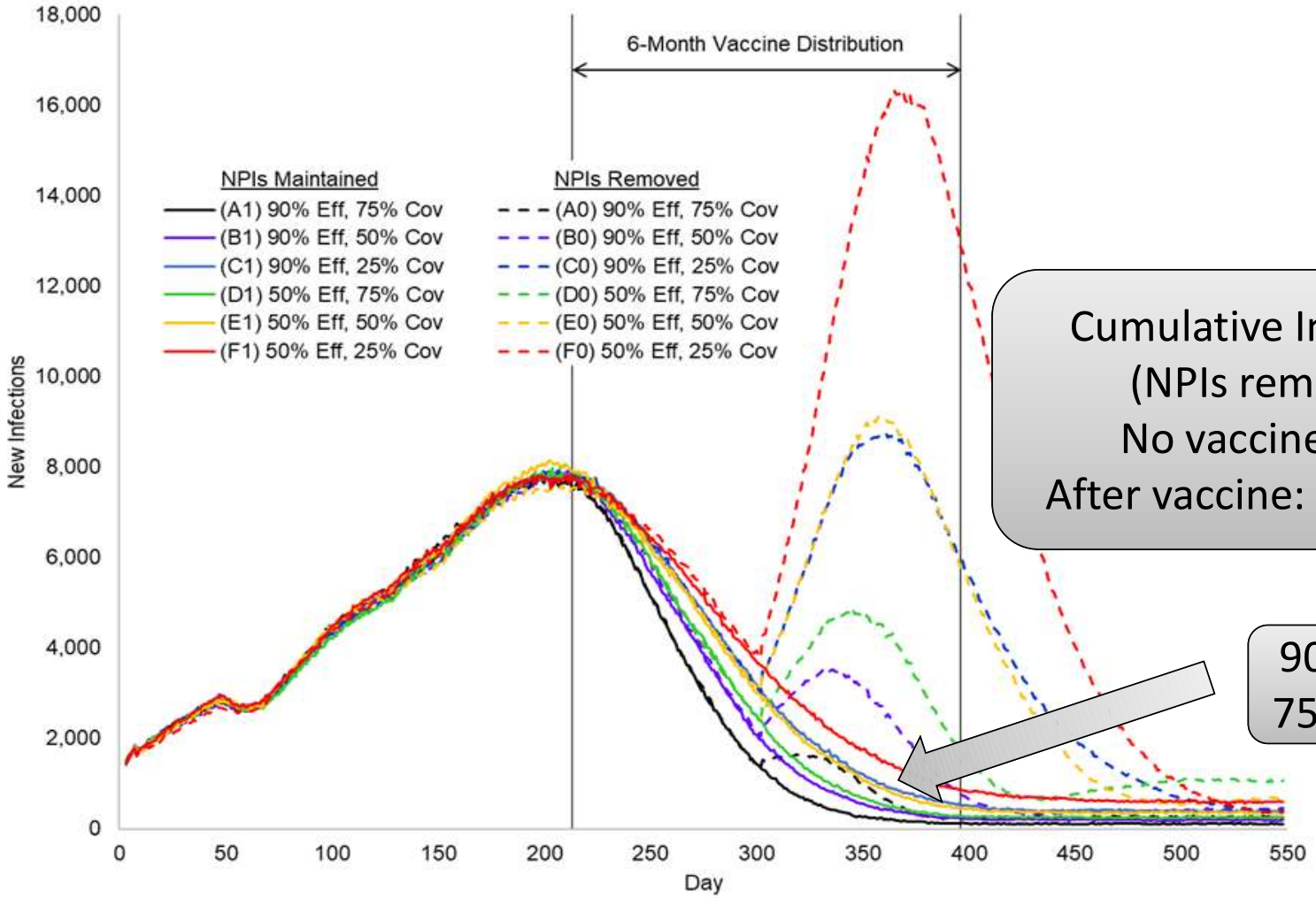
RESULTS FOR NPI SCENARIOS

Daily New Infections by Scenario (NC)



Cumulative Infections
(NPIs maintained):
No vaccine: 20%
After vaccine: 14 to 17%

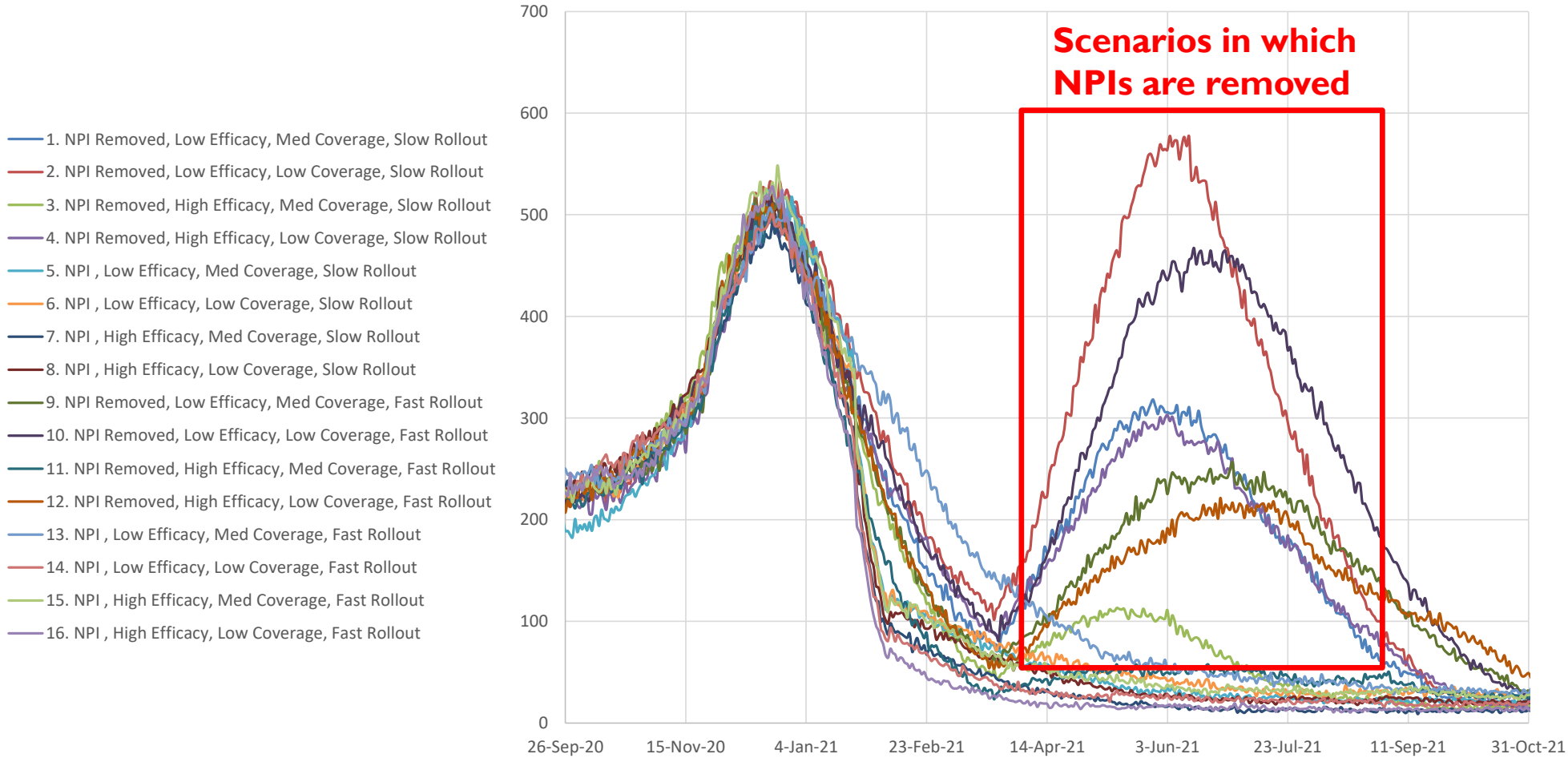
Daily New Infections by Scenario (NC)



Cumulative Infections
(NPIs removed:
No vaccine: 47%
After vaccine: 15 to 31%

90% efficacy;
75% coverage

Daily Infections Over Time in **Forsyth County***



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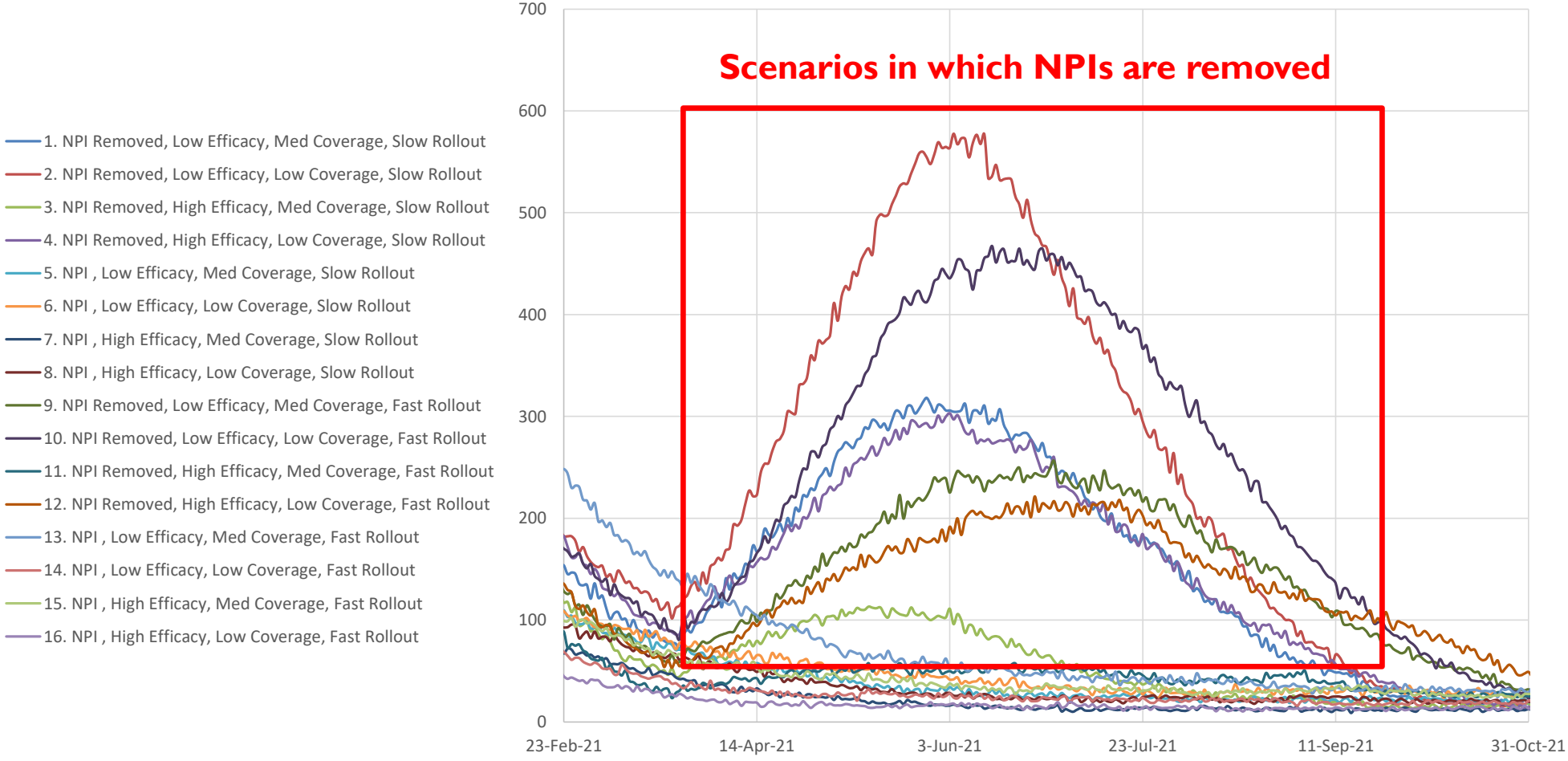
Daily Infections Over Time in **Forsyth County***



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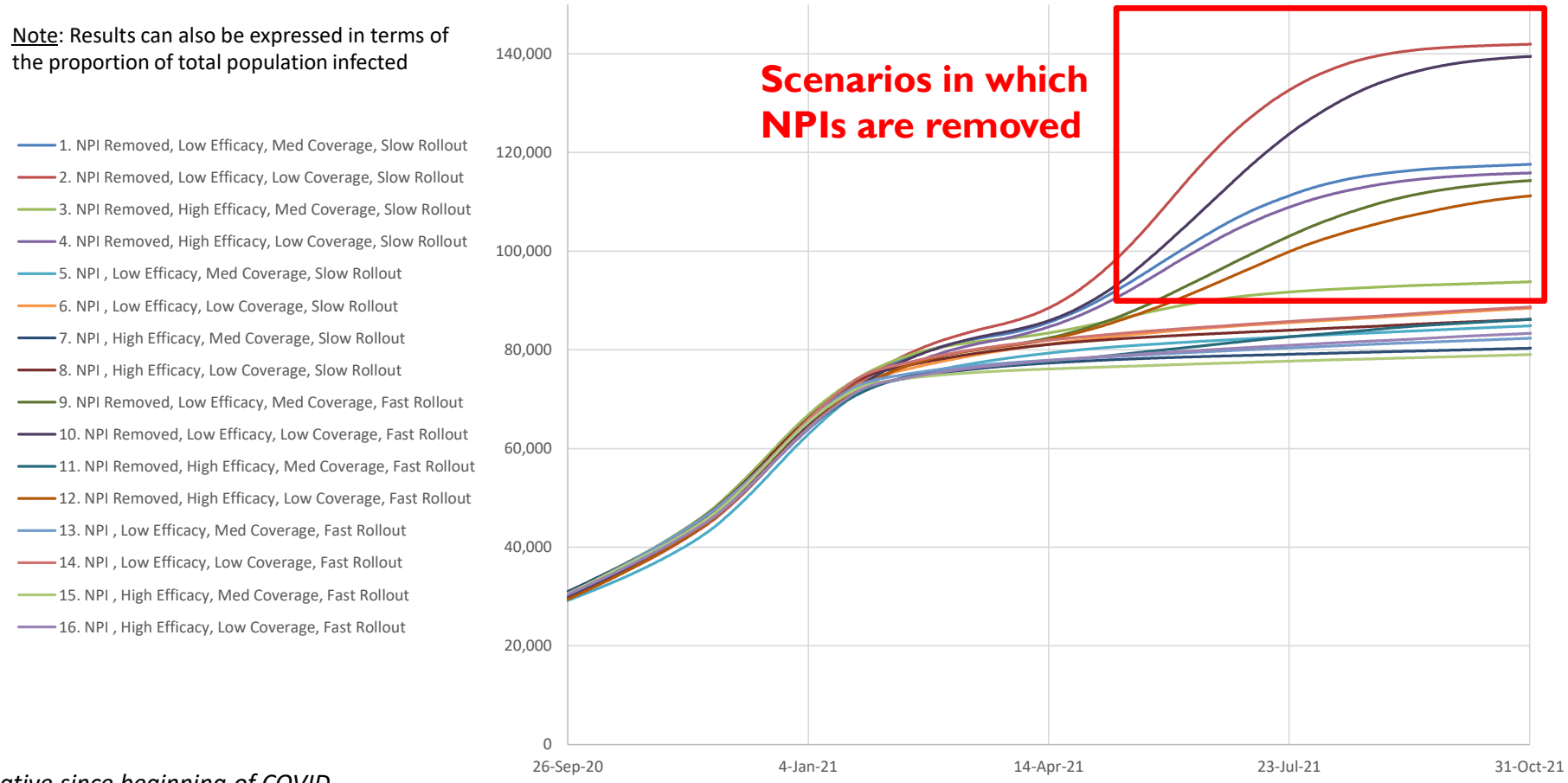
Cumulative[1] Infections Over Time in **Forsyth County***

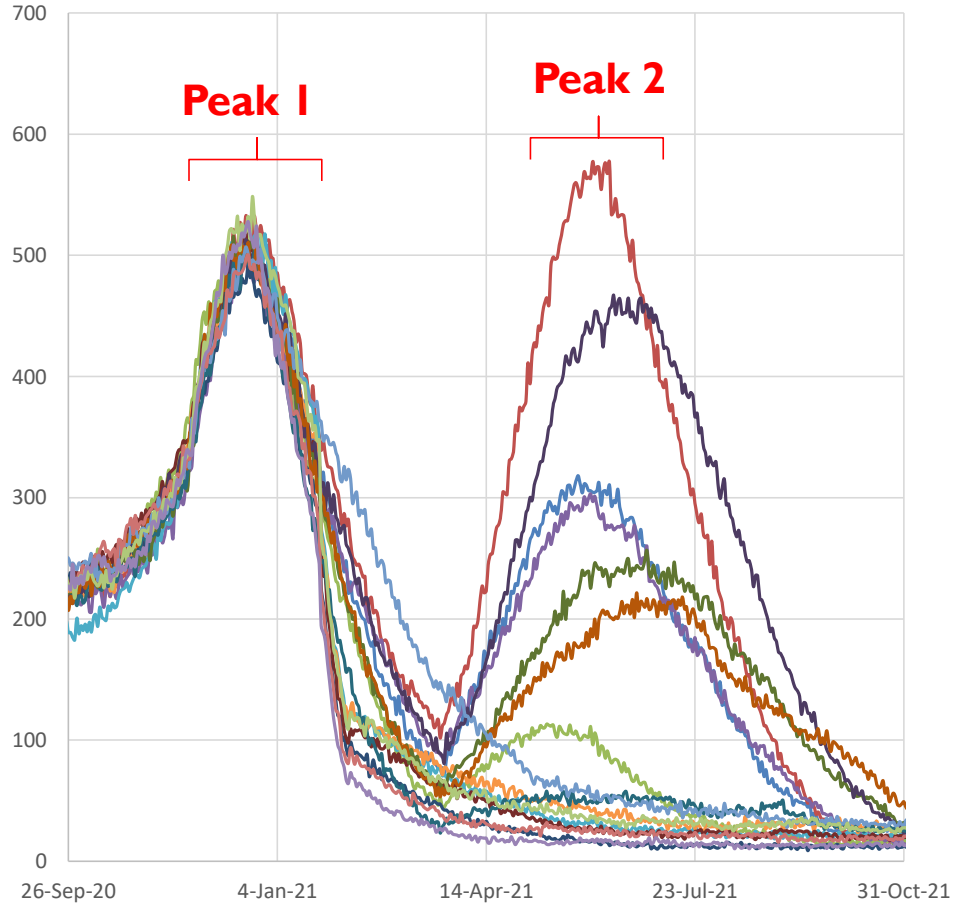
Note: Results can also be expressed in terms of the proportion of total population infected

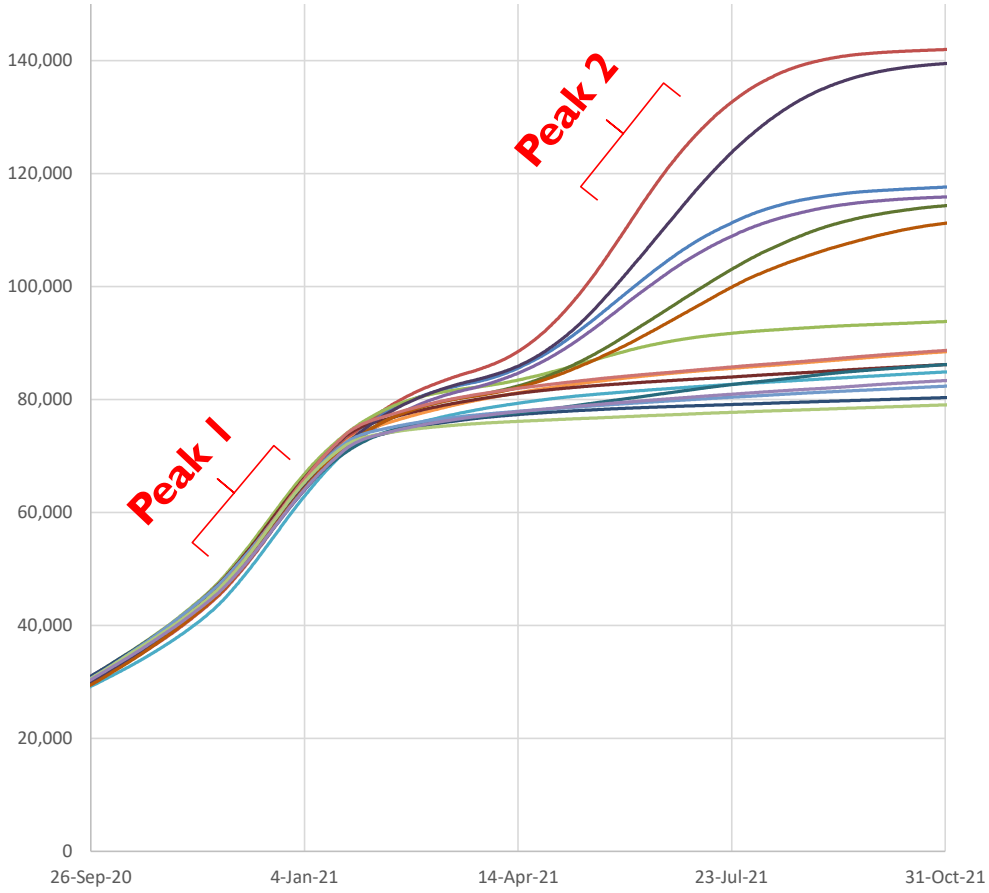


[1]*Cumulative since beginning of COVID pandemic*

**Error bands not shown for presentation clarity*

Daily Infections Over Time* → **Cumulative** Infections Over Time

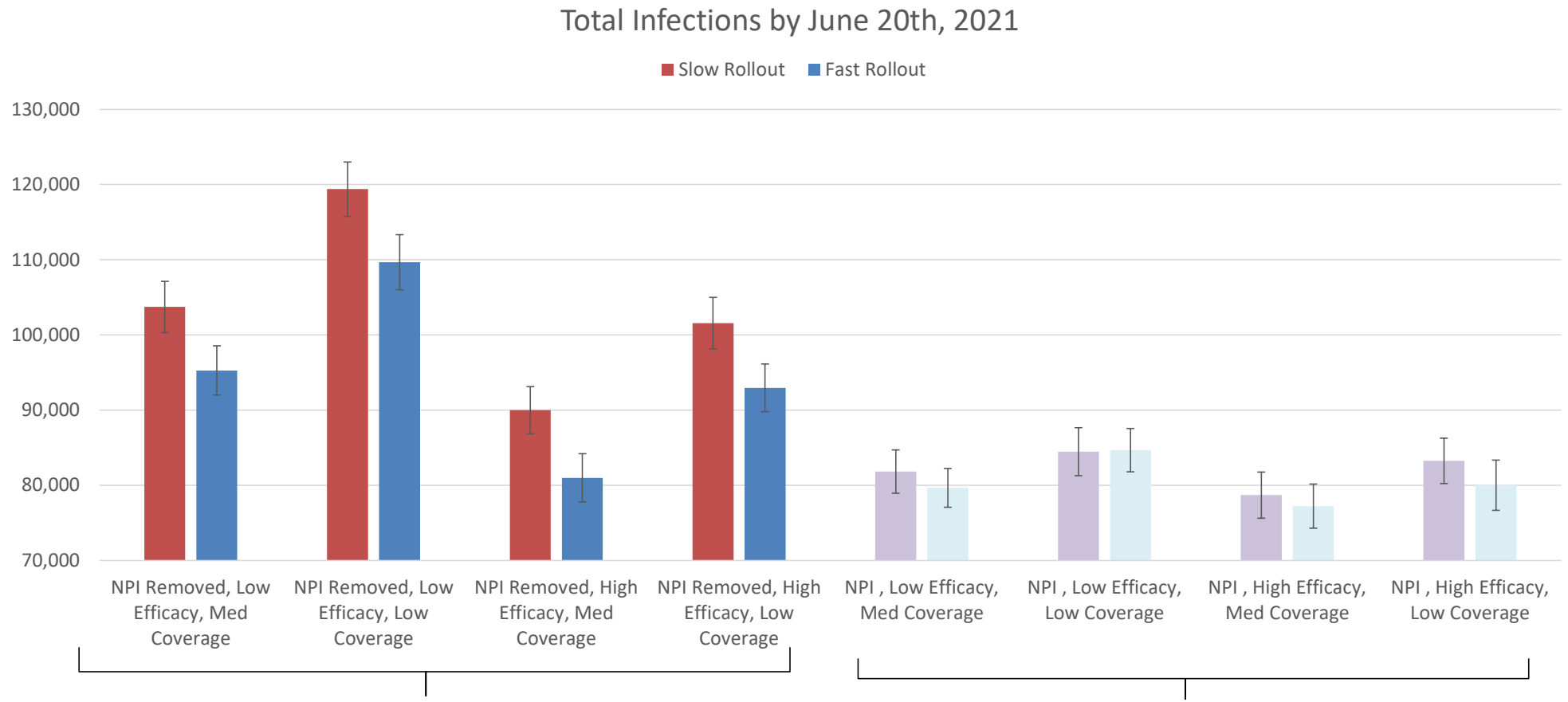




Data from Forsyth County

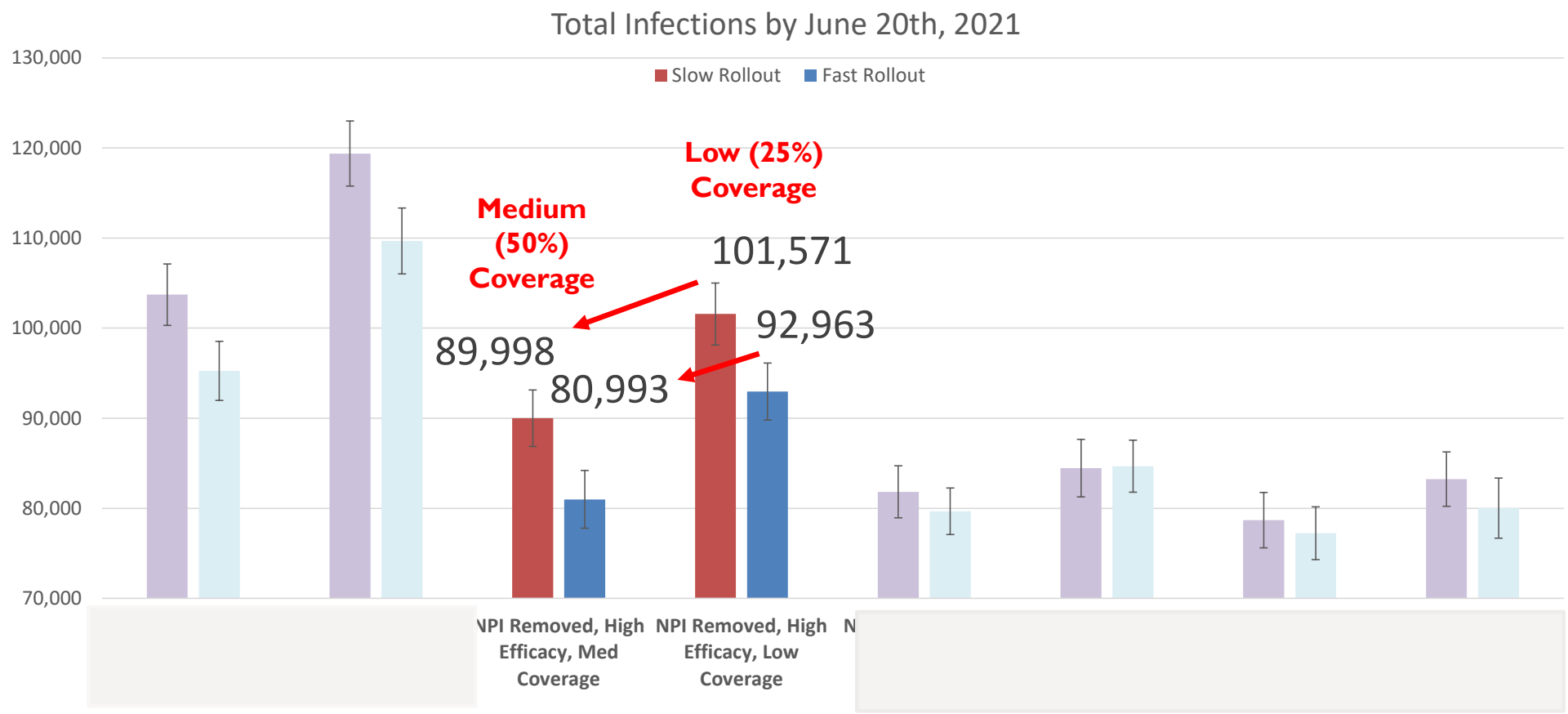
**Error bands not shown for presentation clarity*

Focus #1: Maintaining NPIs is associated with a substantial reduction in cumulative infections by the start of summer…



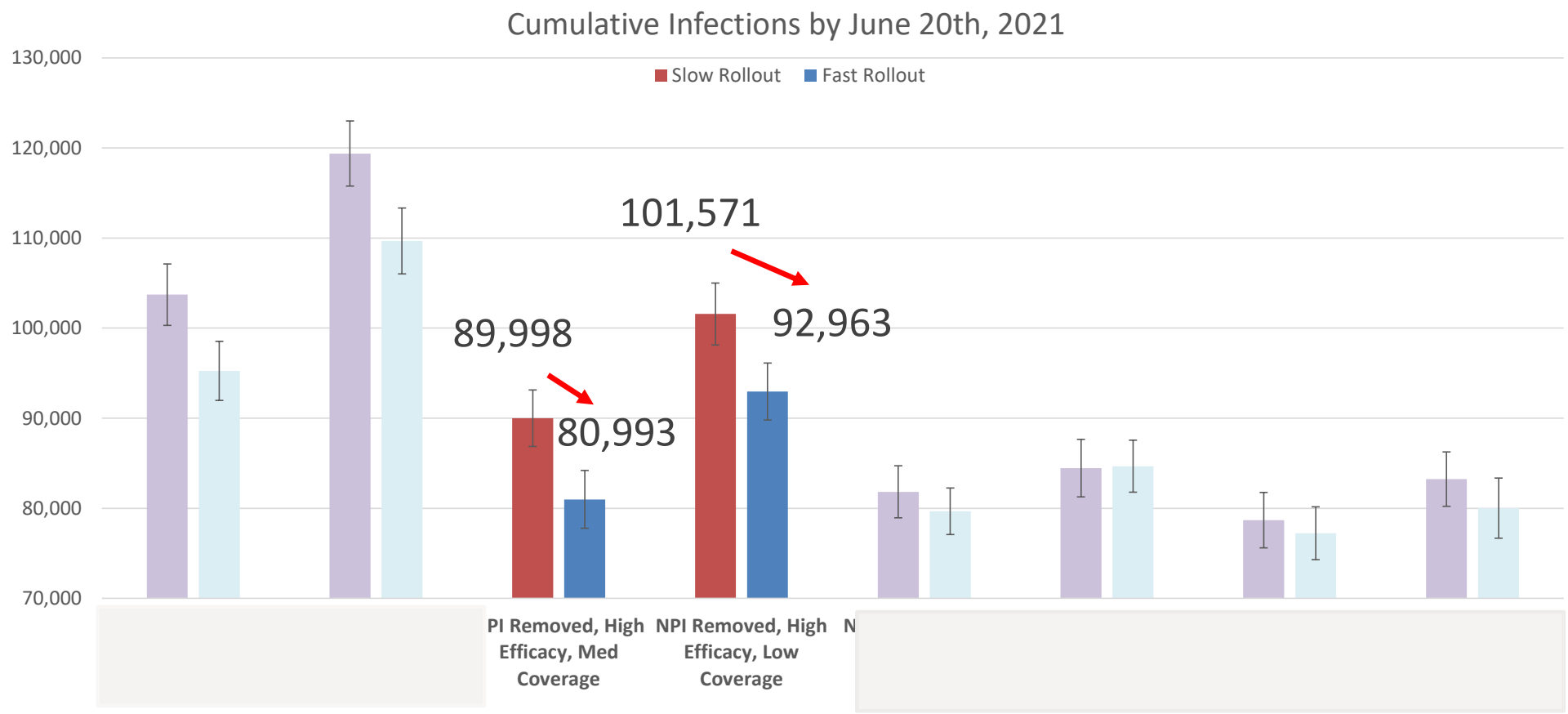
Data from Forsyth County

Focus #2: With NPIs removed, higher vaccine coverage leads to ~10,000 fewer infections by June 20th, 2021, depending on rollout speed…

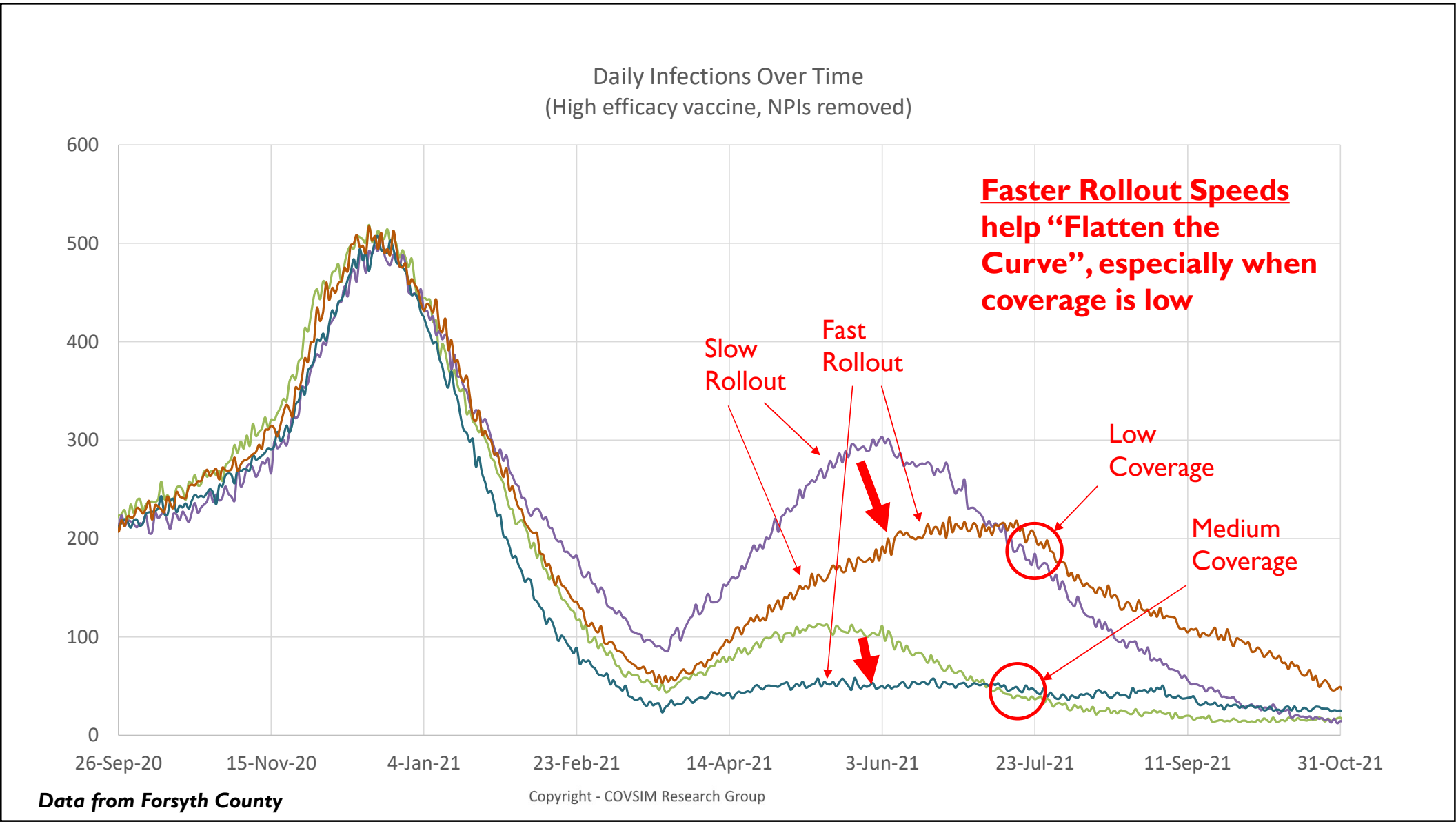


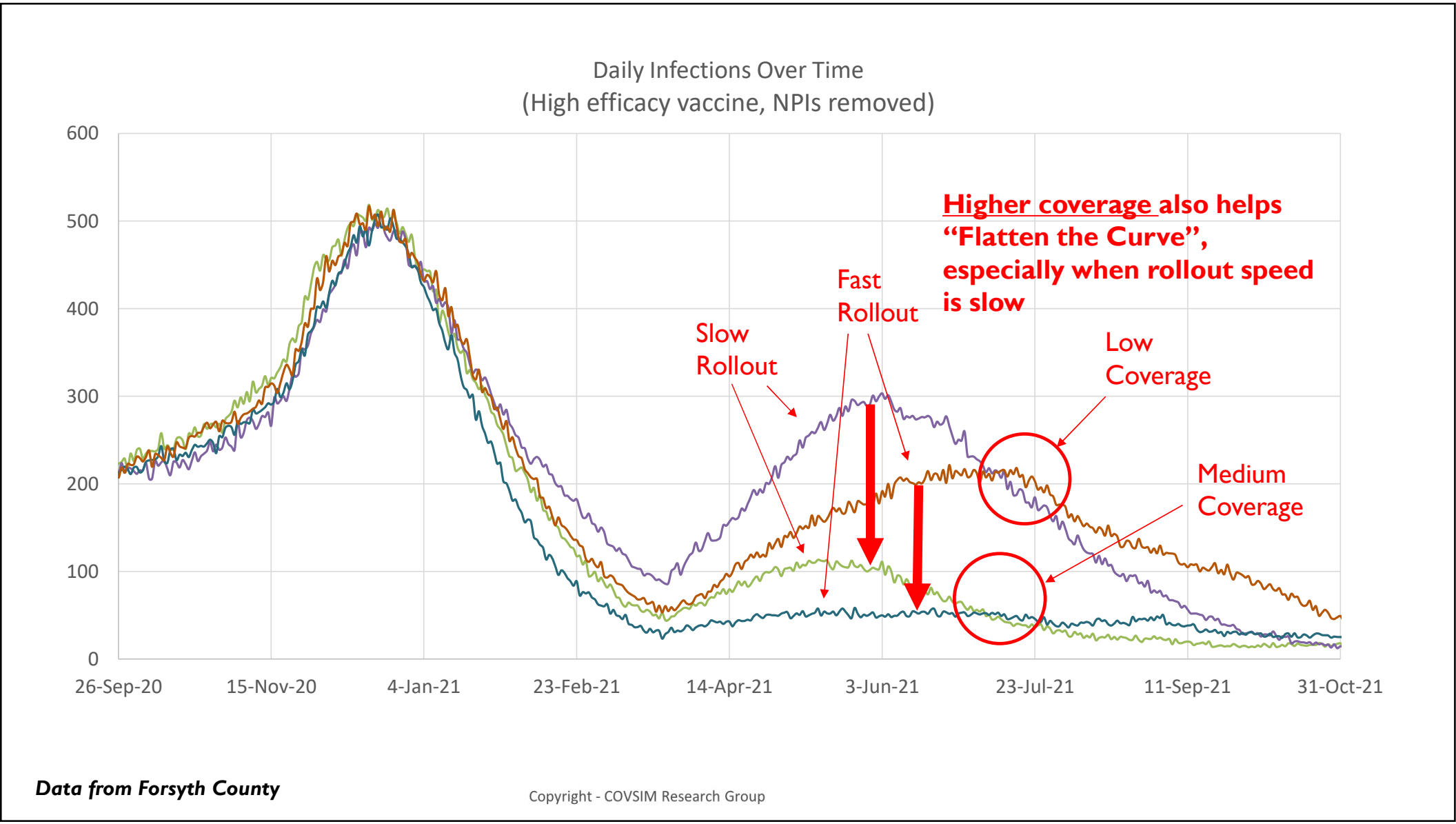
Data from Forsyth County

…and fast rollout leads to ~10,000 less infections compared to slow rollout at the same coverage level



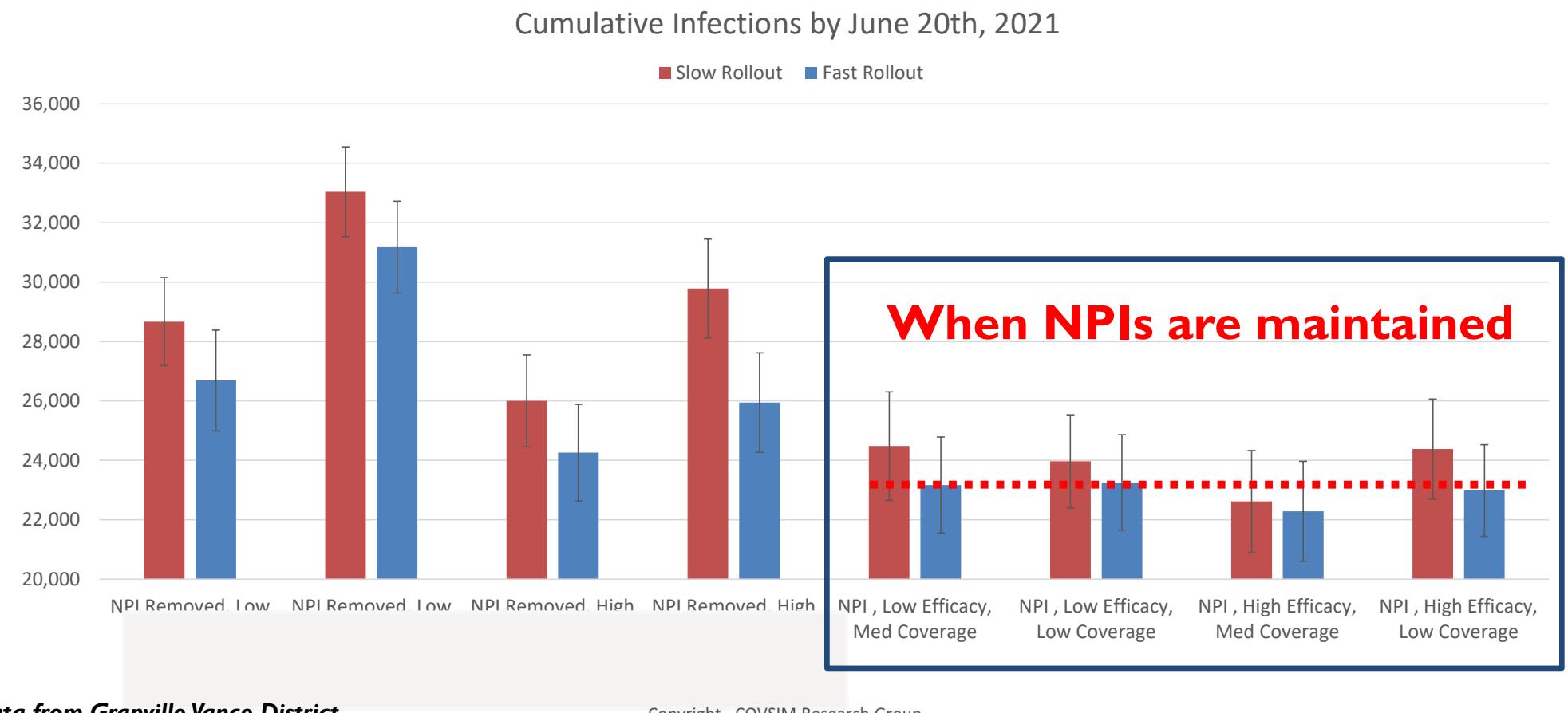
Data from Forsyth County


Daily Infections Over Time
(High efficacy vaccine, NPIs removed)
600
500
400
300
200
100
0
26-Sep-20
15-Nov-20
4-Jan-21
23-Feb-21
14-Apr-21
3-Jun-21
23-Jul-21
11-Sep-21
31-Oct-21
Faster Rollout Speeds help "Flatten the Curve", especially when coverage is low
Slow Rollout
Fast Rollout
Low Coverage
Medium Coverage
Data from Forsyth County
Copyright - COVSIM Research Group



Data from Forsyth County

Focus #3: If NPIs remain, infection levels are less sensitive to vaccine rollout speed, coverage, and efficacy, compared to when NPIs are removed.



Data from Granville Vance District

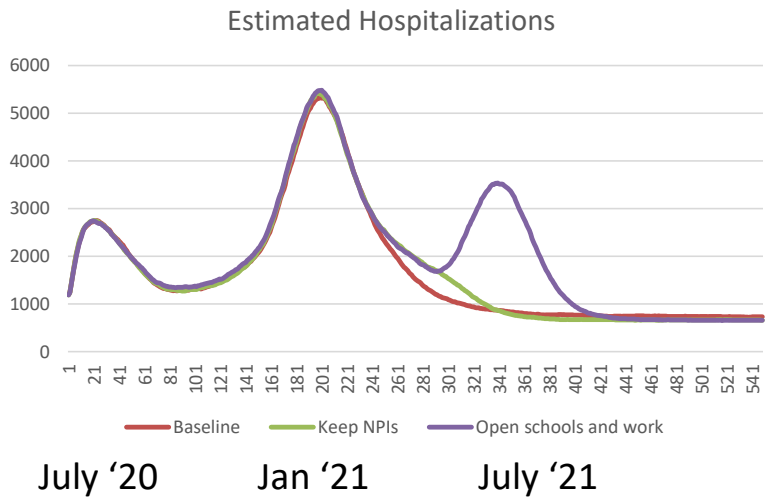
Three Key Takeaways

1. **Maintaining NPIs** is an important mechanism to curb infection rates. Lifted NPIs may allow for disease spread to return to 2nd wave levels during winter holidays
2. **If NPIs are lifted**…
    - Vaccine rollout speed becomes influential in “flattening the curve”, especially at lower coverage levels;
    - Higher vaccine coverage is also influential in “flattening the curve”, especially at low rollout speeds
3. **When NPIs remain…**
    - Our model estimates consistent yet smaller reductions in total infections across different vaccine scenarios, compared to when NPIs are removed.

Variant B.1.1.7 (Quick Results)

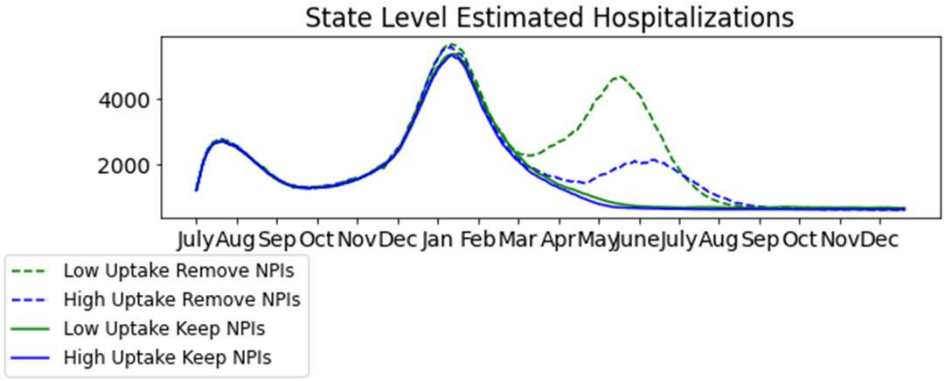
- Scenario assumes variant (50% more infectious) grows from Feb 15 for 10 weeks
- Vaccine distributed ~ Jan to June; limited supply over horizon (6.4M total)
- Uptake like high seasonal flu (60-70% for 65+; 36-45% younger ages)
- Baseline: no variant; NPIs remain; Keep NPIs

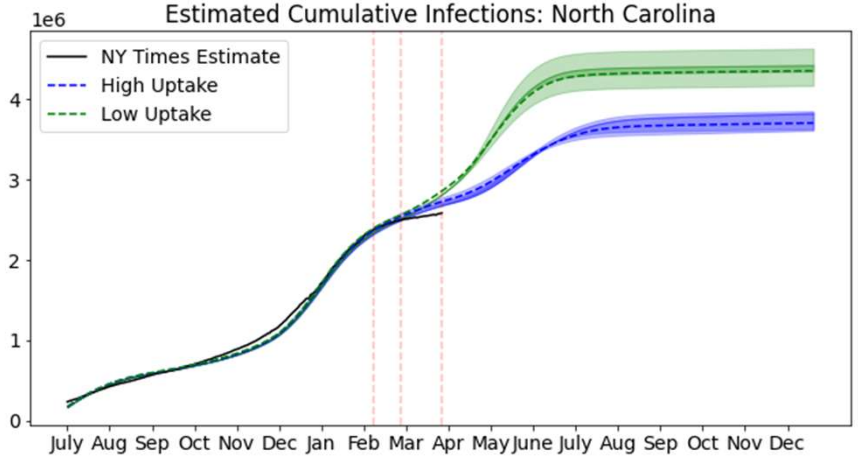
Baseline: no variant, NPIs remain
Keep NPIs: variant, NPIs remain
Open schools and work immediately and variant



Variant B.1.1.7 (Quick Results)

- Variant B.1.1.7 can be 50% more transmissible
- Scenario assumes variant grows from Feb 15 for 10 weeks
- Vaccine distributed ~ Jan to June; 10M doses over horizon
- Highest uptake increases for 65+ (60-80% for 65+; 35-45% younger ages)
- The variant can have an impact even with higher vaccinations.

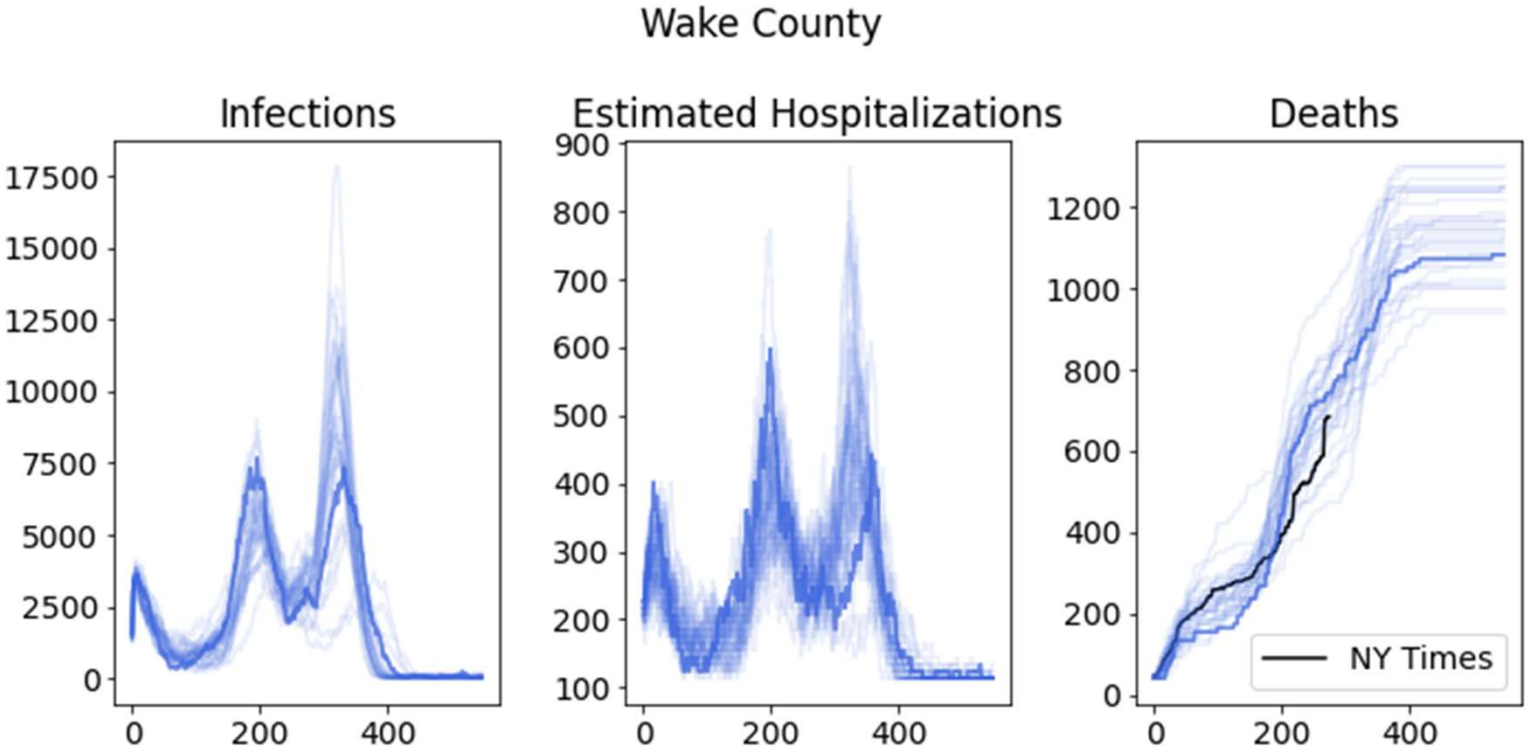




*Cones vary masks, vaccine uptake, and beta values by +/- 10%

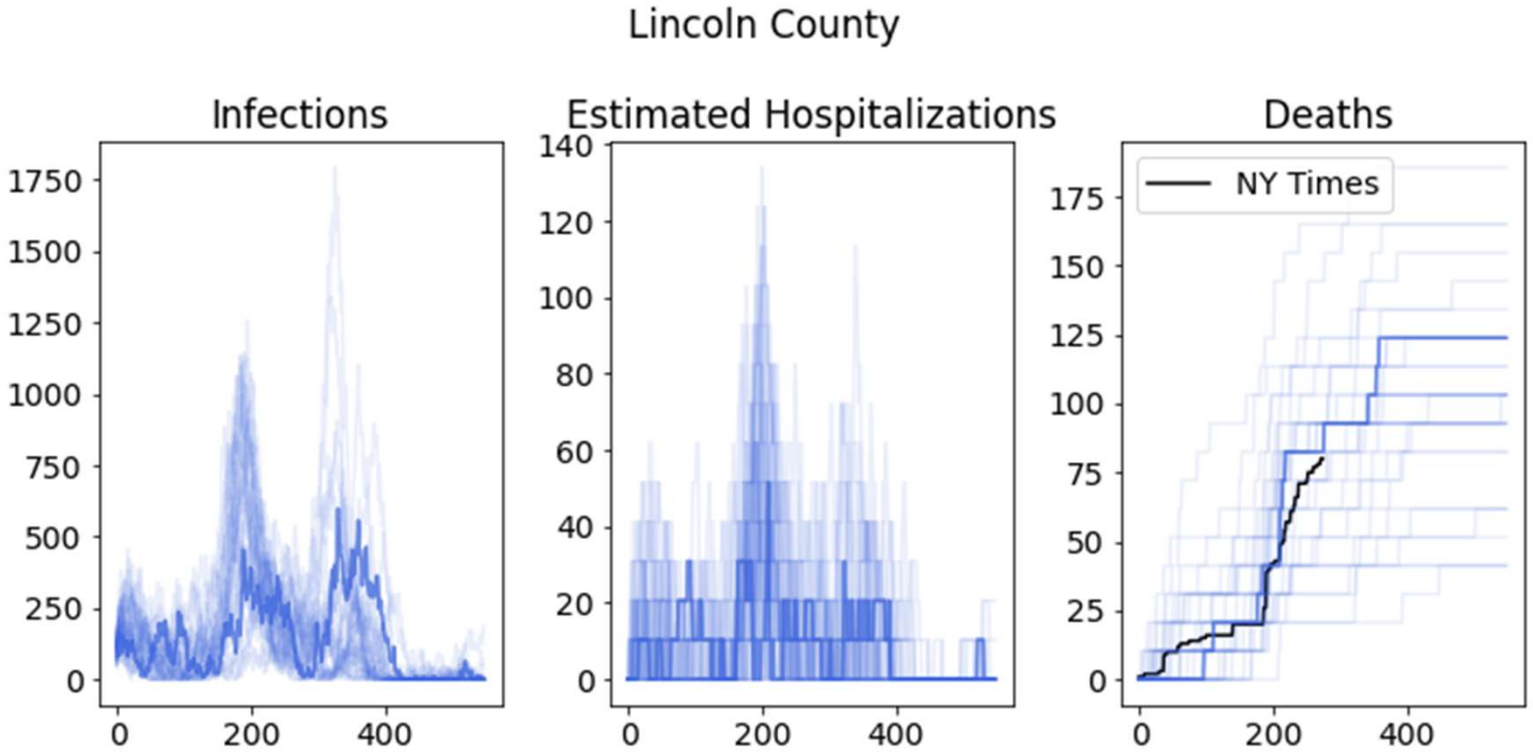
Differential Results by Counties: Urban County

- Highest seasonal uptake; 10M doses; 65+ then essential workers



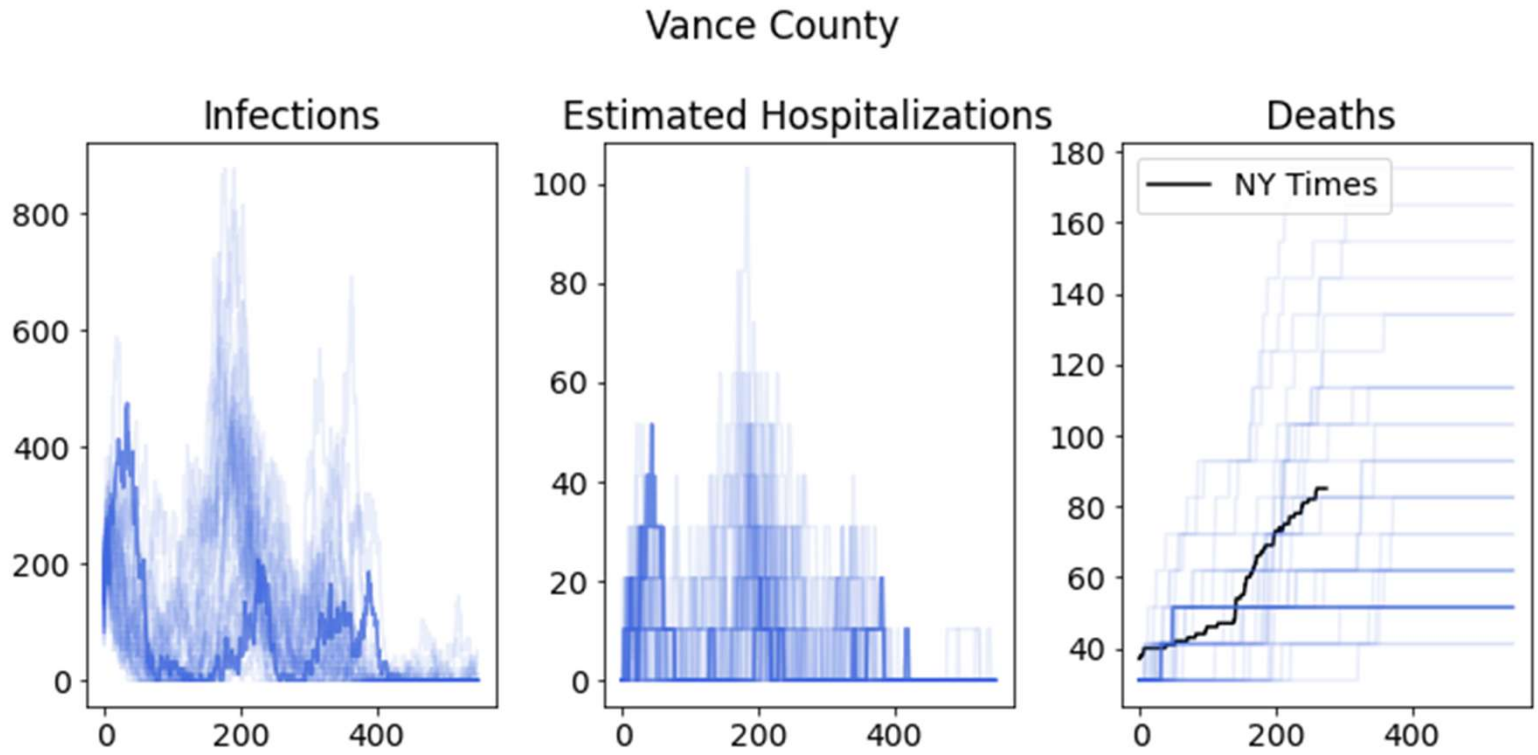
Differential Results by Counties: Suburban County

- Highest uptake; 10M doses; 65+ then essential workers; NPIs lift



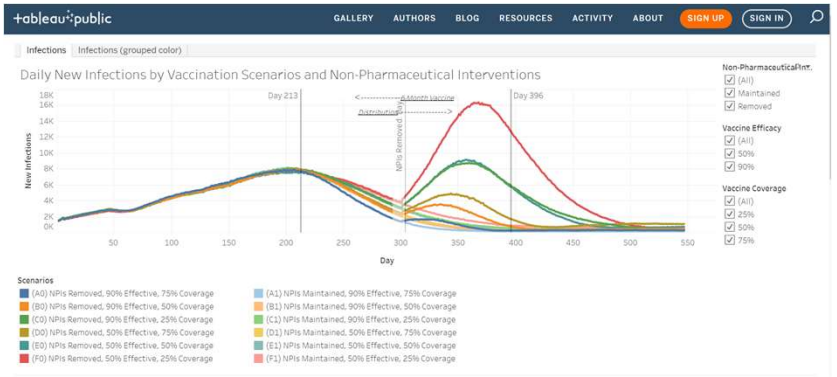
Differential Results by Counties: Rural County

- Highest uptake; 10M doses; 65+ then essential workers; NPIs lift



Dissemination

1. **Tableau Dashboard** with current modeling results at the state level and for each county in NC
2. **Dashboard** in GA with relevant results for that state
3. **Publications,** which present modeling results at the state level and additional background on model structure and capabilities
4. **Engagement** with several NC health departments



Opportunities for further Engagement with COVSIM research team

- Results can be extended to other states and counties
- This can result in communication tools such as:
  1. **Individual Presentations** for local decision makers (with unique county-level data), e.g.
     1. County commissioners
     2. Boards of health
     3. School boards
  2. **Communication output** for social media or email blasts, e.g.
     - "For every 10 more individuals who are vaccinated in [County], we estimate a XX% reduction in total cases by the start of summer."
     - "If [County] residents completely stop following the 3 Ws now, our model estimates that COVID-19 case numbers may return to levels experienced during Christmastime."
  3. P**ress releases** for local newspapers
  4. **Engagement with a simplified version of the model or results** can help local decision makers gain a deeper understanding of COVID-19 dynamics and the impact of changes in things like vaccine coverage, transmission rates, ongoing importance of maintaining components of NPIs, etc.

Questions

- Dr. Julie Swann, jlswann@ncsu.edu

- Acknowledgments:
  - Georgia Tech (GA Covid Model)
    - Faculty: Pinar Keskinocak and Nicoleta Serban
    - Team: John Asplund, Arden Baxter, Buse Eylul Oruc
    - Previous students and collaborators (GA Flu model)
  - NC State
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    - Raymond Smith (ECU)
    - Team: Karl Johnson

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