9-23-20 UM Modeling Update

Compartmental model updates

- Changed community population from Washtenaw to Ann Arbor
- Expanded model of disease progression in asymptomatic individuals and testing in asymptomatic individuals
- Sampling across a wide distribution of parameter values, now updated and expanded
- Added weekly surveillance testing of on-campus individuals (faculty/staff/students), assuming:
  - Latently infected (i.e. infected but not yet infectious) individuals are less likely than infectious (including asymptomatic and presymptomatically infectious) individuals to test positive
  - We assume an otherwise perfect test and do not account for sensitivity and specificity in the transmission dynamics (yet)
- Working on adding the same changes to the network model as well

Results Overview

- 1. Symptomatic Testing
- 2. Surveillance Testing
- 3. Student Return Scenarios
- Appendix
  - 1. Symptomatic Testing Additional Figures
  - 2. Surveillance Testing Additional Figures
  - 3. Student Return Scenario Additional Figures
  - Model description & previous results

Symptomatic & Surveillance Testing Scenarios

Preliminary Results: Symptomatic & Surveillance Testing Scenarios

- Symptomatic testing & isolation of students can substantially reduce infections in both the university and community
  - Shorter time from onset to test and isolation shows strong impact in reducing disease spread in the model
- Surveillance testing can provide further reductions in infection levels
  - Surveillance testing not as effective as rapid symptomatic testing, but still substantial
  - Level and duration of infectiousness of asymptomatic individuals is currently very uncertain, but will affect the estimates of impact of surveillance testing—currently sampling over wide ranges based on preliminary estimates in the literature
- Overall: Surveillance testing may generate substantial reductions, but model suggests it is important to build on a foundation of fast, effective symptomatic testing
- To explore next: targeted & pop up testing (South Quad as an example)

Speed of Symptomatic Testing

Rapid symptomatic testing can substantially reduce cumulative cases over the semester

- Explore scenarios for time from onset to isolation, assuming 75% of students seek testing and isolation is 75% effective
- Note that time from onset to isolation can be affected by:
  - Individuals' time to seek testing once symptoms appear
  - Test turnaround time
  - Time to isolation of ill individuals
- Note that onset-to-isolation times under 1 day may be difficult to achieve in practice, since they rely on both rapid testing and isolation as well as on individuals seeking testing immediately upon symptom onset

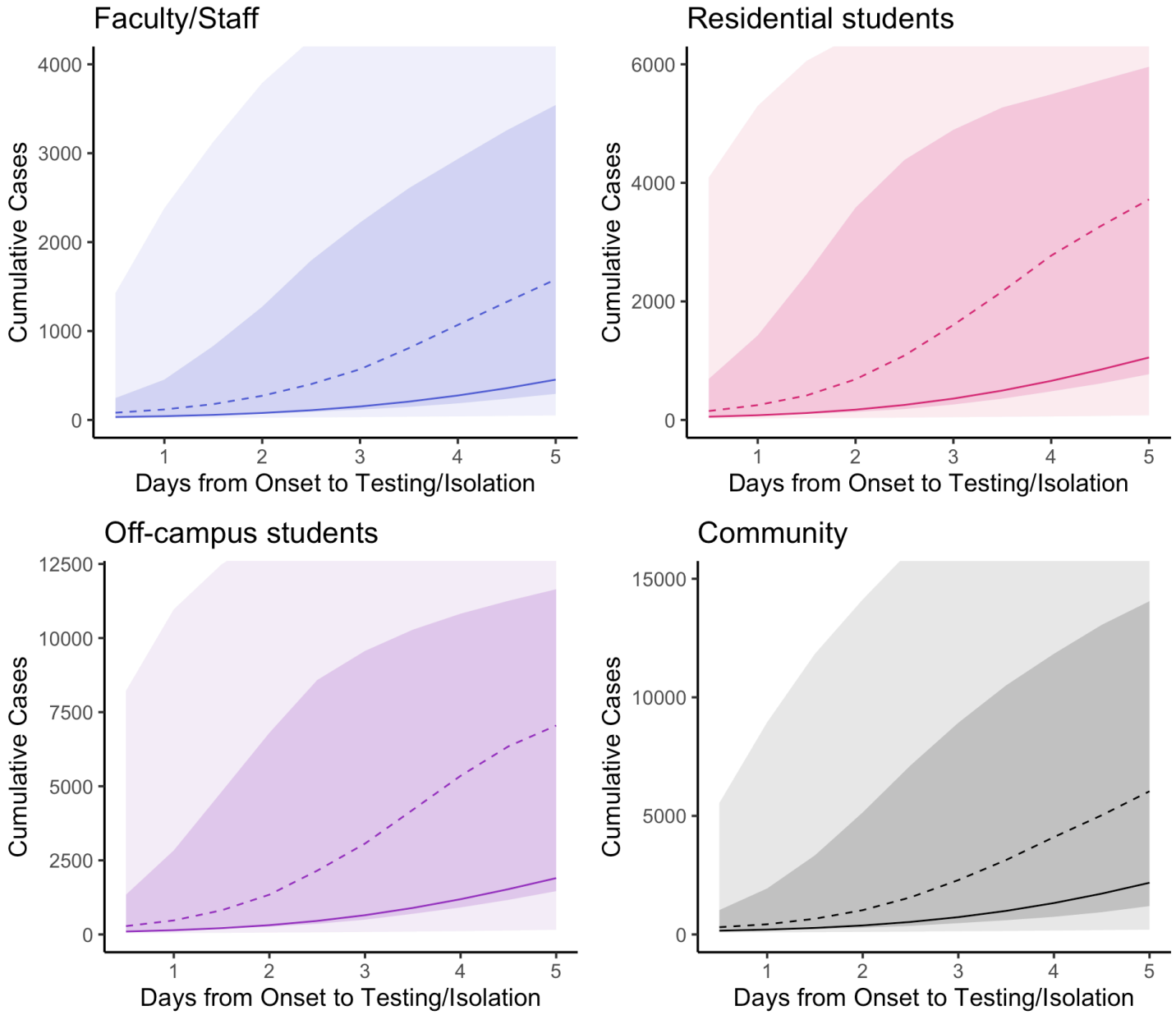

Figure 1a. 1000 simulations of cumulative cases over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles. Note the y-axis cuts off some of the 5-95% quantile, see appendix for zoomed out version.

Complete symptomatic testing and isolation in students

- Assuming 100% of students seek testing and isolation is 100% effective
- Similar effect—rapid testing and isolation can substantially reduce cumulative cases over the semester on campus and in the community
- Note that the y-axis scales are different than the previous slide

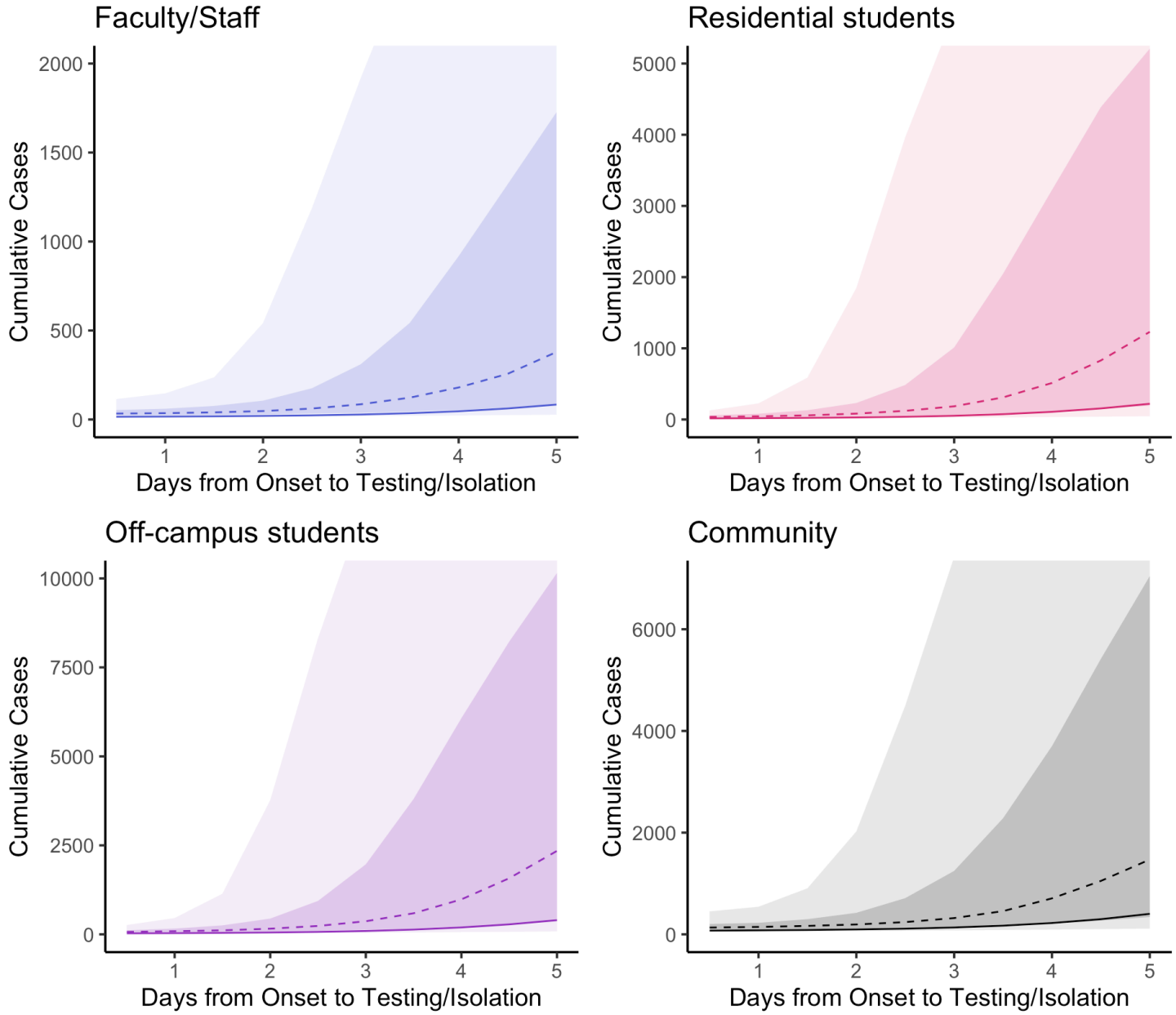

Figure 1b. 1000 simulations of cumulative cases over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles. Note the y-axis cuts off some of the 5-95% quantile, see appendix for zoomed out version.

Symptomatic testing impact on underlying infections

- Same plot as Figure 1a, but plotting underlying infections rather than detected cases
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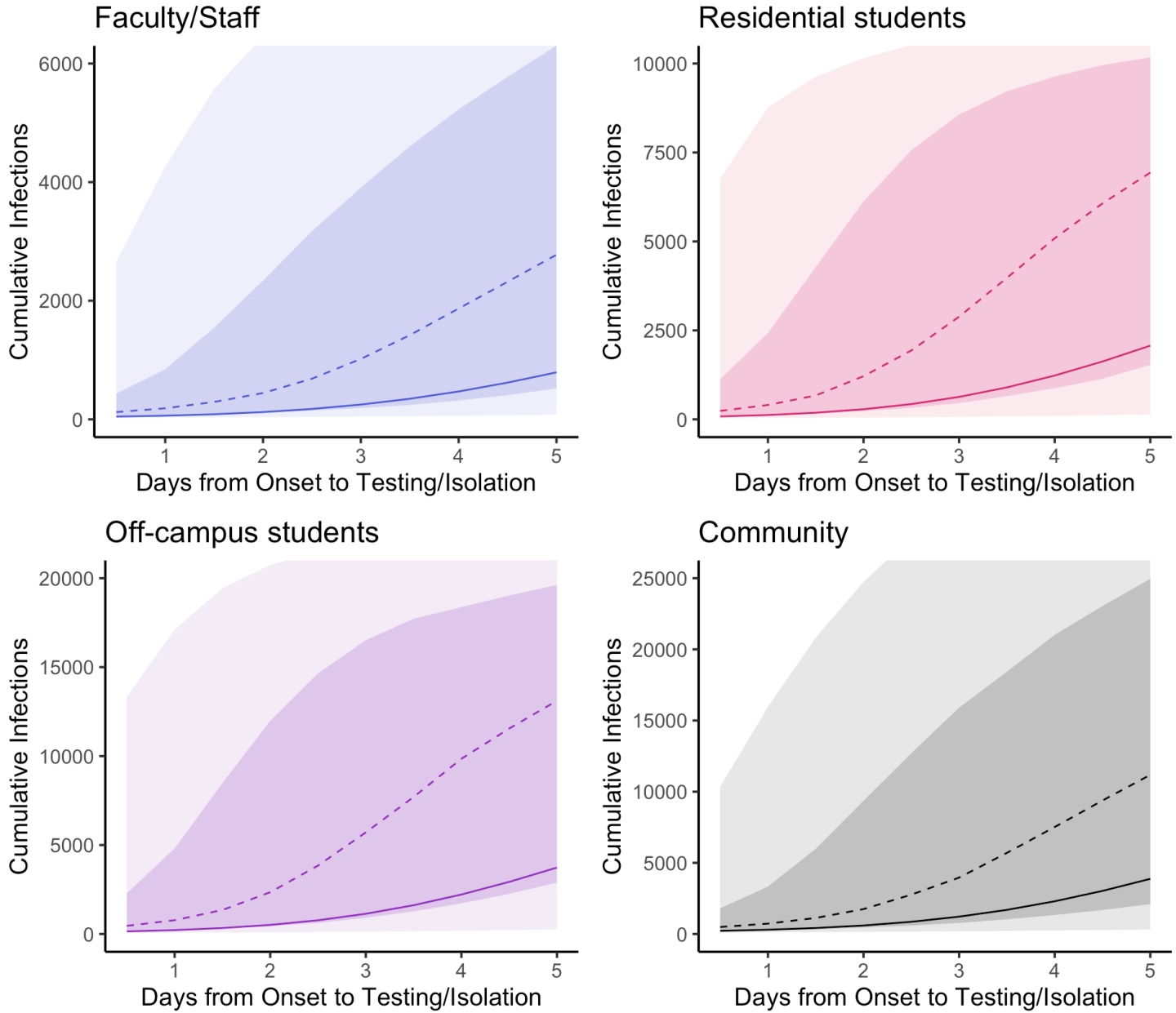

Figure 1c. 1000 simulations of cumulative underlying infections over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles. Note the y-axis cuts off some of the 5-95% quantile, see appendix for zoomed out version.

Symptomatic testing impact on underlying infections

- Same plot as Figure 1b, but plotting underlying infections rather than detected cases
- Assuming 100% of students seek testing and isolation is 100% effective
- Similar effect—rapid testing and isolation can substantially reduce cumulative infections over the semester on campus and in the community
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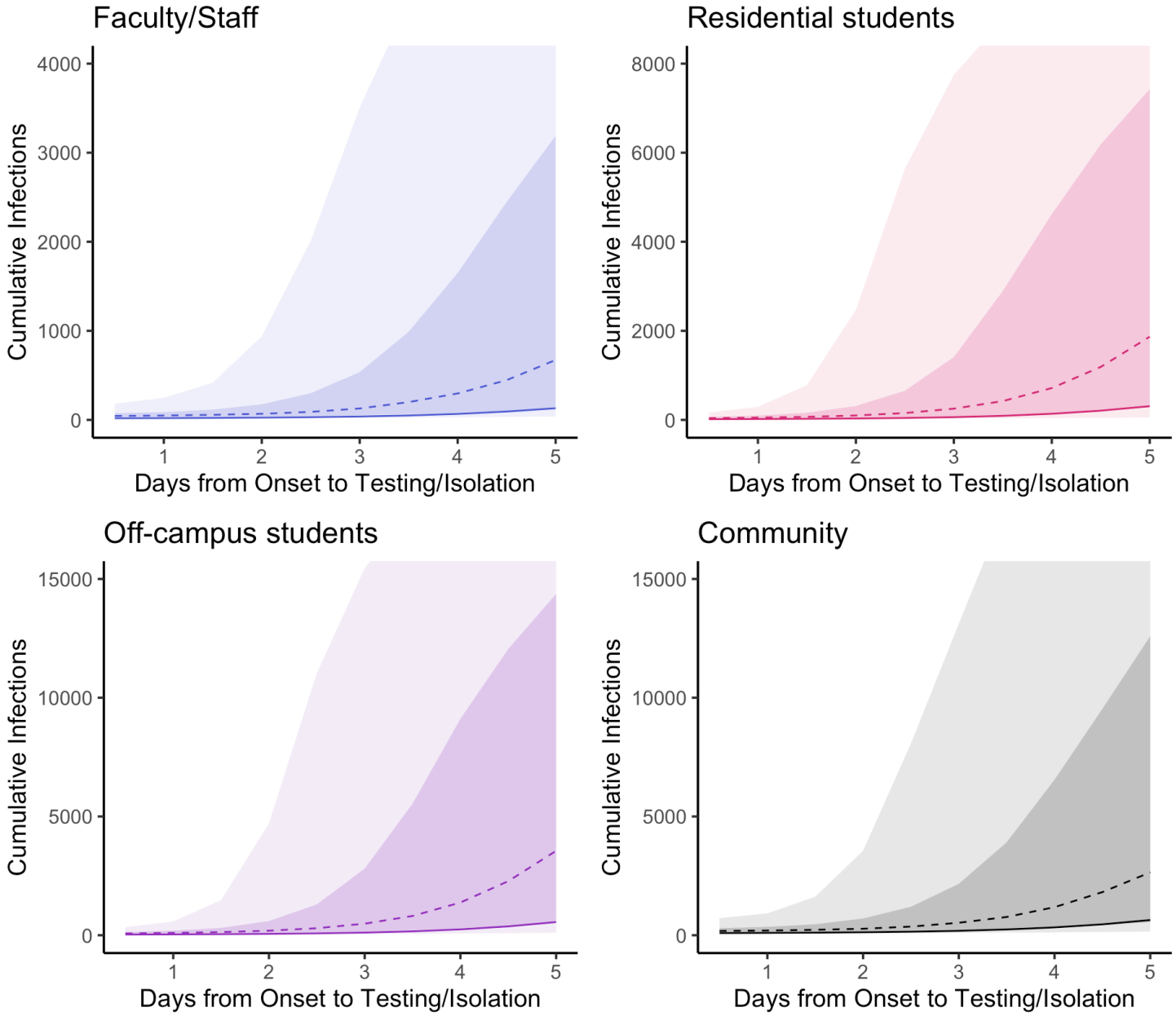


Figure 1d. 1000 simulations of cumulative underlying infections over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles. Note the y-axis cuts off some of the 5-95% quantile, see appendix for zoomed out version.

Scale of Surveillance Testing

Surveillance testing: Cumulative Infections

- Increasing weekly surveillance testing reduces cumulative infections over the semester
- Note that because increased surveillance testing results in increased detection of cases, we examine underlying infections rather than (detected) cases
- Simulations assume baseline symptomatic testing as well, with 1-5 days time from onset to isolation

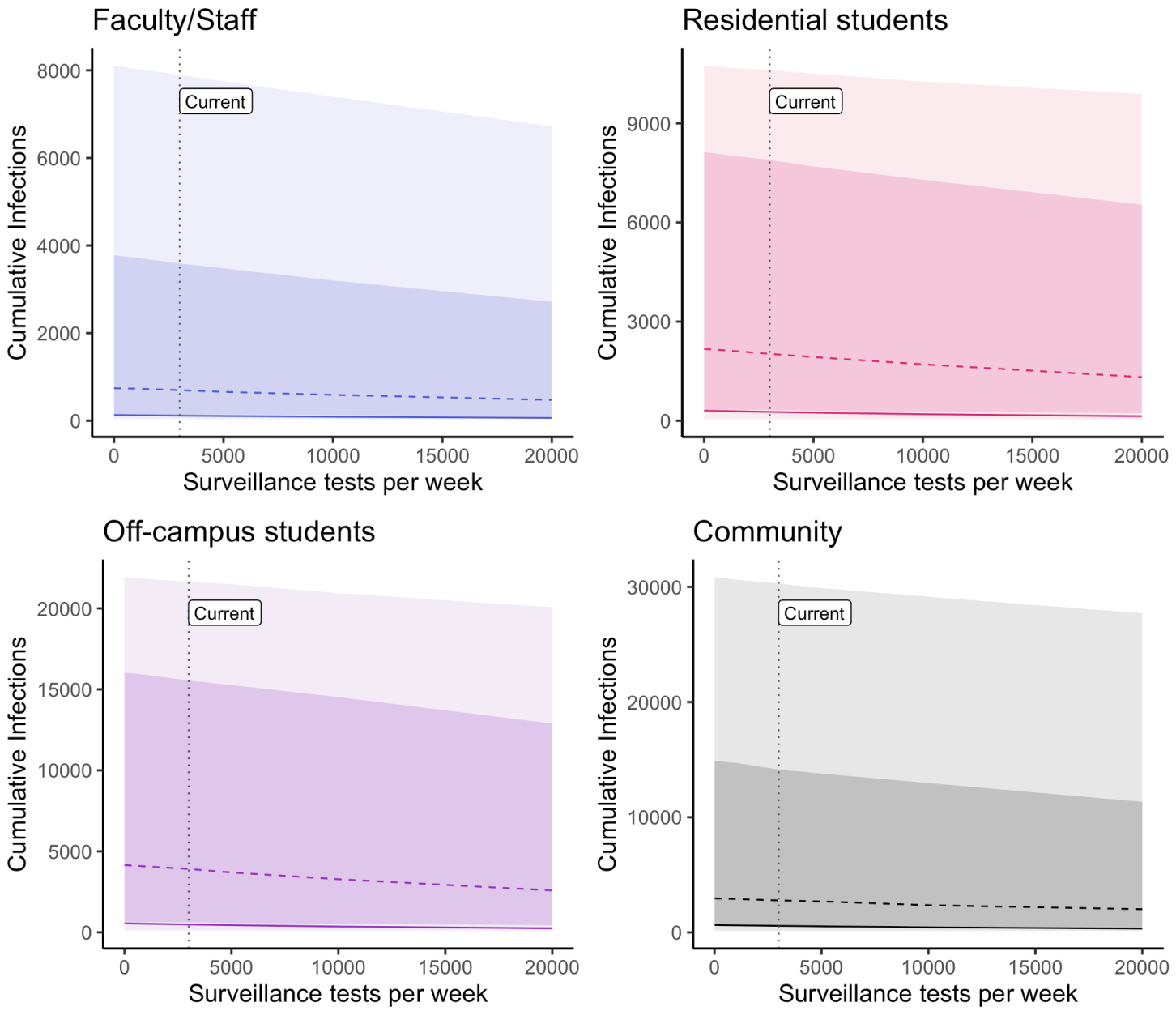


Figure 2a. 1000 simulations of cumulative underlying infections over the Fall 2020 semester across campus and in the Ann Arbor community as a function of surveillance tests per week. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Surveillance testing: Infections Prevented

- Increasing weekly surveillance testing prevents infections over the semester
- Note that because increased surveillance testing results in increased detection of cases, we examine underlying infections rather than (detected) cases
- Simulations assume baseline symptomatic testing as well, with 1-5 days time from onset to isolation

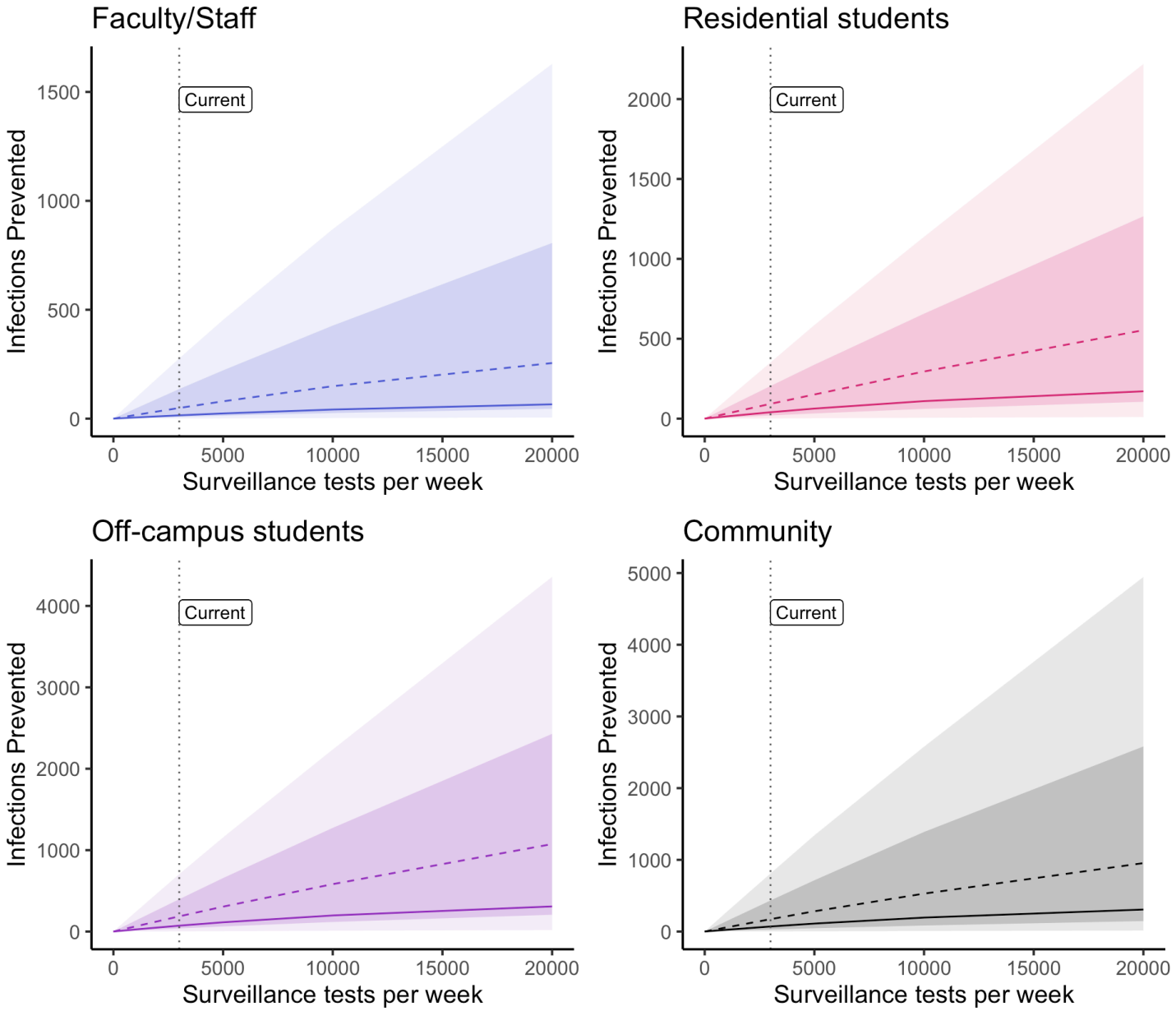


Figure 2b. 1000 simulations of infections prevented over the Fall 2020 semester across campus and in the Ann Arbor community as a function of surveillance tests per week. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Student Return Scenarios

Preliminary Results:
Impact of Students Returning

- Campus and community cases may increase substantially with increasing students returning
- Current student return levels appear to avoid the worst increases in cases for the campus and community
- Case increases are smaller but still substantial if we only consider the return of residential students
- For reference when looking at these results—the average daily incidence of cases in Ann Arbor in August was ~6.5 cases/day, which would be 585 cases over the 90-day simulation time range

Impact of residential and off-campus students returning to Ann Arbor

- Students returning may lead to a substantial increase in cumulative cases over the whole semester
- However, current levels of student return (near 75% for off campus and a bit lower for residential students) lead to smaller increases in cases than full student return would have
- Note that a student return of 0 would likely be impossible but is included for reference
- Simulations assume students are present for the entire semester, and do not account for intervention and mitigation efforts that would likely occur in response to case increases

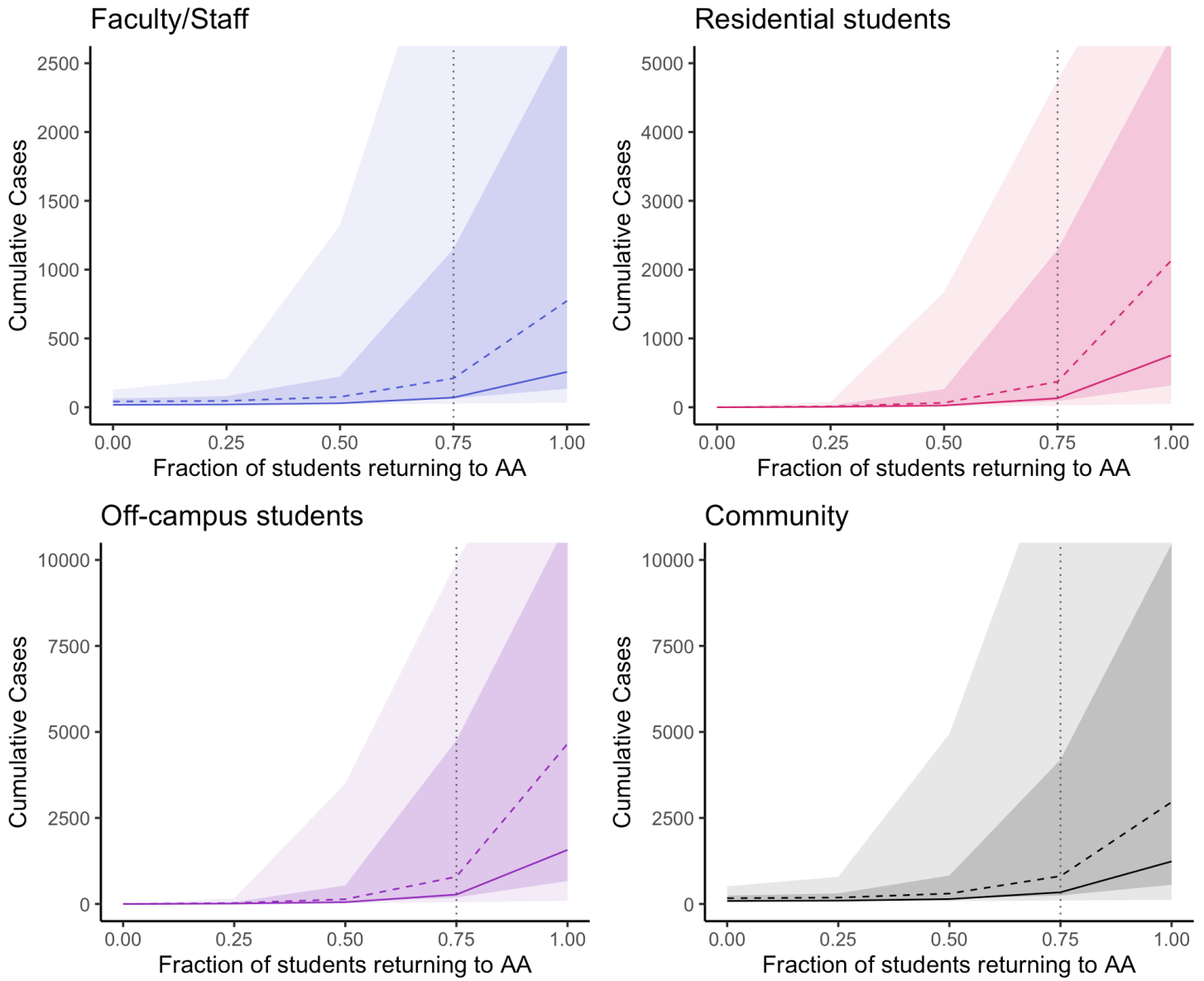
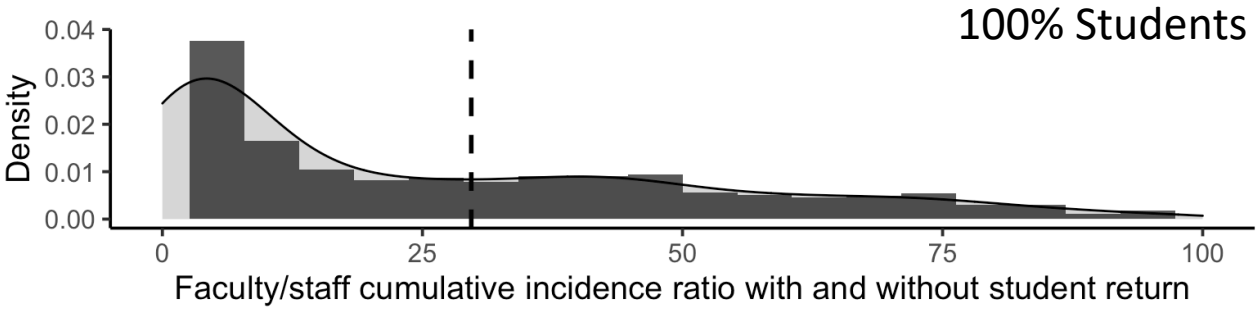
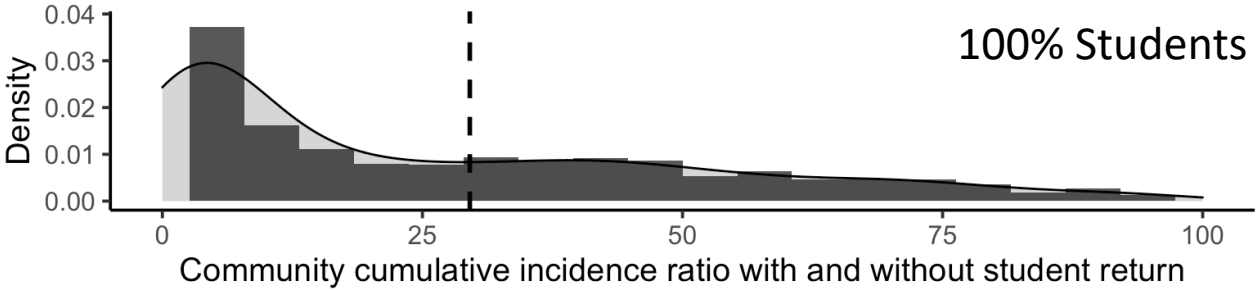


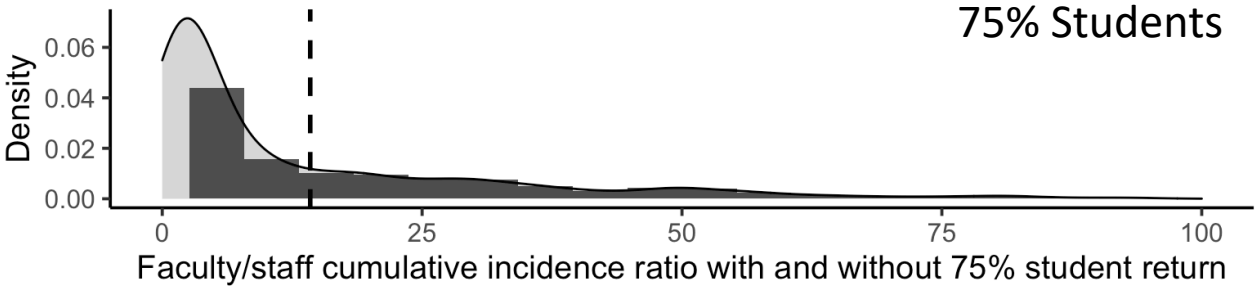
Figure 3a. 1000 simulations of cumulative cases over the Fall 2020 semester across campus and in the Ann Arbor community as a function of the fraction of off-campus and residential students who return for Fall semester. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

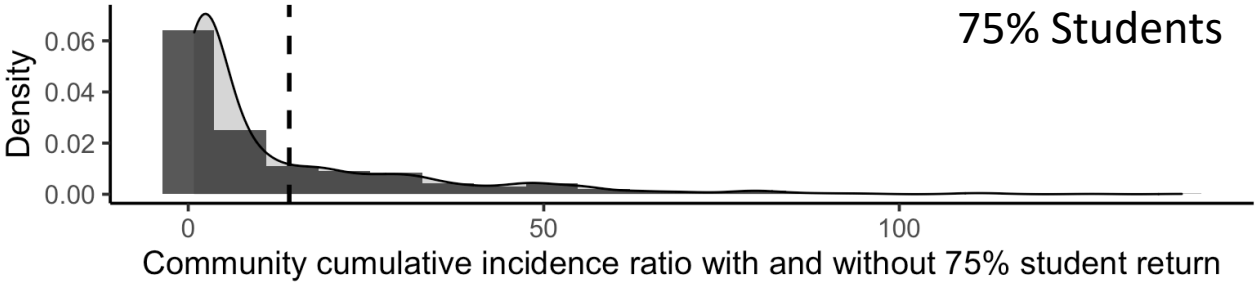
Cumulative case incidence ratio with and without student return

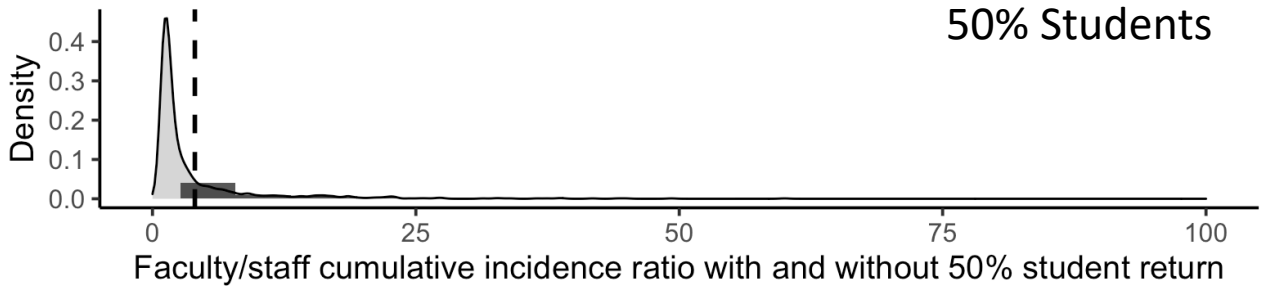
- Distribution of 1000 simulations, showing how many times higher the cumulative cases are with students returned to Ann Arbor than without
- Distribution shifts leftward as smaller numbers of students return
- Dashed line indicates the mean
- Plots of the 100% and 75% student return distributions are truncated at cumulative incidence ratio of 100, a small number of samples extend beyond that point and are not shown

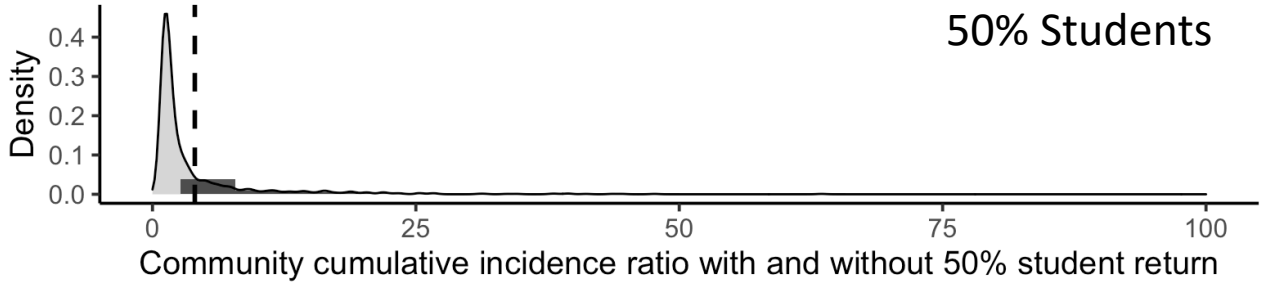












Histogram of model simulations of the ratio of cumulative cases with/without student return. Shaded region represents the estimated density based on the histogram.

Impact of residential students returning to Ann Arbor

- Increasing residential student return only causes smaller but still substantial increases in cases (note y-axis scale is different)
- Assumes that off campus students returning to AA are unchanged (using estimates that 18750 of the total 25000 off campus students have returned)
- The “current occupancy” line is estimated based on housing occupancy estimate of 8199 out of 12000 assumed total residential students
- Minimum dorm occupancy is estimated at 15% based on the students who could not reasonably leave on-campus housing even if the dorms were largely closed
- Simulations assume students are present for the entire semester, and do not account for intervention and mitigation efforts that would likely occur in response to case increases

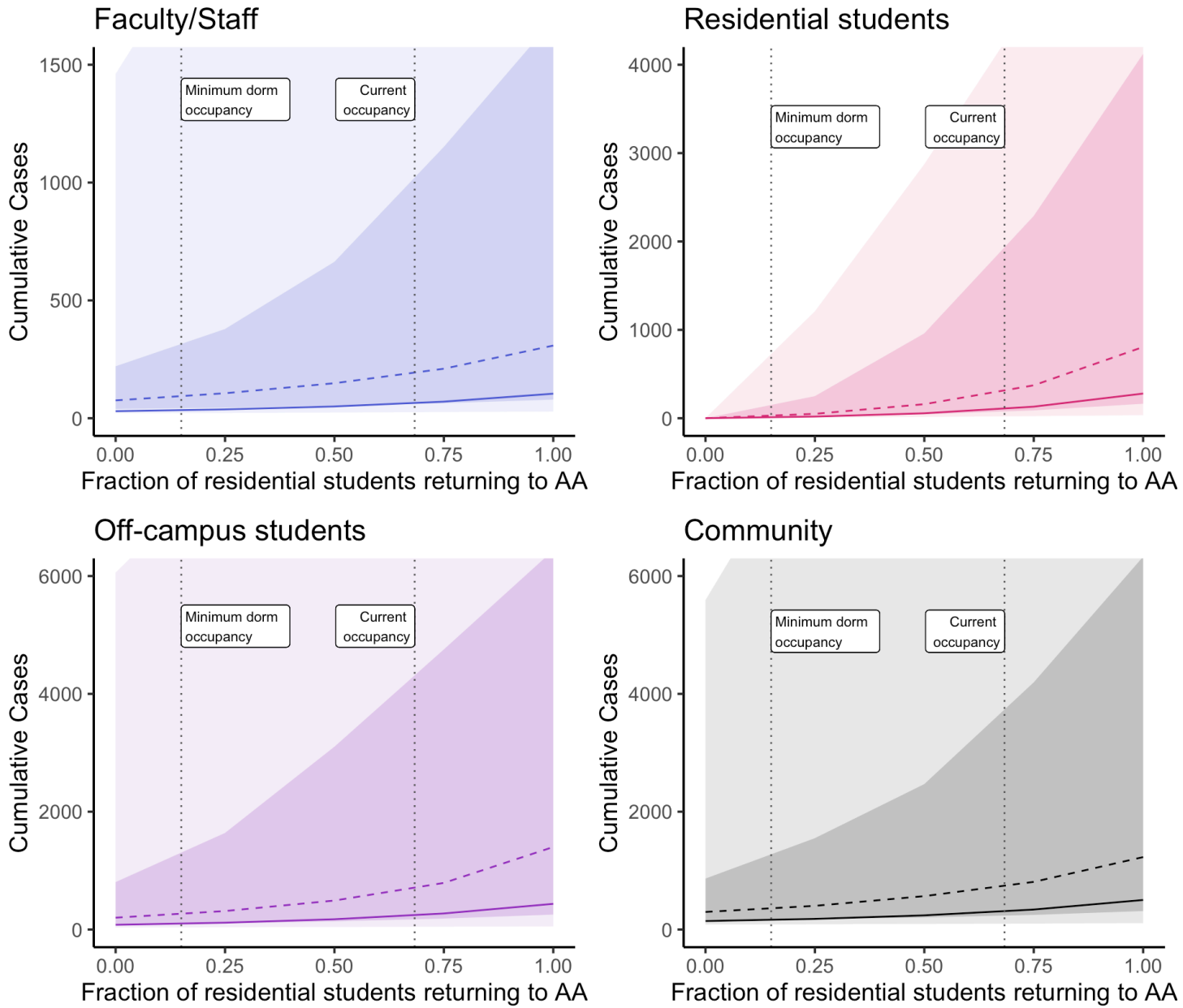
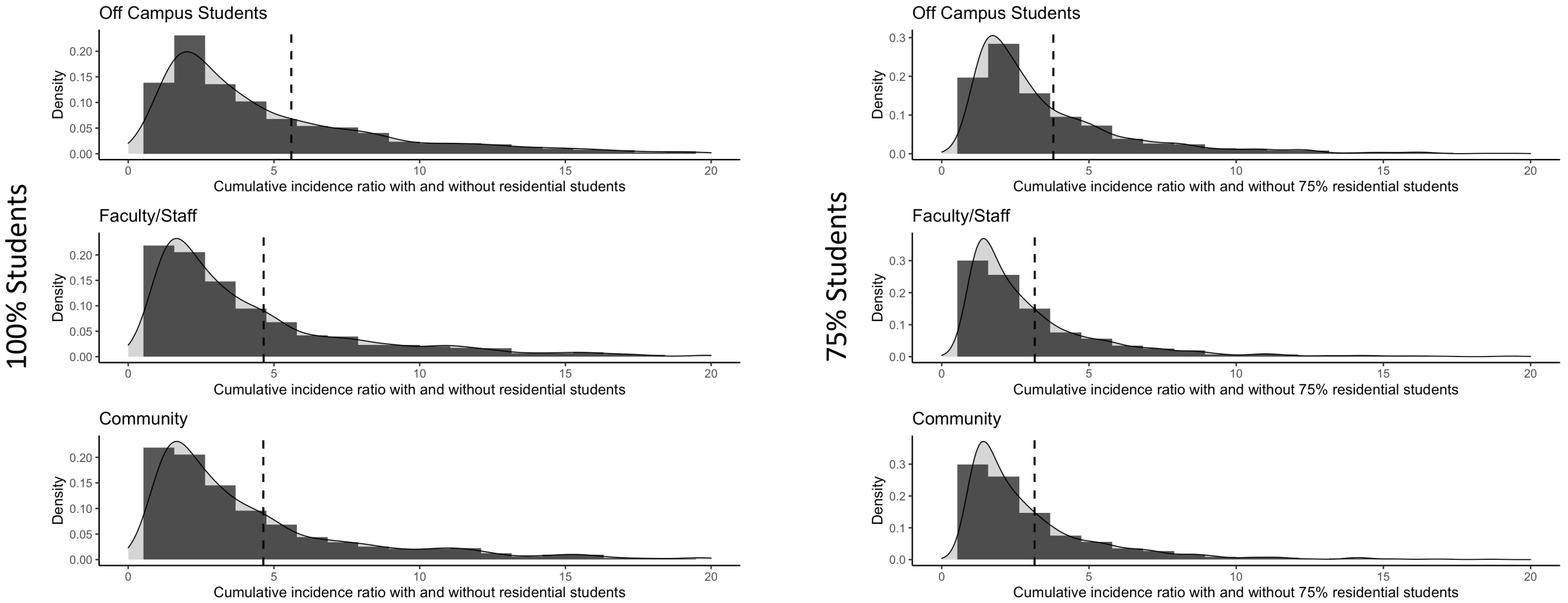


Figure 3b. 1000 simulations of cumulative cases over the Fall 2020 semester across campus and in the Ann Arbor community as a function of the fraction of residential students who return for Fall semester. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Cumulative case incidence ratio with and without residential student return

- Distribution of 1000 simulations, showing how many times higher the cumulative cases are with residential students returned to Ann Arbor than without
- Distribution shifts leftward as smaller numbers of residential students return
- Dashed line indicates the mean
- Plots of the distributions are truncated at cumulative incidence ratio of 20, a small number of samples extend beyond that point and are not shown



Histogram of model simulations of the ratio of cumulative cases with/without student return. Shaded region represents the estimated density based on the histogram.

Next Steps

- Examine targeted testing based on early indicators
- Additional surveillance testing scenarios
  - Is there an optimal testing allocation for a given level of tests/week?
  - Accounting for estimates of test sensitivity/specificity, what capacity will be needed for isolation housing under different testing levels?
- Contact tracing and testing scenarios
  - Examine asymptomatic testing of contacts
    - What day to test contacts? (e.g. Day 5?)
  - Is it useful to trace and test contacts of contacts (2 rings) (and when to test?)
  - Evaluate speed of case investigation and contact tracing
- Semester-end and next semester start—examine residence hall pre-testing scenarios
- Begin generating forecasting models for university cases
  - May not yet be enough campus data for this, but in anticipation of wanting this soon

Appendix

Additional Figures: Symptomatic Testing

Rapid symptomatic testing can substantially reduce cumulative cases over the semester

- Zoomed out version of Figure 1a
- Assuming 75% of students seek testing and isolation is 75% effective

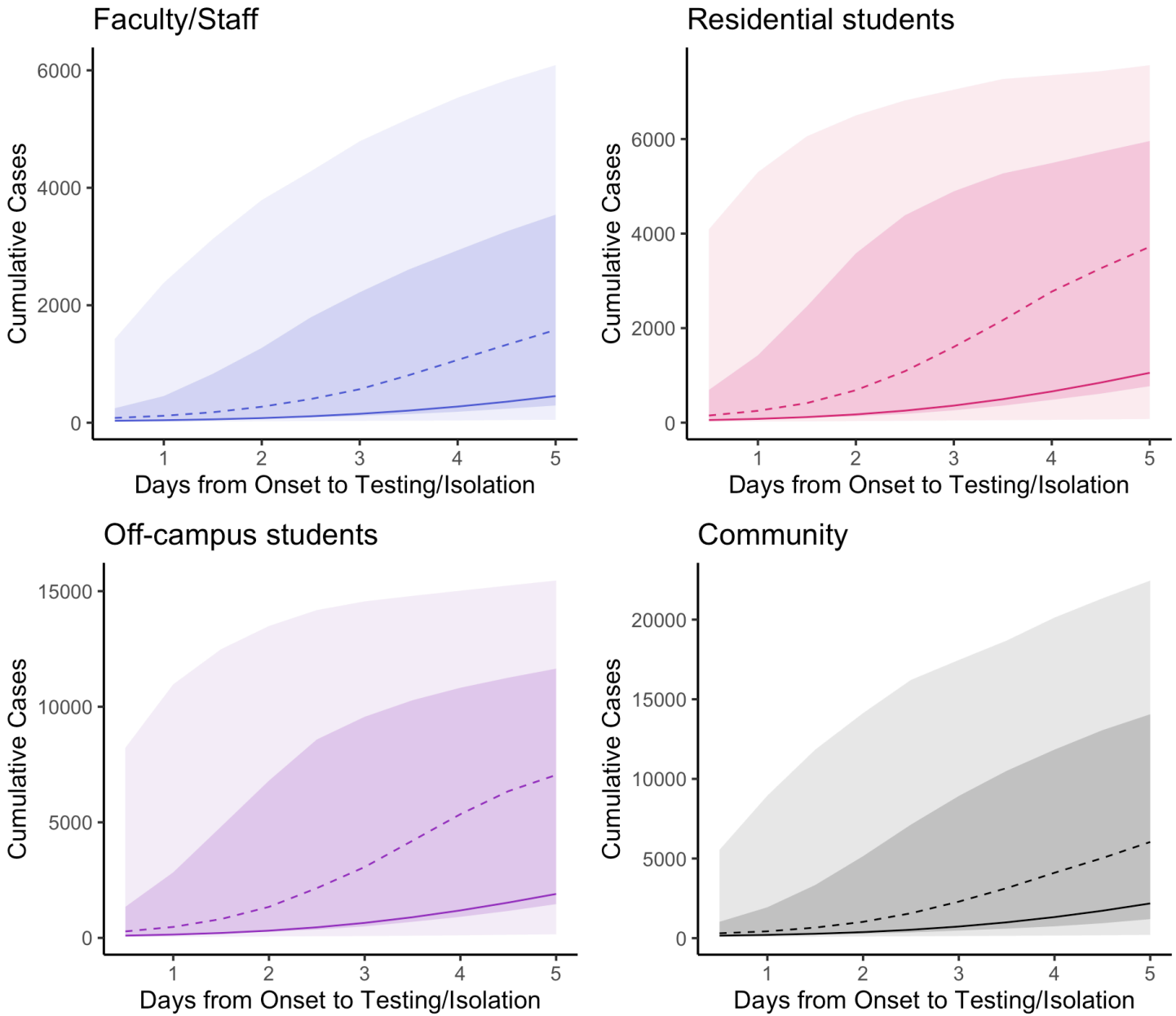


Figure 1e. 1000 simulations of cumulative cases over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Complete symptomatic testing and isolation in students

- Zoomed out version of Figure 1b
- Assuming 100% of students seek testing and isolation is 100% effective

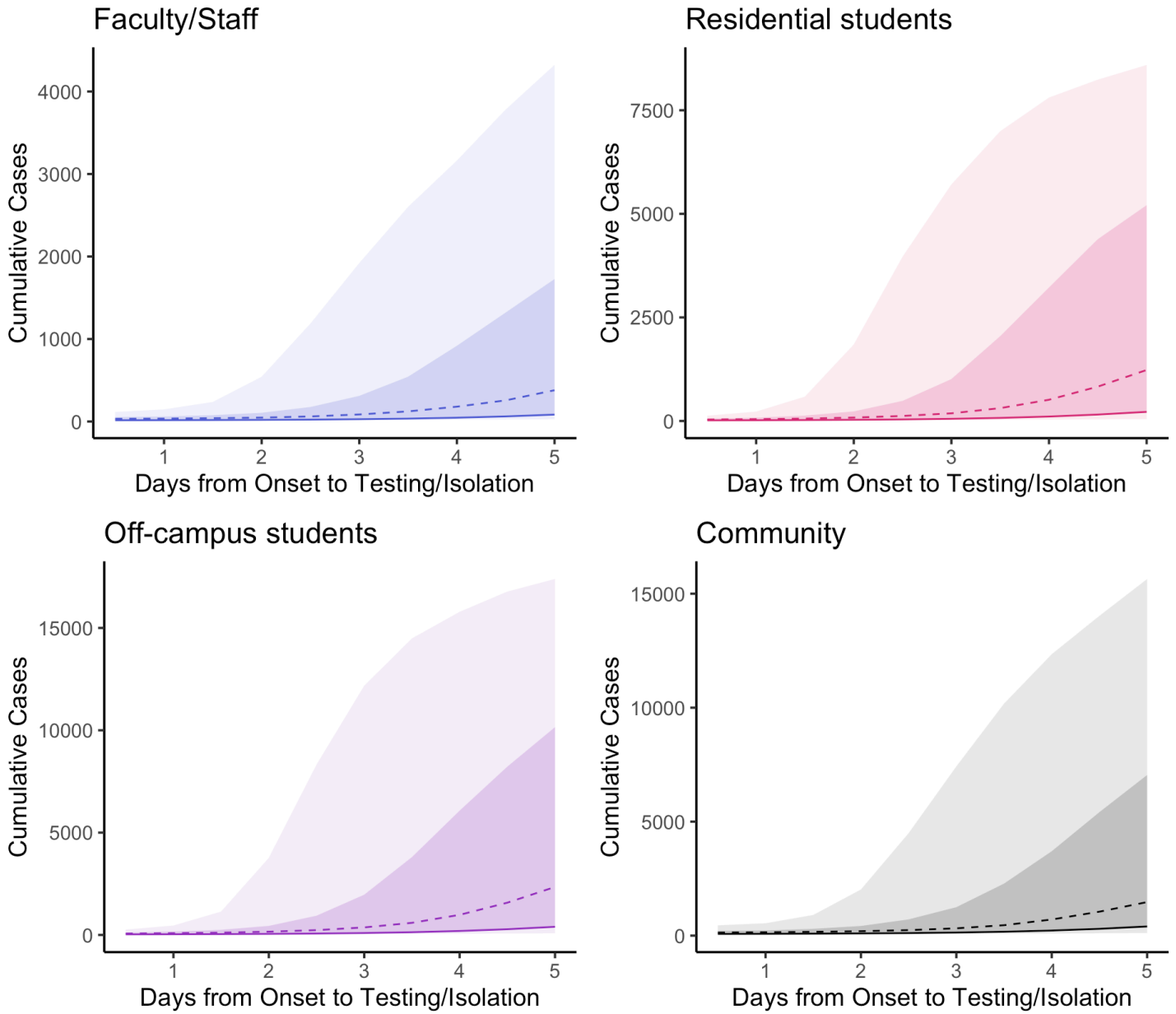


Figure 1f. 1000 simulations of cumulative cases over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Symptomatic testing impact on underlying infections

- Zoomed out version of Figure 1c
- Plotting underlying infections rather than detected cases
- Assuming 75% of students seek testing and isolation is 75% effective

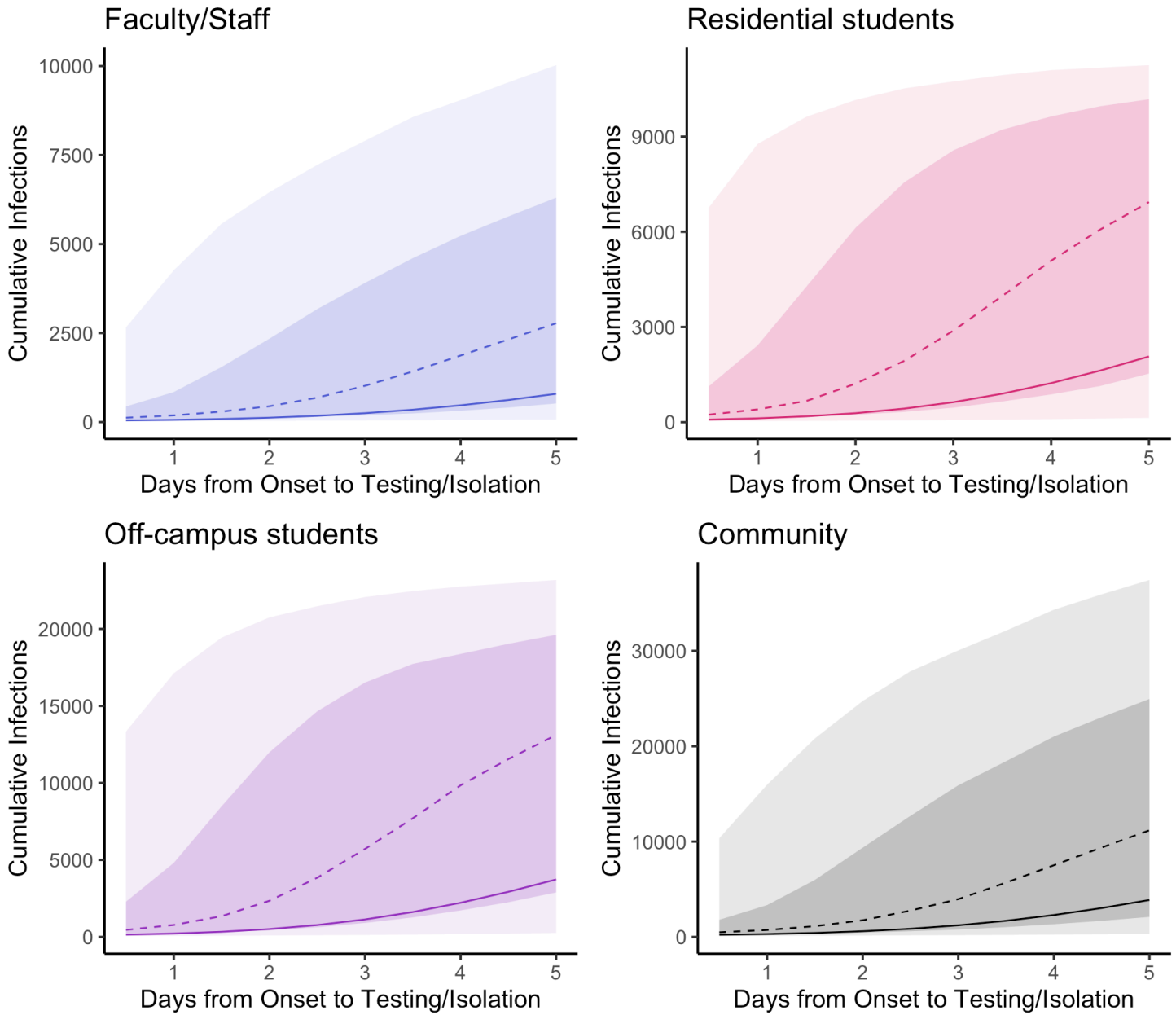


Figure 1g. 1000 simulations of cumulative underlying infections over Fall 2020 across campus and in the Ann Arbor community as a function of the time from symptom onset to testing and isolation. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Symptomatic testing impact on underlying infections

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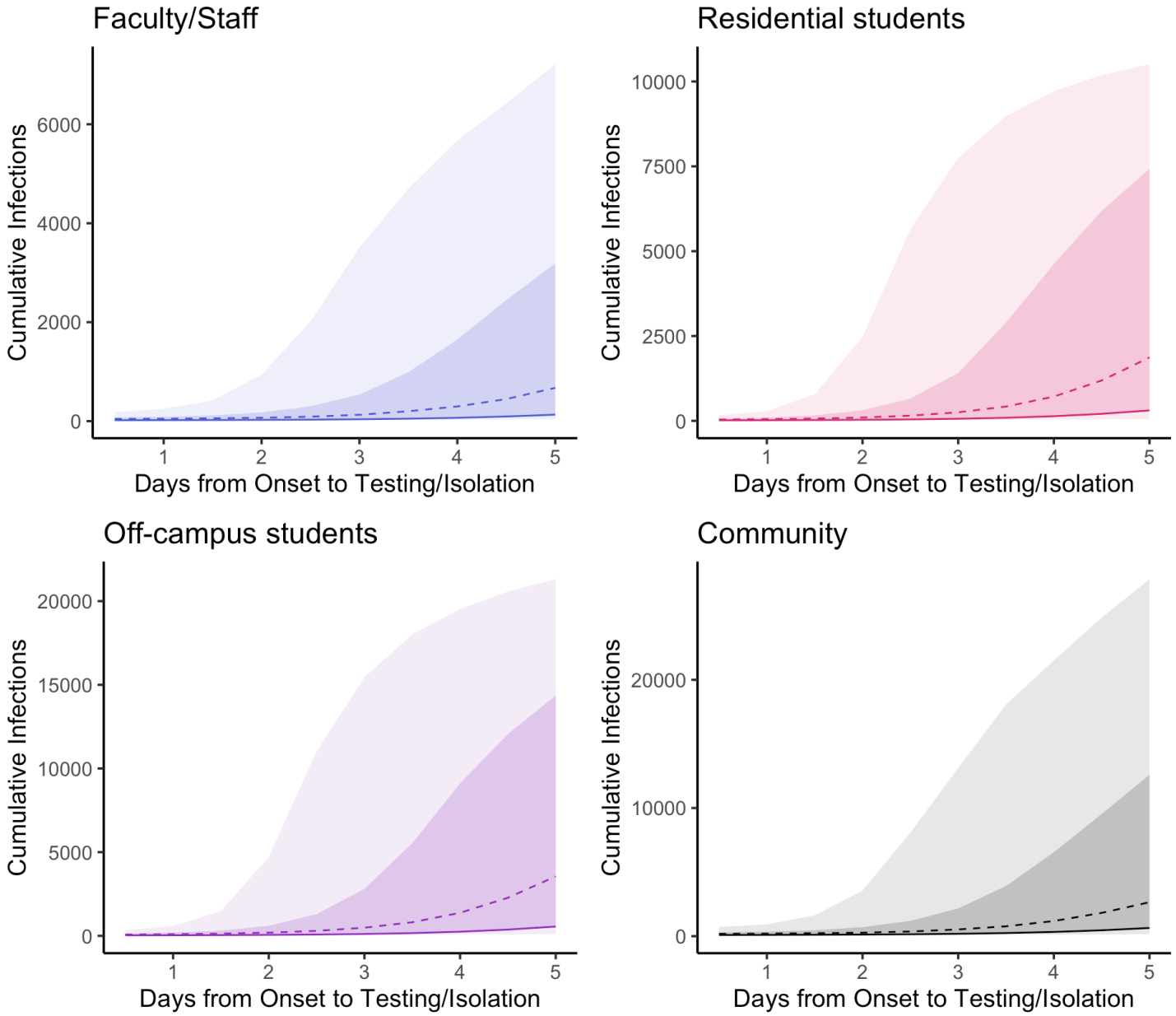

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Additional Figures: Surveillance Testing

Surveillance testing: Cumulative Cases

- For illustration, the same simulations as Figure 2a, but with cases as the output rather than underlying infections
- Increasing testing appears to show little effect on cases on campus, because increasing testing also increases detection of cases

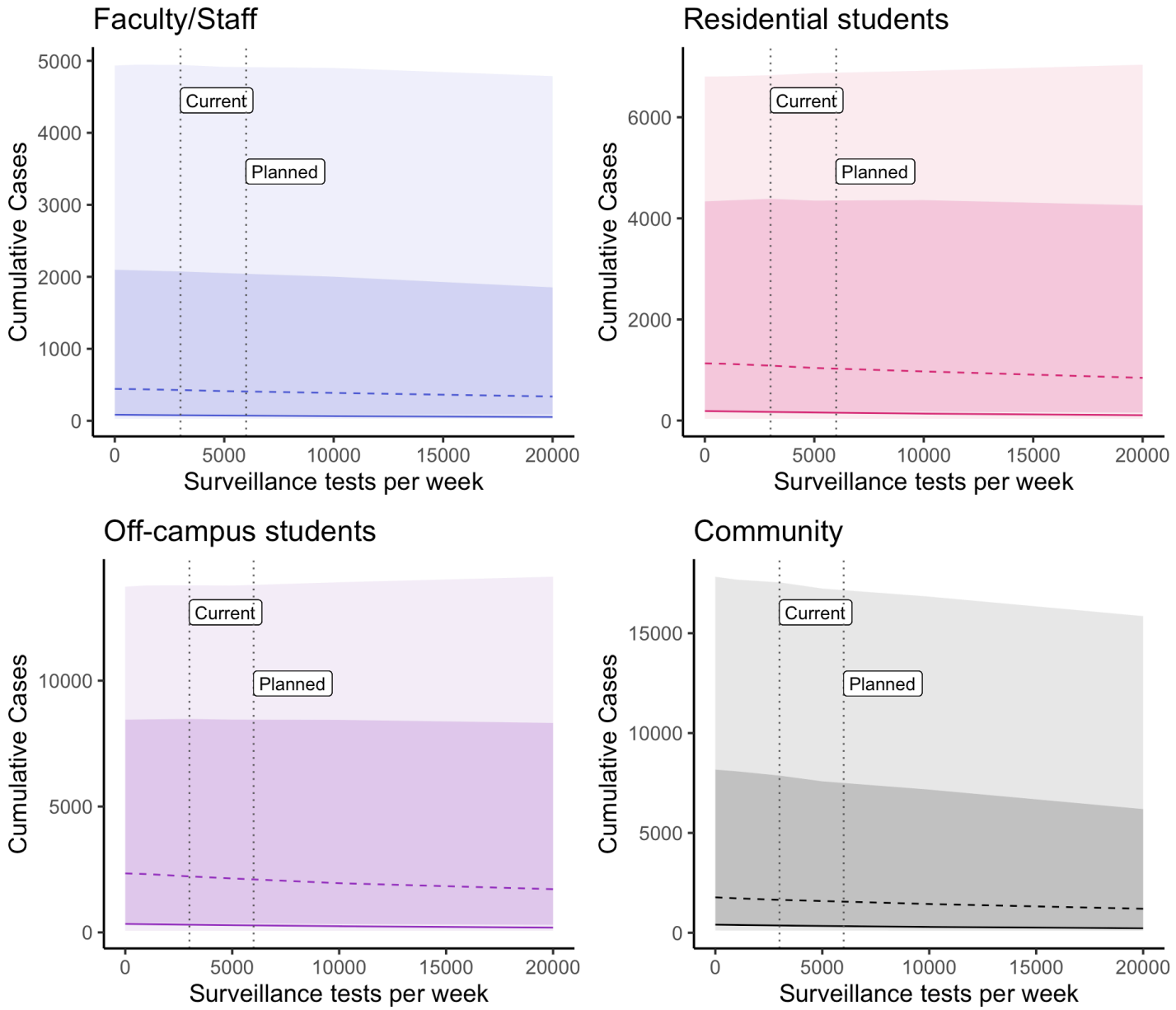

Figure 2c. 1000 simulations of cumulative cases over the Fall 2020 semester across campus and in the Ann Arbor community as a function of surveillance tests per week. Dashed line is the median across simulations and solid line is the default parameters. Light shaded regions show the 5-95% quantiles and dark shaded regions show the 25-75% quartiles.

Surveillance testing: Cases Prevented

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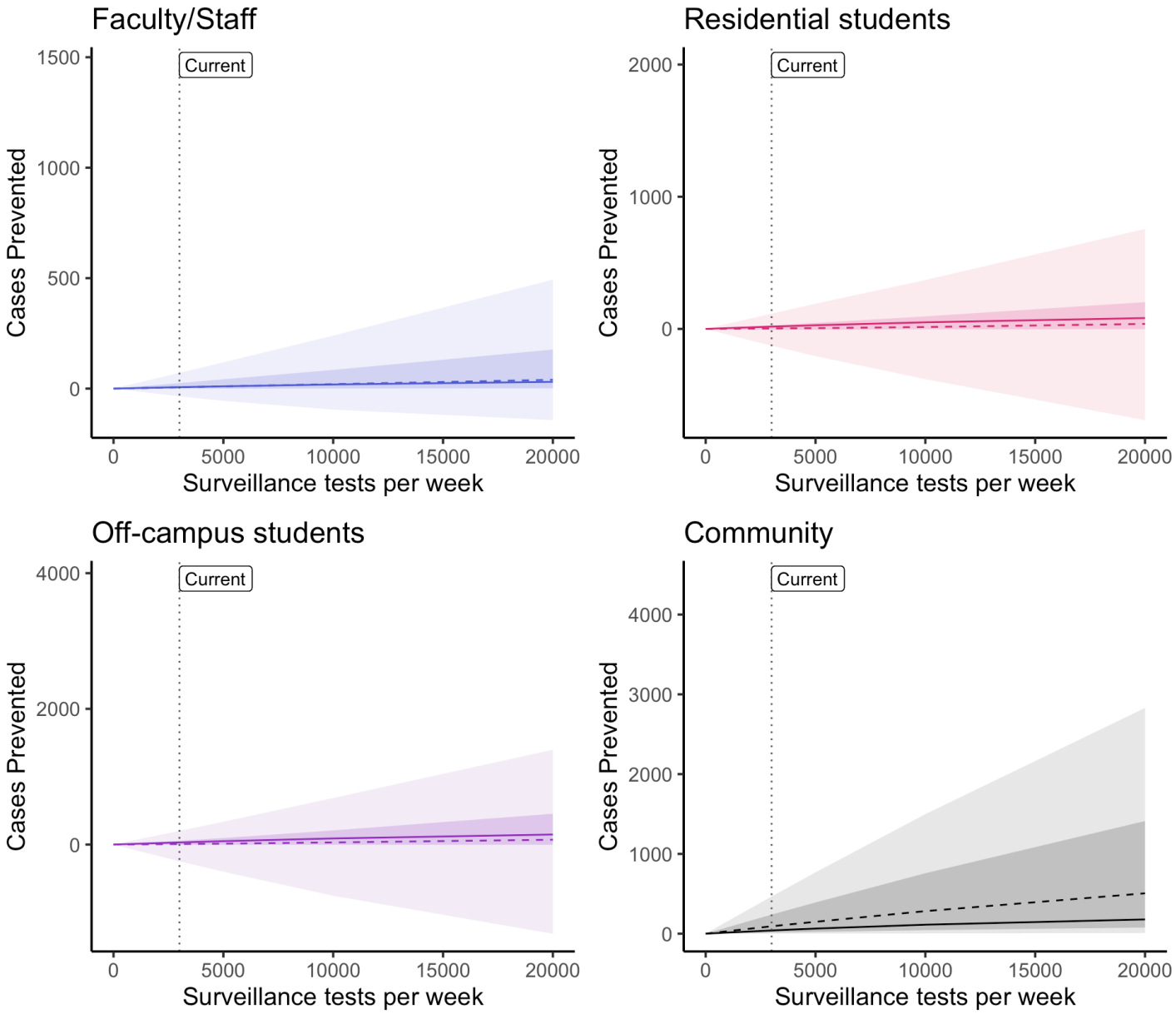

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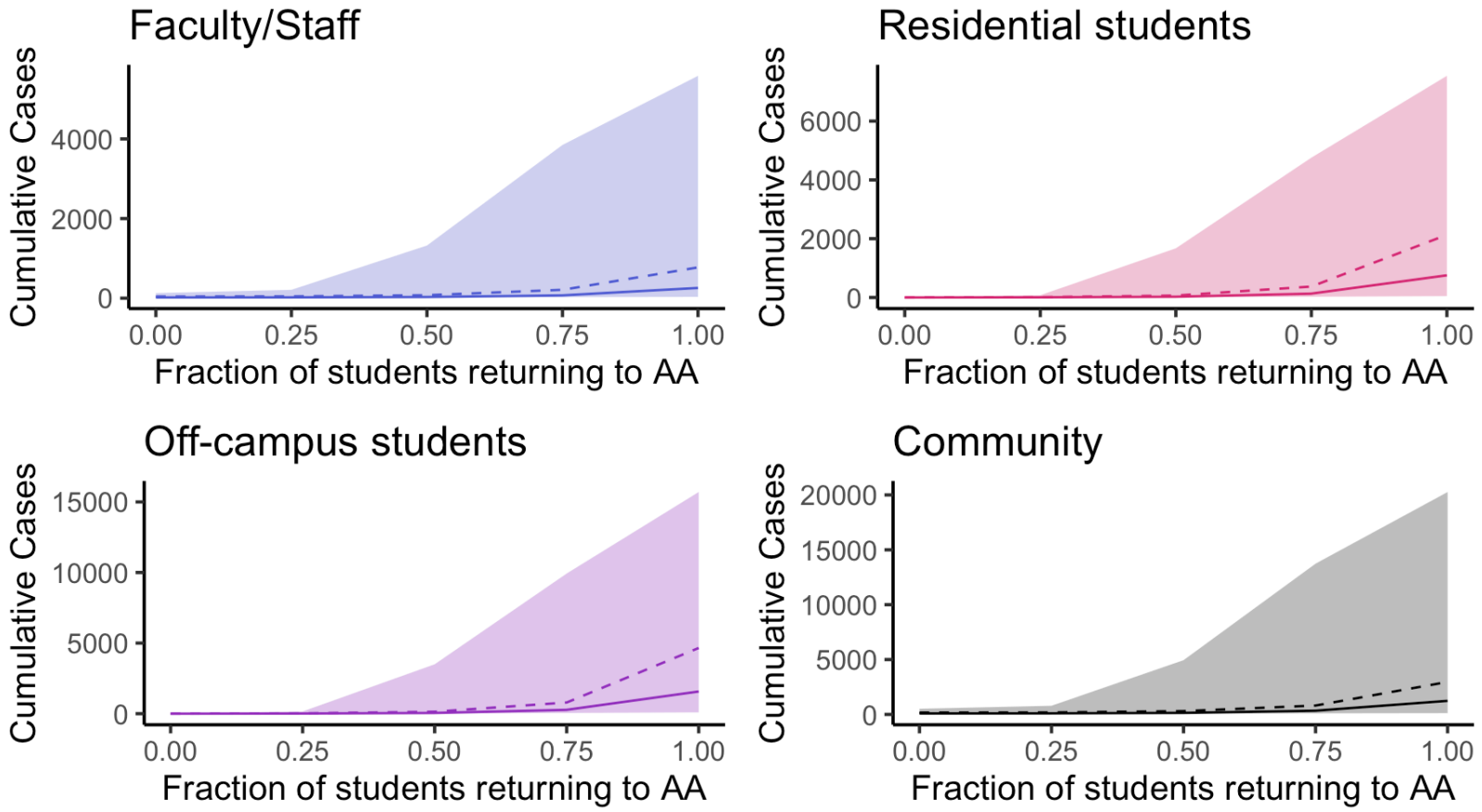
Additional Figures: Student Return Scenarios

Impact of residential and off-campus students returning to Ann Arbor: Extended plots

Same plot as Figure 3a, but with expanded axes so that the full 90% quantile range can be seen. Shaded region indicates the 5-95% quantile range across 1000 simulations.

Simulations of cumulative cases over the Fall 2020 semester across campus and in the Ann Arbor community as a function of the fraction of off-campus and residential students who return for Fall semester. Dashed line is the median across simulations and solid line is the default parameters.



Impact of residential students returning to Ann Arbor: Extended plots

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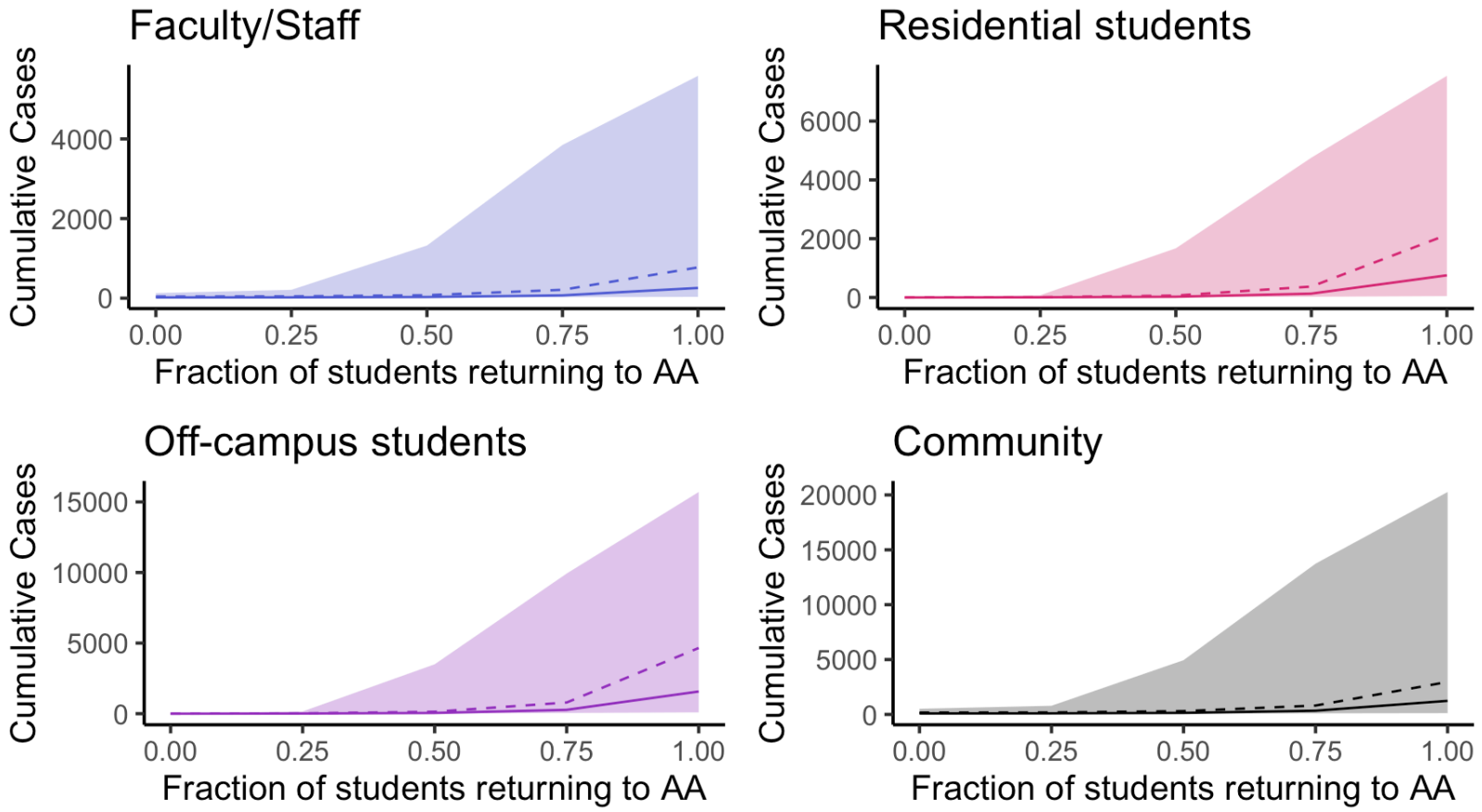
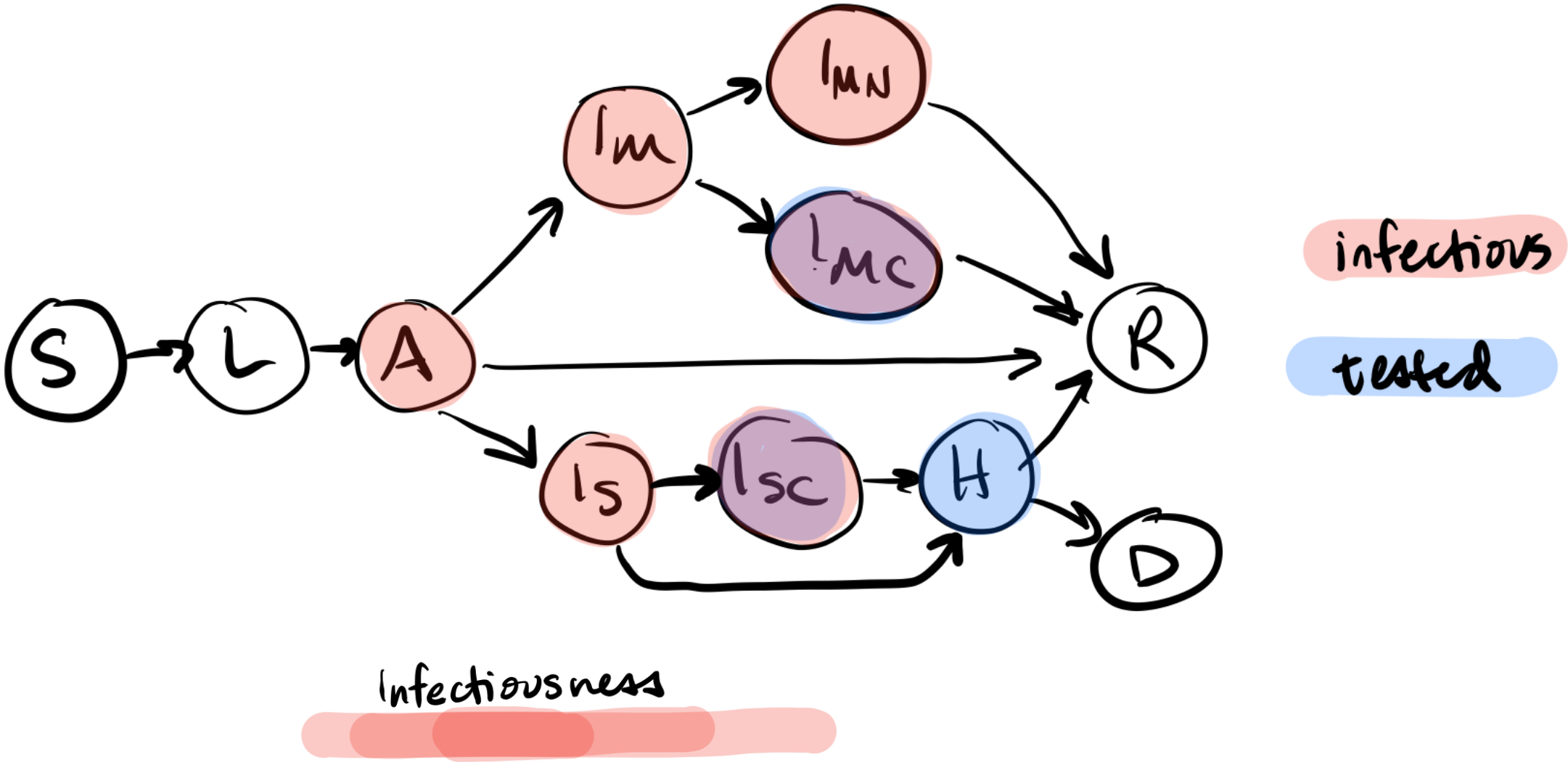


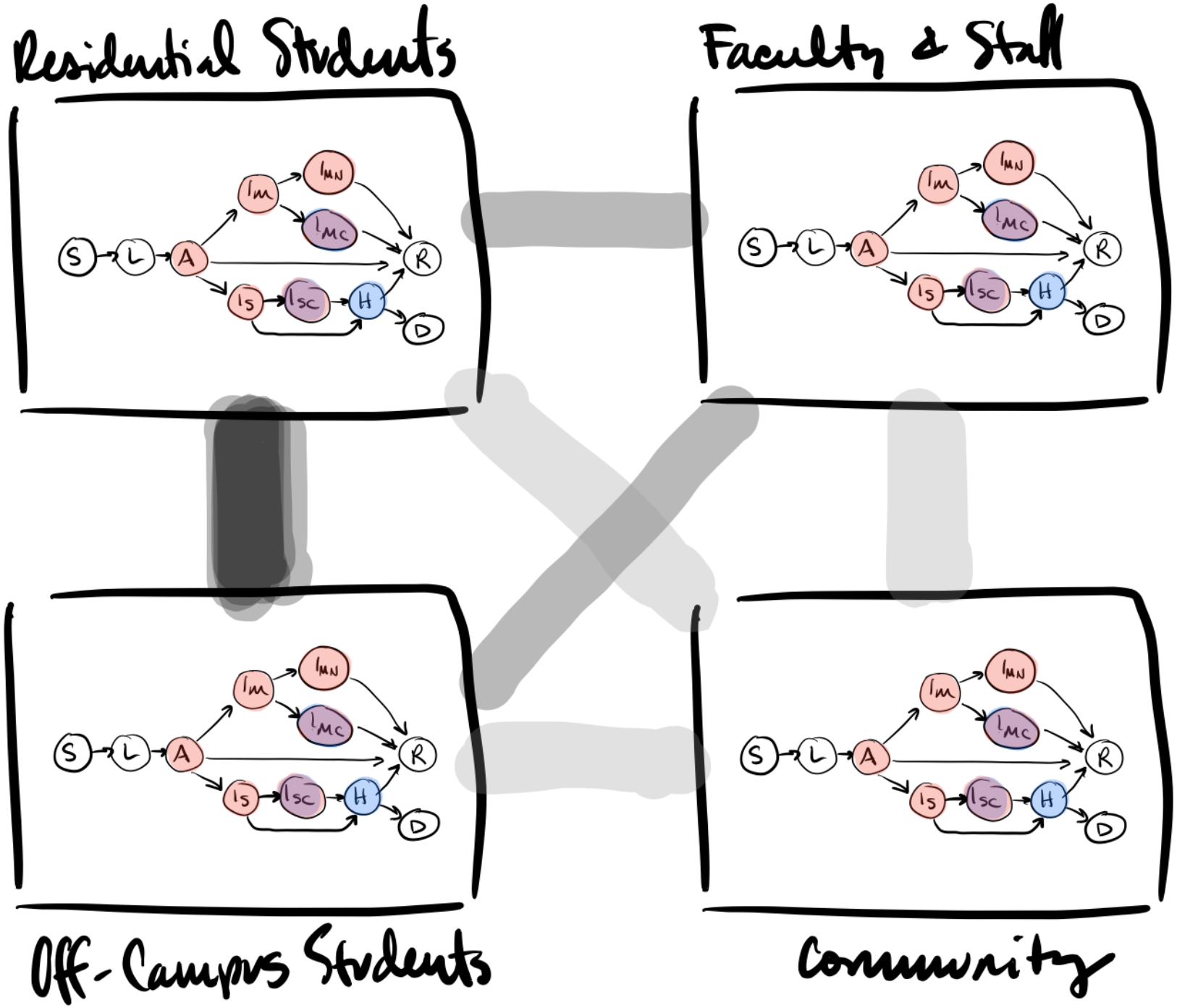
Model description & previous results

Overall UM Modeling Plan

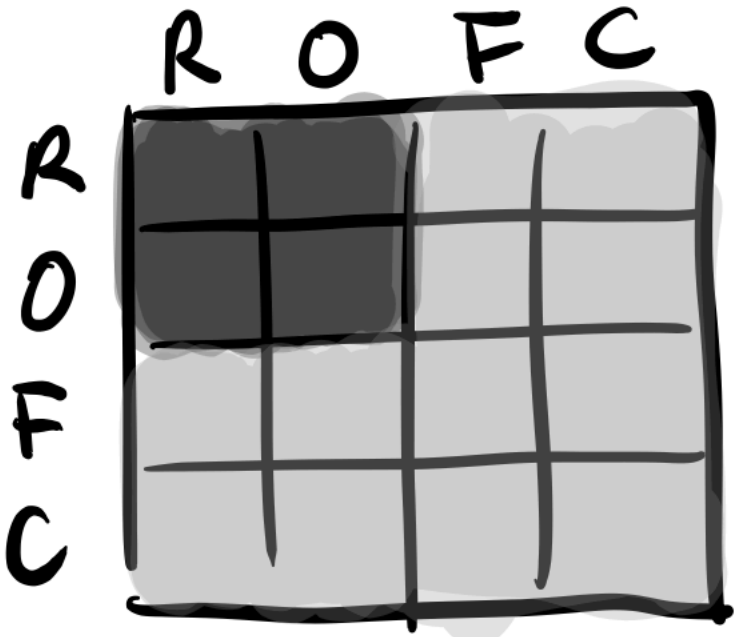
- Goals
  - Evaluate and forecast epidemic spread and capacity needs (testing, etc.)
  - Run scenarios for different testing and intervention strategies
- Compartmental model
  - Populations: Residential students, off-campus students, faculty & staff, community
  - Model includes asymptomatic, pre-symptomatic, mild, severe, as well as care-seeking/testing and hospitalization
- Network model
  - Individual based
  - Adds classroom, housing, and friendship networks, plus additional force of infection to capture larger population patterns (community etc.)

Disease model structure





Simplified contact matrix



Modeling progress

- We are developing a high-level population model and a more detailed network model of SARS-CoV-2 transmission among students, faculty, staff, and the broader community

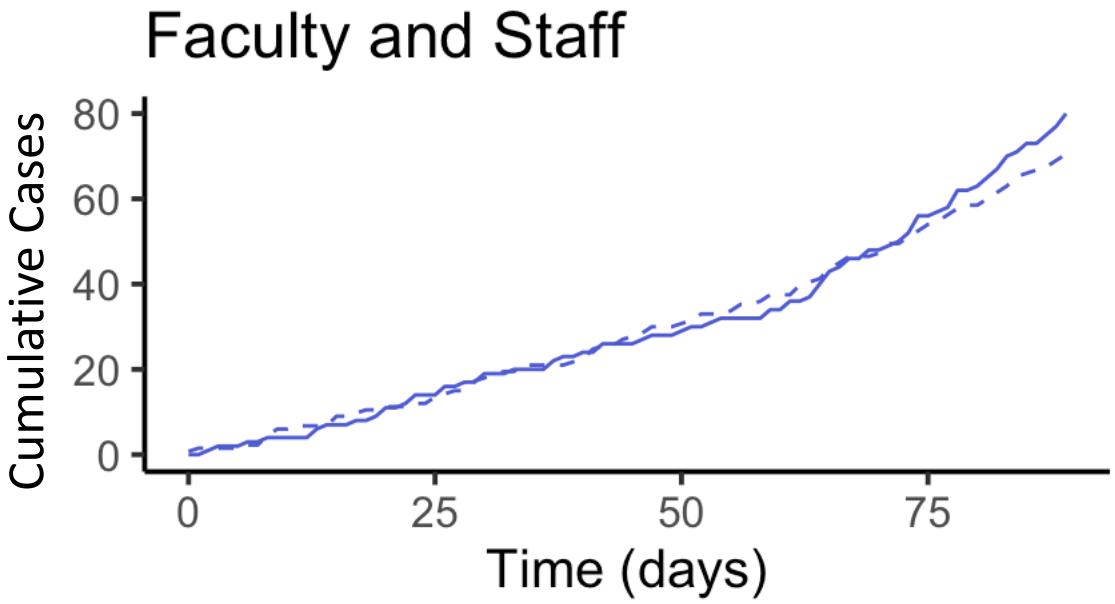
- The compartmental model is largely implemented, pending a couple of updates
- The network model is implemented, but the classroom and housing networks are currently simplified
- Both models are in progress in terms of parameter estimation

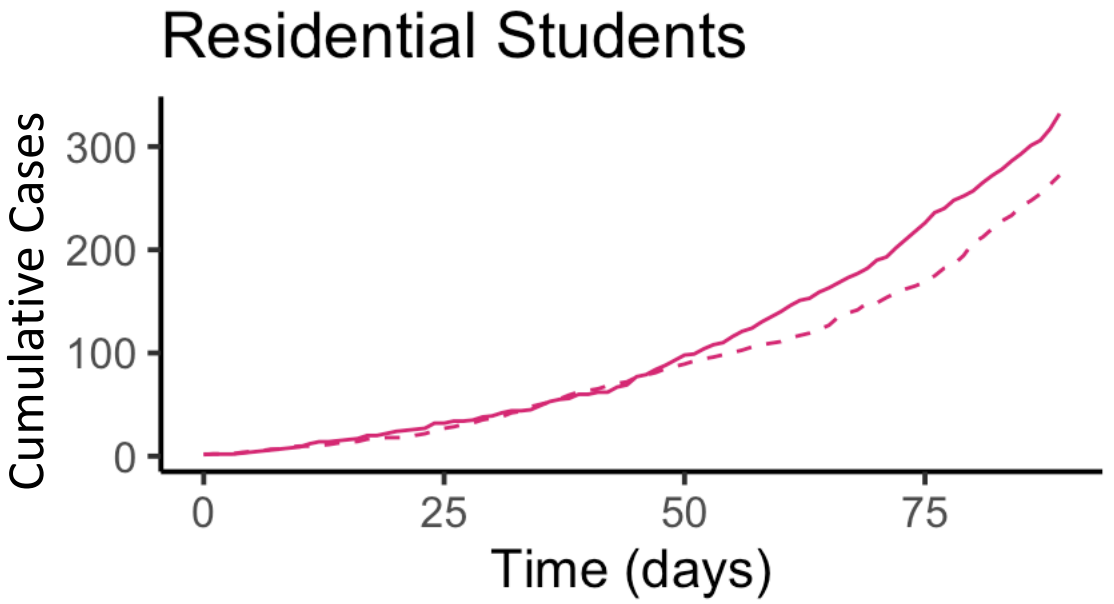
9-4-20 Preliminary Results – Network Model

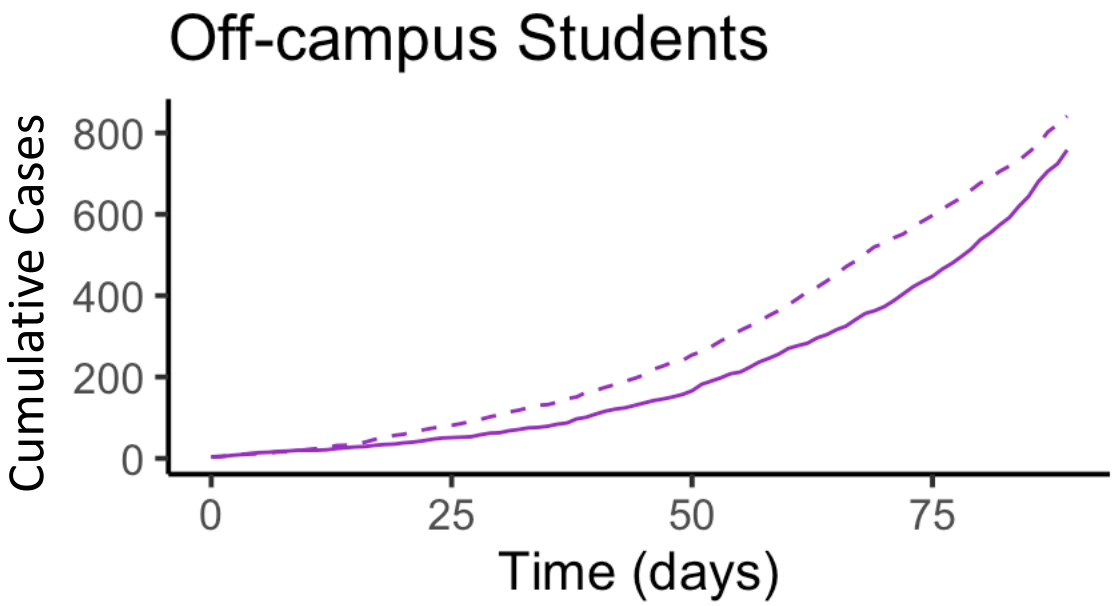
- **Additional classroom mitigation/online courses**: Eliminating classroom transmission (e.g. by moving to entirely online courses) appears to prevent relatively few cases

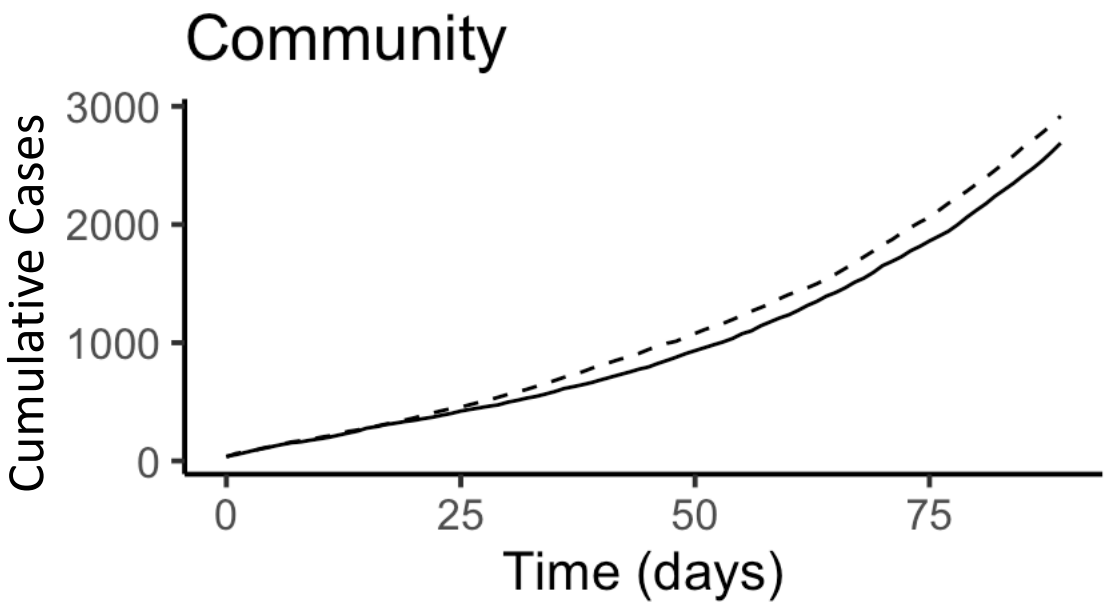
- **Online courses + residential students move home**: Adding on residential students going home increases the reduction in cases for both the university and the community

Online-only classes









Online-only classes and residential students return home