California State Prisons During the COVID-19 Pandemic

A Report by the CalPROTECT Project

Edited by

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California **P**rison **Ro**admap for **T**argeting Efforts to Address the **E**cosystem of **C**OVID **T**ransmission

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CalPROTECT, a special project of Amend at UCSF, is an initiative across University of California, San Francisco and University of California, Berkeley. CalPROTECT is comprised of a multidisciplinary team of academics and healthcare professionals with expertise in clinical medicine, public health, epidemiology, economics, environmental and exposure science, public policy, infectious disease, health systems, geriatrics, and palliative care. The CalPROTECT team is co-led by Dr. Brie Williams and Dr. Stefano Bertozzi, and the effort is co-directed by Dr. Ada Kwan and Dr. David Sears, all four of whom were editors for this report.

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Acronyms & Abbreviations

ACH – Air changes per hour

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

CCHCS – California Correctional Health Care Services

CDC – Centers for Disease Control and Prevention

CDCR – California Department of Corrections and Rehabilitation

CDPH – California Department of Public Health

COVID-19 – Coronavirus Disease 2019

CPR – California Prison Receivership

ED - Emergency department

FDA – Food and Drug Administration

GUV – Germicidal Ultraviolet

HVAC – Heating, Ventilation, and Air Conditioning

IAC – Inmate Advisory Council

ICP – Incident Command Post

ICU - Intensive care unit

MERV – Minimum efficiency reporting value (for air filters)

NPI – non-pharmaceutical interventions

PCR – Polymerase chain reaction [tests]

PPE - Personal protective equipment

PPM – Parts per million

RT-PCR – Reverse transcription polymerase chain reaction [tests]

SARS-CoV-2 – Severe acute respiratory syndrome coronavirus 2

UC Berkeley – University of California, Berkeley

UCSF – University of California, San Francisco

WGS - Whole genome sequencing

WHO – World Health Organization

The following CDCR abbreviations for each CDCR institution are used throughout this report:

ASP, Avenal State Prison
CAC, California City Correctional Facility
CAL, Calipatria State Prison
CCC, California Correctional Center
CCI, California Correctional Institution
CCWF, Central California Women's Facility
CEN, California State Prison, Centinela
CHCF, California Health Care Facility, Stockton
CIM, California Institution for Men
CIW, California Institution for Women
CMC, California Men's Colony
CMF, California Medical Facility
COR, California State Prison, Corcoran
CRC, California Rehabilitation Center
CTF, Correctional Training Facility
CVSP, Chuckawalla Valley State Prison
DVI, Deuel Vocational Institution
FSP, Folsom State Prison
HDSP, High Desert State Prison
ISP, Ironwood State Prison
KVSP, Kern Valley State Prison
LAC, California State Prison, Los Angeles County
MCSP, Mule Creek State Prison
NKSP, North Kern State Prison
PBSP, Pelican Bay State Prison
PVSP, Pleasant Valley State Prison
RJD, Richard J. Donovan Correctional Facility
SAC, California State Prison, Sacramento
SATF, Substance Abuse Treatment Facility and State Prison, Corcoran
SCC, Sierra Conservation Center
SOL, California State Prison, Solano
SQ, San Quentin State Prison
SVSP, Salinas Valley State Prison
VSP, Valley State Prison
WSP, Wasco State Prison

Introductory Remarks

The entire CalPROTECT team would like to acknowledge the extraordinary efforts made by the California Department of Corrections and Rehabilitation (CDCR) and the California Correctional Health Care Services (CCHCS) to respond efficiently and effectively to the COVID-19 pandemic. There were many instances in which medical treatment and/or the implementation of public health recommendations within California prisons met or even exceeded the community standards in California, against the backdrop of rapidly evolving scientific knowledge. We would like to explicitly highlight these instances here, because they can be easily overlooked in this report. Throughout our research, we uncovered many important examples of what is possible when healthcare leadership, custody leadership, and frontline healthcare and custody staff work in tandem to deliver exceptional care in the setting of an evolving pandemic emergency. While we were not asked explicitly to analyze these interventions, as they are being assessed and described elsewhere, we believe it is crucial that they be mentioned at the outset of this report.

Most notably, before vaccines became available, CCHCS initiated and successfully rolled out the use of monoclonal antibodies to treat COVID-19 to an extent that far eclipsed their use in California's community healthcare settings. This early and dedicated use of monoclonal antibodies required frontline healthcare professionals to become rapidly knowledgeable about the indications and use of these lifesaving treatments, which required concerted efforts by healthcare leadership at both the institution and headquarters levels to implement state-of-the-art treatment protocols and to educate healthcare staff in the facilities as the treatment was becoming available. The early use of this treatment certainly resulted in large numbers of emergency department visits and hospitalizations averted and lives saved.

A second notable achievement, touched on in this report, was the exceptionally high rate of vaccination uptake among incarcerated individuals. This high vaccine uptake among CCHCS patients is a testament to CCHCS and CDCR's dedication to helping patients get the health information they needed from trusted sources (including but not limited to CCHCS healthcare professionals, outside healthcare professionals, community leaders including current and formerly incarcerated persons, and attorneys) through a wide variety of approaches (e.g., public service announcements that were played on prison television channels; vaccination-information health fairs; articles published in prison-based newspapers; and the introduction of vaccine information circulated from outside healthcare professionals).

Another notable intervention was the early adoption of wastewater surveillance testing and data analysis through collaborations with scientists at local universities. These efforts helped healthcare and custody leaders identify early stages of outbreaks in dormitories and other

housing units so that they could act upon detection signals with large-scale testing and quarantine where needed in order to introduce mitigation measures to prevent larger, facility-wide outbreaks.

Added to this list of examples of exceptional care and response to threats from COVID-19 in California state prisons should be the actions of countless individual healthcare and custody professionals throughout CDCR and CCHCS who went above and beyond their job descriptions to try to protect the health and safety of staff and incarcerated individuals. These staff members worked a tremendous number of extra hours; advocated for patients; developed and implemented new health measures; volunteered their time on information panels, in national conferences, and in partnership with governmental agencies such as the Centers for Disease Control and Prevention; and published opinion pieces in the national lay press. These latter efforts not only helped generate more knowledge about the impact of COVID-19 in our nation's prisons as information was evolving, but also helped disseminate ideas for best practices across prisons and other detention facilities throughout our nation and the world.

While we were not asked explicitly to catalog the many heroic measures taken by individual healthcare and custody professionals, we want to take this opportunity to applaud the staff who chose to stay the course, continuing to work in prisons despite the exceptional hardship and risk to themselves and their families posed by the COVID-19 pandemic. In the years to come, we believe many will look back to identify the unsung heroes of this global disaster, and we hope that the individual efforts of the many exceptional CDCR and CCHCS staff are recognized in this historical accounting of the American COVID-19 experience.

1. Executive Summary

Introduction

In early 2020, the California Prison Receivership (CPR) contracted with the authors of this report to describe the impact of the coronavirus disease 2019 (COVID-19) pandemic on California prisons and to provide recommendations for mitigating the risk posed to the residents and staff who live and work in California Department of Corrections and Rehabilitation (CDCR) prisons. In addition to providing timely, actionable recommendations in response to the threat from COVID-19, the goal of this report is to highlight opportunities for stakeholders to aid California Correctional Health Care Services' (CCHCS) ongoing advancement towards achieving what we have termed a "healthy health care system." Such a health care system is self-examining, responsive to evolving community standards, and rooted in a systems-driven culture of patient safety, quality improvement, and ongoing learning.

As the focus of this report is to highlight opportunities for improvement during the next phases of the COVID-19 pandemic (or when California prisons are inevitably faced with another threat from a respiratory pathogen), we do not focus on the many things that went well in CDCR's and CCHCS's response to COVID-19. Chief among these is the effective mass vaccination campaign of CDCR residents, the use of system-wide health data to guide policy, and the tireless efforts of many staff members despite extraordinarily difficult working conditions.

The recommendations made throughout this report draw upon the evolving scientific knowledge of the virus, analysis of anonymized resident and staff level data from CCHCS, evaluation of statewide and institution-level policies, and primary quantitative and qualitative data collected during site visits to CDCR prisons during the pandemic. Each section in this report can be read on its own—as a self-contained mini-report—or as part of the report as a whole.

The following is a summary of our key findings and recommendations, organized by the section of the report from which they are drawn. This Executive Summary is intended to serve as a brief, high-level, overview as of May 1, 2022. Further details relevant to these findings and recommendations can be found in the body of the report.

Key Findings & Recommendations

Section 4. Incarcerated People in CDCR Prisons throughout COVID-19: Population Demographics and Epidemiology of SARS-CoV-2 Infection and Disease

⇒ How did the population of residents in CDCR prisons change during the pandemic? Were residents with higher risk of severe COVID-19 prioritized for release?

Key finding: Population reduction was modest and was primarily accomplished by expediting planned paroles and halting intake from county jails, where residents also faced a high risk of contracting COVID-19.

Key finding: Population reduction did not significantly prioritize the release of older adults or those with higher COVID-19 risk scores.

⇒ How should crowding be addressed in CDCR prisons during the pandemic?

Recommendation 4.1: In the setting of ongoing COVID-19 risk, CDCR prisons remain overcrowded and decarceration remains a vital tool for safeguarding individual and public health. Policymakers should focus on the expedited release of older adults and people with high COVID-19 risk scores. Such a focus will necessitate considering a second look to evaluate appropriate people for the possibility of early release or parole to people serving three strikes or life without the possibility of parole sentences since these populations are overrepresented with older adults. Guidance might become available shortly as California has commissioned the California Committee on the Revision of the Penal Code to provide state leadership with consensus, evidence-based recommendations that are designed to improve public safety and reduce unnecessary incarceration across the state.

Recommendation 4.2: For the population remaining in CDCR prisons, physical distancing is exceedingly difficult; overcrowding undoubtedly contributed to the explosive COVID-19 transmission experienced in the last year and a half. If the pandemic continues with new, more transmissible variants, we recommend that population reduction be prioritized and that planned prison closures be delayed until after the pandemic has reached an endemic state to reduce population crowding.

⇒ How do medical conditions influence the risk of severe COVID-19 among CDCR residents?

Key Finding: CDCR residents have high rates of medical comorbidities that are known to increase the risk for severe COVID-19. Medically high-risk individuals are disproportionately housed in select prisons.

⇒ Did the pandemic significantly affect the movement and housing of CDCR residents who never tested positive for COVID-19?

Key finding: Irrespective of infection status, most CDCR residents had been tested, quarantined, and isolated for COVID-19 symptoms or exposures during the study period.

⇒ How successful were efforts to protect the most medically vulnerable CDCR residents from COVID-19 infection?

Key finding: Despite efforts to protect the most vulnerable residents from COVID-19, the 5% of residents with the highest COVID-19 risk scores were more likely to have a documented COVID-19 infection than those with lower risk scores.

⇒ How did COVID-19 outbreaks within CDCR institutions affect surrounding community hospitals?

Key finding: COVID-19 placed a significant strain on the health systems of prisons and surrounding communities, leading to at least 1,661 community ED visits, 1,049 hospital admissions, and 152 ICU admissions related to COVID-19. Many of these cases occurred over short periods of time during rapidly spreading outbreaks.

⇒ Were there race-based disparities in the risk of severe COVID-19?

Key finding: Non-white residents had a higher risk of COVID-19 hospitalization than white residents when adjusting for sex, age group, mental health conditions, and health-related impairments.

⇒ How should CCHCS evaluate their procedures related to the transfer of patients with COVID-19 to community hospitals?

Recommendation 4.3: CCHCS's mortality review process should examine the cases of residents who died of COVID-19 prior to transfer to a community hospital with the aim of determining whether opportunities exist to improve the early detection of clinical

deterioration among patients with COVID-19 and/or whether care in these cases reflected the wishes of patients who declined to transfer to the community hospital/ED setting.

⇒ Which factors were associated with an increased risk of death among people infected with COVID-19?

Key finding: Older age, mental health conditions, and mobility impairments were associated with a higher adjusted risk of COVID-19 death among people diagnosed with COVID-19.

⇒ How did the burden of COVID-19 in CDCR prisons compare to surrounding communities? How should policymakers respond to the excess COVID-19 burden in CDCR prisons?

Key finding: The COVID-19 case rate is over three times higher among CDCR residents than among residents of the counties in which CDCR prisons are located. Every CDCR prison exceeded the case rate in its surrounding county, although true differences between the two populations may be smaller given higher levels of testing in CDCR prisons.

Key finding: Despite having a smaller proportion of older adults compared to the general population, COVID-19 deaths per population among CDCR residents has exceeded the death rate in California and the United States as a whole.

Recommendation 4.4: Policymakers should respond to the disproportionate burden of COVID-19 infections, hospitalizations, and deaths experienced within CDCR prisons by both removing as many medically vulnerable people as possible from congregate living facilities with shared air spaces, and greatly increasing the resources available to mitigate the effects of COVID-19 (described in **Section 7**) for those who remain incarcerated.

⇒ How did the CCHCS COVID-19 risk score perform in predicting the likelihood of hospitalization and death among those infected with COVID-19?

Recommendation 4.5: CCHCS's COVID-19 risk score can reasonably categorize patients into three tiers to predict the likelihood of hospitalization and death if infected with COVID-19. Individuals at intermediate and high risk could benefit from enhanced mitigation efforts (e.g., housing in buildings that are less conducive to the spread of COVID-19) and access to therapeutics that can reduce the risk of severe COVID-19 (e.g., antiviral medications as they become available and monoclonal antibody treatment).

⇒ How did the burden of COVID-19 in CDCR prisons compare between those younger and older than 55 years?

Key finding: Compared to younger CDCR residents, those age 55 years or older spent more time in quarantine and medical isolation and had dramatically higher rates of COVID-19 infection, hospitalization, and death.

Recommendation 4.6: We recommend that future research compare the general population by age to the incarcerated population. Making a direct comparison to the general population solely on proportions is difficult because people who were incarcerated during the pandemic, especially in California state prisons, were tested with markedly higher frequency than the general population. We note that nearly half of state prisons reported that confirmed cases of COVID-19 among incarcerated people were 4 to 15 times higher than rates found in the community. COVID-19 deaths among incarcerated people have been three times those in the general population. This is, in large part, because it is incredibly challenging to provide the same level of protection from infection in crowded prisons compared to the community (where many older adults can shelter in place).

⇒ In what ways have vaccines improved outcomes throughout CDCR prisons?

Key finding: Vaccination has had a dramatic impact on COVID-19 case rates, hospitalizations, and deaths in CDCR, including protective effects for unvaccinated residents.

Section 5. Staff at CDCR Prisons during COVID-19: Demographics and Epidemiology of SARS-CoV-2 Infection and Disease

⇒ How do the demographics of CDCR staff compare to the California population?

Key Finding: CDCR staff are more likely to be men and younger compared to the general California population. At least three quarters have jobs that entail direct resident contact.

⇒ What work-related activities might contribute to the risk of COVID-19 infection among staff?

Recommendation 5.1: Investigate ridesharing as a source of COVID-19 transmission between staff members. Reinforce (particularly for unvaccinated staff) the COVID-19 mitigation measures that can be taken when ridesharing (masking, traveling with the windows down, not eating or drinking).

⇒ How did the burden of COVID-19 among CDCR staff compare to the California population?

Key finding: Compared to the adult population of California, CDCR staff have higher rates of COVID-19 infection and lower rates of COVID-19 death. These findings likely relate to: (i) the higher rates of testing of people with asymptomatic infections, (ii) the increased occupational risk of COVID-19 infection, (iii) the relatively younger age of CDCR staff compared to the population at large, and (iv) the possibility that CDCR staff may be less likely to be vaccinated and/or less likely to engage in safer behaviors in the community (definitive data are not available regarding the last point). Further research on these topics may be illuminating.

⇒ Which staff were most likely to have been infected with COVID-19? How should policymakers respond to the excess COVID-19 burden in CDCR prisons?

Key finding: Staff characteristics associated with COVID-19 infection were: being of younger age, working in custody, education or operations (compared to healthcare), having a position that involves contact with residents, and having a job that does not require a college degree or equivalent.

Recommendation 5.2: Policymakers should respond to the disproportionate burden of COVID-19 infections among staff by greatly increasing the resources available to mitigate the risk of COVID-19 faced by staff. Recommendations for reducing the risk to staff are described in **Section 7.6**.

⇒ How does vaccination among CDCR staff compare to the California population? What is the profile of staff members who should be the target for vaccination campaigns?

Key finding: CDCR staff, as a whole, appear to be less likely to be vaccinated than other adults in California. Staff who work in custody or operations, or who are contractors or have unknown job classifications have the highest odds of being unvaccinated.

Recommendation 5.3: Efforts to address vaccine refusal should be delivered by messengers who are more likely to be trusted by unvaccinated staff who are disproportionately younger in age, men, have a work type that is not in healthcare or education, and have a job that involves contact with residents.

Section 6. The Built Environment

⇒ How is the built environment associated with crowding in CRCR prisons?

Key finding: CDCR institutions were constructed at different times over more than a century. The oldest institutions were more likely to have had occupancy levels below their architectural design capacities at some point during the pandemic.

⇒ Which CDCR housing types are associated with increased or decreased risk of COVID-19 infection among residents? How should information on differential risk be used for housing decisions?

Key finding: When we include more detailed features about the housing room types that are not available in the CDCR/CCHCS data, increased risk of COVID-19 infection was found—on two different analyses—in 270 dorms, double cells with open or barred doors, and D dorm pods. Decreased risk of COVID-19 infection was found—on two different analyses—in single cells, small standalone dorms, and one dorm room per floor. This metric differs from the one used in Section 10 analyses, which utilize CDCR/CCHCS room type classifications without these nuanced room features.

Key finding: The risk of COVID-19 acquisition in double cell and single cell housing units appears higher in older institutions with open/barred doors and lower in newer institutions with closed/solid doors.

Recommendation 6.1: Initial findings on higher and lower risk building types should be paired with widespread indoor air quality assessments (described in **Section 7.3**) and with multivariable analyses to identify appropriate buildings for quarantine housing and to preferentially house high- and low-risk patients based on COVID-19 risk scores and vaccination status.

Section 7. Outbreak Prevention and Mitigation Efforts

Section 7.2. Reduce the population to decrease crowding

⇒ How should crowding in CDCR prisons be addressed both before and during an outbreak of a respiratory pathogen such as SARS-CoV-2?

Key finding: In a densely crowded prison setting, many of the non-pharmaceutical interventions to reduce COVID-19 transmission are impossible to fully implement (e.g., masks cannot always be worn when around others as people are sharing the same airspace

24 hours a day, cellmates cannot physically distance, even individuals in cells with solid walls and solid doors must come out of their cells for showers, meals, and other activities). The success of all COVID-19 mitigation measures described in this report is highly dependent upon reducing crowding in housing units in CDCR prisons.

Recommendation 7.2.1: In the absence of a pandemic, consistent public health guidance is needed regarding maximum residential room occupancy in buildings, particularly for congregate, high-density living environments that can be dangerous.

Recommendation 7.2.2: When a respiratory pandemic occurs, a pandemic preparedness plan should outline steps for emergency evacuation of high-risk prison housing units that cannot be made significantly safer in the event of an infectious disease outbreak.

Recommendation 7.2.3: Planning for pandemics involves implementing three levels of safety: (1) ensuring housing units do not exceed safe occupancy levels under normal circumstances in the absence of an epidemic; (2) emergency reduction of occupancy of high-risk housing units when faced with an epidemic in the community to further reduce risk of transmission within the institution; and (3) further emergency reduction of occupancy when an outbreak occurs within an institution (converting affected housing units into safe quarantine and further reducing risk in unaffected housing units). Early designation of quarantine and medical isolation space should be a part of pre-pandemic planning, and this must include identifying locations that can appropriately and safely house a sufficient proportion of the needs of the population, including people with disabilities. These planning efforts must also recognize that percent capacity across an entire institution can still mean that certain units are overcrowded.

Section 7.3. Ventilation and Air Filtration

⇒ How do ventilation and filtration in CDCR prisons compare to standards for healthcare settings?

Key finding: Air changes per hour (ACH) measurements were below the recommended minimum of 12 ACH for isolation/quarantine areas, below the 15-20 ACH minimum for congregate dorm areas, and three settings had measured ACH below the minimum 6 ACH standard for general hospital wards.

Key finding: ACH readings at SATF and SQ found low air exchange during winter months compared to summer months, indicating a higher risk of COVID-19 transmission, likely due to closing windows and doors and the use of recirculated air in HVAC systems.

Key finding: When visited, many of the institutions had heating and cooling systems with malfunctioning exhaust and supply vents, filters that were ineffective in removing virus laden aerosols, settings that maximized heating efficiency by greatly increasing the use of recirculated air, and static pressure that, by design, created positive pressure inside cells. All of these findings have the potential to heighten the risk of COVID-19 transmission.

Key finding: Engineering and facilities staff have frequently not been involved in decisions around quarantine space and resident movement that has aimed to mitigate the risk of COVID-19 transmission.

⇒ How can the risk of aerosol transmission inside CDCR facilities be reduced through environmental measures?

Recommendation 7.3.1: Reduce occupancy, especially in open dorms and other high-density housing units with shared airspaces.

Recommendation 7.3.2: Increase air exchange rates by opening windows to the outdoors, using supplemental air cleaners, and setting HVAC controls to minimize recirculation.

Recommendation 7.3.3: Ensure the proper functionality of the existing ventilation system by hiring a test and balance engineer.

Recommendation 7.3.4: Monitor ventilation with CO_2 monitors.

Recommendation 7.3.5: Increase yard time to allow high respiration activities to stay outdoors.

Recommendation 7.3.6: Educate and empower facilities staff and involve them in decision making about use of facilities for quarantine and isolation.

Section 7.4. Testing: Rapid Antigen vs PCR Testing

⇒ What is the optimal use of rapid antigen vs PCR tests for COVID-19?

Recommendation 7.4.1: Use rapid antigen testing in place of PCR testing in most scenarios when the PCR testing turnaround time is ≥2 days. If a patient is in safe, individual isolation or quarantine while awaiting test results then PCR testing (with turnaround time ≥2 days) is appropriate.

Recommendation 7.4.2: When capacity to perform widespread antigen testing is diminished, prioritize antigen testing in settings with the potential for rapid transmission (e.g., dorms and during large uncontained outbreaks) and/or where medically vulnerable residents are housed.

Recommendation 7.4.3: Cross-train additional staff on the administration of antigen tests so that each institution can rapidly and effectively test, particularly in response to an outbreak. Current self-administered test technology is such that it would not be difficult for existing staff in a housing unit to administer such tests to a housing unit daily.

Section 7.5. Quarantine & Medical Isolation

⇒ What type of buildings were used for quarantine or medical isolation of residents?

Key finding: Almost 20% of quarantine days for residents occurred in dormitory style housing units, with 3.7% of quarantine days occurring in large standalone dorms (such as E-type).

Key finding: Housing units without solid doors to separate residents (dorms and cells with open/barred doors) were used for quarantine and isolation at the same time. Some institutions such as San Quentin had to primarily isolate and quarantine residents in these types of housing units.

Key Finding: There are inconsistencies in quarantine and isolation data that warrant further investigation.

Recommendation 7.5.1: Investigate discrepancies in quarantine and isolation data to better understand quarantine and isolation practices and constraints, particularly during large outbreaks.

Recommendation 7.5.2: Due to incredible difficulty of following recommended quarantine and isolation procedures in the prison environment, consider revising each institutions quarantine and isolation plans based on the infrastructure limitations of that institution. Assess past quarantine and isolation successes and failures to further improve plans for future quarantine and isolation.

Recommendation 7.5.3: Reducing the prison population is an important component of the COVID-19 response particularly in prisons that lack sufficient safe quarantine and isolation space.

Recommendation 7.5.4: Consider creating sub-categories of quarantine to reflect different types of quarantine, including those that safely match the needs of the population (e.g., ADA-accessible spaces), with different associated quarantine protocols.

Section 7.6. Preventing COVID-19 Transmission from Staff

⇒ What measures should be implemented to reduce the risk ofCOVID-19 introduction and transmission from staff?

Recommendation 7.6.1: Full vaccination should be required for any eligible employee, contractor, volunteer, government official, visitor, or other non-resident adult entering a CDCR prison. The definition of full vaccination should be changed to require CDC-recommended booster dosing, with sufficient time for individuals to meet this new requirement.

Recommendation 7.6.2: Continue to address staff disincentives to report symptoms and take sick leave; problems that are still prevalent based on interviews with staff.

Recommendation 7.6.3: Mandate at least twice weekly testing among staff who are not fully vaccinated. Testing should be conducted as close as possible to the start of a shift and would ideally be done with rapid antigen tests. Pooled staff testing with on-site PCR could also be explored.

Recommendation 7.6.4: Continue to work with custody leaders to improve cohorting of staff so as to minimize the risk of transmission between housing units, yards, facilities, and institutions. Employ same-day rapid testing when staff begin a work assignment with a different cohort in institutions with any active cases. Staff assigned to housing units used for

isolation or quarantine should not work in other parts of the institution and should test daily if the institution has any active cases.

Section 7.7. Outbreak Identification and Early Response

⇒ How did CDCR institutions respond with testing when a first case of COVID-19 was detected in their institution?

Key finding: There was frequently a delay between the first case detection in an institution and mass testing of exposed residents in response.

Key finding: Large numbers of cases were often detected when mass testing was deployed, indicating that multiple cycles of transmission likely occurred prior to mass testing

⇒ How can a new case introduction be detected more expeditiously inside a prison?

Recommendation 7.7.1: Given the importance of rapid testing turnaround time, policymakers should consider negotiating contracts with testing companies where payment for tests is contingent upon results returning within 48 hours. If tests are not returning within 48 hours, institutions should work with their county Department of Public Health to explore options for expedited testing.

Recommendation 7.7.2: Remove barriers to the reporting of symptoms by residents (e.g., avoiding isolation or quarantine cells that are otherwise used for solitary confinement, allowing residents to bring their belongings with them when isolated, maximizing return of residents to their original housing location, facilitating communication with loved ones, education from trusted sources on the importance of symptom self-report).

Recommendation 7.7.3: Remove barriers to the reporting of staff symptoms (e.g., guaranteeing fully paid sick leave, offering on site testing, education from trusted sources on the importance of symptom self-report).

⇒ What are key features of a robust and effective response to a new case detection inside a prison?

Key finding: Features of an effective incident command post (ICP) include strong cooperation between custody and healthcare staff, prominent roles for high-ranking staff, frequent

communication among ICP members, and decisive and clearly communicated decision-making

Recommendation 7.7.4: Each institution should have a memorandum of understanding (MOU) with their local Department of Public Health (DPH) regarding the role DPH will play in outbreak response and what conditions will trigger the involvement of DPH.

Recommendation 7.7.5: Exposed residents should be housed in areas that maximize environmental mitigation measures described throughout the report. This includes (but is not limited to): 1) maximizing outside air exchange (opening windows and doors to the outside, setting HVAC systems to maximize the intake of air from the outside), 2) housing residents in areas where negative pressure can be achieved within cells, expelling potentially infectious aerosols to the outside, and 3) increasing air filtration (e.g., deploying MERV13 or higher air filters in the HVAC system and adding supplemental filters such as Corsi-Rosenthal boxes).

Recommendation 7.7.6: Respond to a new staff case with immediate, broad, testing of all potentially exposed residents and staff (rapid antigen testing preferred if PCR testing turnaround is ≥2 days or more). This includes all residents who are in any housing units where the staff member may have worked while infectious and any others who may be housed in the same shared airspace where the staff member worked while infectious (irrespective of distance). Other staff and resident close contacts should be identified and immediately tested.

Recommendation 7.7.7: Respond to a new resident case with immediate, broad, testing of all potentially exposed residents and staff (rapid antigen testing preferred if PCR testing turnaround is ≥2 days or more). This includes all residents who are in the same housing unit and any others who may be housed in the same shared airspace as the index case (irrespective of distance). Other staff and resident close contacts should be identified and immediately tested.

Recommendation 7.7.8: The ideal testing strategy for a housing unit with an outbreak is to test daily until no new cases are identified. Once no new cases are identified testing can be spaced out to every 2-3 days until no new cases have been identified for 14 days (if new cases are identified then testing frequency should revert back to daily). Rapid antigen testing is preferred if the PCR testing turnaround time is ≥2 days.

Section 7.8. Vaccination

⇒ What measures can help improve vaccination rates among residents?

Recommendation 7.8.1: Offer vaccination to every resident who is unvaccinated or not boosted at every encounter with the healthcare system.

Recommendation 7.8.2: Target vaccine messaging campaigns to the demographic groups most likely to be unvaccinated; this includes residents who are Black/African American, of younger age, have a lower COVID-19 risk score, and who have not been previously infected

⇒ Who should be considered fully vaccinated and how should vaccination rates be tracked within institutions?

Recommendation 7.8.3: To be considered fully vaccinated, individuals must have received a complete primary vaccination series (two mRNA vaccines or a single shot of the Ad26.COV2.S vaccine, also known as the Janssen/Johnson & Johnson vaccine) followed by a booster dose with an mRNA vaccine if they are eligible for a booster.

Recommendation 7.8.4: Vaccination rates should be tracked at the level of individual buildings and housing units; areas with low vaccination rates may be higher priority for measures to reduce the risk of COVID-19 introduction and spread.

Recommendation 7.8.5: Engage with external partners to build institutional capacity to promote vaccination and tailor an ongoing vaccination campaign to the unique needs of their residents and staff.

Section 8. Experiences of the COVID-19 pandemic among those working and living in CDCR institutions

⇒ Did correctional staff and/or residents believe that the correctional system was prepared to weather an emergency such as the COVID-19 pandemic?

Key finding: Many residents and staff believed that the correctional system was unprepared to respond to an emergency at the scale of the COVID-19 pandemic. As one staff member noted, "The system needs to already be in place when you really need it."

Recommendation 8.1: Emergency contracts, equipment, policies, and relationships with community partners need to be established *before* times of crisis. For example, the

department might consider establishing longer-term contracts now with the companies that supplied needed resources during this pandemic, so that these contracts can be called on quickly in the future if needed.

Recommendation 8.2: Draw on lessons learned during this pandemic to develop clear plans for how to maintain critical operations during prolonged emergency situations at every institution. These plans should outline several contingency strategies for how an institution might respond to different scenarios, so that local leadership can adapt to the specifics of their own situation.

Recommendation 8.3: If not already in existence, establish a community liaison unit at every institution that builds on or shores up community partnerships so that institutions can turn to them for support during future emergencies.

⇒ Were Inmate Advisory Councils underutilized as partners during the pandemic?

Key finding: Inmate Advisory Councils (IACs) were often left out-of-the-loop around policies (e.g., why residents were being moved, or how the institution was responding to the pandemic). As a result, prisons missed an important opportunity to share information and get feedback on potential barriers to optimizing policies at the local level.

Recommendation 8.4: Develop (or enhance if one already exists) a feedback process for IACs during emergencies that allows residents to bring hidden concerns and ideas to leadership.

⇒ Were there opportunities to improve emergency communications in CDCR prisons during the COVID-19 pandemic?

Key finding: Many opportunities exist to improve emergency communication between residents and staff, between staff and institutional leadership, and between institutional leadership and headquarters.

Recommendation 8.5: Create streamlined, clear, and centralized pathways for communication during emergencies, including clearly delineating who is responsible for communicating specific content and to which specific groups of recipients.

Recommendation 8.6: Create a clear and consistent structure for communication during an emergency. This could include: (1) providing daily updates for IACs about programming, new institution-level and system-wide policies; (2) increasing residents' access to communication by prioritizing finding ways for the IAC to share information (perhaps via the prison television channel if in-person communication is unsafe or not possible); (3) holding all-staff meetings with the CME at least weekly during medical emergencies, so that staff can get timely answers to their questions and to help reduce uncertainty about how to keep themselves and others safe.

Recommendation 8.7: Emergency communications should provide information about the content of policy changes AND about the underlying logic for their change.

Recommendation 8.8: Consider adding members of all ranks to emergency response teams to optimize pathways of communication throughout the hierarchical chain of each facility's staff.

Key finding: Having family members of residents calling in and showing up in protest was clearly a source of stress for families, residents, and staff/institutional leadership during the pandemic.

Recommendation 8.9: Crisis communication procedures should provide guidance to facilities about how best to share information externally (e.g., with the families and friends of residents). We echo the recommendation of both staff and residents to develop a committee that is responsible for maintaining a dedicated phone line, email system, and/or other external communication platform during crises. This could enable streamlined communications with families, as well as from the IAC to headquarters, to keep all stakeholders informed during an emergency response.

⇒ How might CDCR/CCHCS headquarters recognize and support the hard work and effort of specific leaders, staff members, IACS, teams, and institutions throughout the pandemic?

Recommendation 8.10: Collect and disseminate examples of institution-specific successful and innovative strategies to use now and in future crises.

Recommendation 8.11: Provide public recognition and gratitude to specific leaders, staff members, IACS, teams and/or institutions for their heroic hard work and efforts to save people's lives and/or improve people's well-being during the pandemic.

Recommendation 8.12: Headquarters staff should make regular in-person visits to facilities to help brainstorm local solutions when unique constraints prevent them from following directives.

Recommendation 8.13: Both headquarters and institutional leadership should consider incorporating a formal "devil's advocate" into strategic decision-making processes. This technique can enable consideration of multiple perspectives when it is difficult for those with minority opinions or contradictory information to speak up.

⇒ What was the impact of lack of space in prisons during COVID-19 according to staff and residents?

Key finding: Staff and residents contended that a lack of space resulted in an inadequate ability for medical staff to ensure appropriate quarantine and medical isolation spaces.

Recommendation 8.14: To increase the amount of available space to quarantine and isolate affected residents, and to help address availability constraints for programming during epidemic emergencies, the state should maintain plans for emergency decarceration, pre-identifying residents who could be temporarily released immediately without posing undue danger to their communities.

⇒ What are some opportunities to identify new solutions to improving vaccine uptake?

Recommendation 8.15: There is an opportunity (in those Institutions not already doing so) for leadership to partner with IAC members to elicit suggested solutions for improving vaccine and booster rollout.

Recommendation 8.16: There is an opportunity (in those Institutions not already doing so) for leadership to partner with custody staff to identify rumors and misconceptions about vaccines and boosters to that they can be addressed.

⇒ Did the pandemic have an adverse impact on the mental health of prison residents?

Key finding: The adverse mental health impact of the pandemic on prison residents has been profound. Many described increased feelings of depression, anxiety, and post-traumatic stress symptoms.

Recommendation 8.17: Given the importance of contact with loved ones during an emergency, increase availability of phones in housing units/facilities, provide as many free phone calls as possible, and continue rolling out the tablet program throughout CDCR. Phones, including those for people with hearing disabilities, should also be available to people in quarantine and medical isolation.

Recommendation 8.18: Consider increasing mental health services as soon as possible, screen all residents for serious mental health-related consequences of the pandemic (even those who did not have mental health needs prior to the pandemic), and appropriate the resources needed to offer mental health services to those suffering from the trauma of being imprisoned during the pandemic.

Recommendation 8.19: Ensure that mental health staff are present in person, in sufficient numbers at each institution during emergency situations.

⇒ Did the pandemic have an adverse impact on the mental health of prison staff?

Key finding: The adverse mental health impact of the pandemic on prison staff has been profound.

Key finding: Large-scale correctional staff turnover in coming months or years is likely in the wake of trauma related to the experience of working in prisons during the pandemic.

⇒ What are opportunities to address trauma and mental health among staff?

Recommendation 8.20: Consider implementing a confidential peer support program that allows staff to share advice and stories anonymously, perhaps in partnership with the California Correctional Peace Officers Association (CCPOA) as one potential strategy to foster trust and buy-in in the program. Low-cost interventions such as this have been shown to reduce employee burnout and decrease turnover in high-stress occupations within law enforcement.

Recommendation 8.21: Develop an emergency employee needs committee that can be activated during emergency situations to identify and address immediate basic needs as well as emergent mental health needs related to the emergency situation. Basic needs might include those that correctional staff who responded to our 2020 survey indicated would be most useful, including more or better food options, having a place to change after work, access to laundry services, and having a place to shower after work.

⇒ Is there a role for data-driven policy solutions in the department's future emergency preparedness?

Recommendation 8.22: The department should continue to take an empirical, data-driven approach to solutions whenever feasible. This could include future randomized controlled trials for testing intra-departmental communications, including those related to health. The department should also continue investing in building infrastructure and research staff to expand capacity for innovation and data analysis and to draw on best practices from existing research with the goal of achieving quick learning, optimization, and the scale-up of solutions once they have been proven to work.

Section 9. Other CalPROTECT efforts related to optimizing health in CDCR institutions during the COVID-19 pandemic

⇒ How familiar are community healthcare partners with the care of incarcerated people? How can CCHCS ensure that these partners provide care to residents that respects their rights and dignity as patients?

Key finding: Many community healthcare partners are unfamiliar with navigating the legal and ethical issues surrounding the care of incarcerated people in community healthcare settings. This lack of knowledge has profound implications for patient care as well as potential significant moral injury to community healthcare professionals

Recommendation 9.1.1: CCHCS should consider using or adapting CalPROTECT materials on the care of incarcerated people in community healthcare settings. These materials could be distributed with each CCHCS patient transferred to a non-CCHCS health care facility.

⇒ How can community partners—specifically those who may be highly trusted by CDCR residents—be engaged to educate residents on measures to protect themselves from COVID-19 while incarcerated?

Recommendation 9.2.1: Trusted community partners can serve a critical role in providing high quality, science-based, community-driven educational materials to incarcerated people. CCHCS should consider continuing to engage community consultants in the development of such materials when the need emerges.

Recommendation 9.3.1: Continue to refine and replicate the highly successful CDCR vaccination events at all prisons. These events draw upon multiple principles of successful vaccination campaigns including: making the event enjoyable, optimizing participation, offering immediate vaccines with choices available, providing a diversity of sources of information (including from community leaders), ensuring access to high-quality information, and continuing to provide vaccination opportunities following the event.

Section 10. Effective Reproduction Numbers in COVID-19 Transmission in California State Prisons

⇒ Which housing units across CDCR were associated with highest reproduction numbers?

Key finding: In aggregate, celled housing has overall not been clearly protective compared to dorm housing, an important finding given that celled housing has been assumed safer and less conducive to transmission than dorms. Housing identified as "Cell," as distinct from 180 cells and 270 cells, had slightly higher hazard of test positivity than "Dorm" when controlling for other factors. At the same time, "270 Dorm" had higher infection risk than all other room types. (Note: These room type metrics are directly from CDCR/CCHCS and do not include the more detailed features reported in Section 6. Refer to Section 6 for an evaluation of the risk of infection based on a more nuanced description of cell and dorm housing types using a different analytic approach.)

⇒ How much did transmission slow purely because of the decline in the proportion of residents who were susceptible?

Key finding: Reproduction numbers declined very quickly after the start of an outbreak and less rapidly over time, when controlling for the fraction of people still susceptible in each housing unit. This suggests that control measures taken in the immediate wake of an outbreak onset such as quarantine and isolation and/or protective changes in individual behaviors have had an effect on limiting outbreaks. At the same time, there is a significant and substantial correlation between the fraction susceptible and reduction in reproduction number, when controlling for time passed, suggesting that outbreaks may have to some extent been limited by accumulation of naturally acquired immunity.

Section 11. Correlates of COVID-19 Transmission Risk in CDCR Institutions

⇒ Which race/ethnicity groups had the highest COVID-19 infection hazard and reproductive numbers?

Key finding: Residents identified by CDCR as Mexican Hispanic/Latino, non-Mexican Hispanic/Latino, Asian, and American Indian/Alaskan Native had the highest infection hazard and/or reproduction numbers, mirroring disparities seen in California COVID-19 transmission overall. The per capita association of Black/African American race with transmission risk was lower than for all other races. However, because of the high proportion of Black/African American prisoners, it must be noted that these outbreaks produced a relatively higher proportion of Black/African American cases in the prison setting than seen in California's community transmission.

Section 13. Emergence of the Omicron Variant of Concern

⇒ How can Omicron be tracked in CDCR prisons and what preemptive efforts should be undertaken to protect residents and staff from this new variant?

Recommendation 13.1: Rapidly identify variants causing any new outbreaks through CDCR partnerships with laboratories at the California Department of Public Health, MiraDx, and academic institutions (particularly as the Quest COVID-19 PCR assay does not lead to the S-gene target failure that can be a marker of Omicron).

Recommendation 13.2: Current data suggest that mRNA vaccines are preferable to the Janssen/Johnson & Johnson vaccine and that boosting is particularly beneficial in protecting recipients from the Omicron variant, thus heightening the importance of efforts to continue to offer primary vaccination and boosters to all eligible residents and staff.

Recommendation 13.3: Where policies call for different approaches for individuals who are fully vaccinated vs not fully vaccinated, define full vaccination as those who completed a primary immunization series (2 doses of an mRNA vaccine or one dose of the Janssen/Johnson & Johnson vaccine) followed by an mRNA booster (if eligible) and, potentially, those who have completed a primary immunization series (with or without boosting) and have also been infected.

Recommendation 13.4: Activities allowing for increased mixing among vaccinated residents will also need to be reevaluated until more is known about Omicron transmission and virulence.

Recommendation 13.5: If individuals infected within the previous 90 days with a non-Omicron variant are then exposed to the Omicron variant, they should be managed similarly to those who have not been infected in the previous 90 days. This includes testing for infection within the 90-day window (which as of January 2022, was being done for transfers). Do not, however, place individuals who test positive within 90 days into group isolation unless they are confirmed to have a new infection.

Recommendation 13.6: Ensure access to the monoclonal antibody sotrovimab for the early treatment of COVID-19 and preemptively identify individuals at high risk for severe disease who may benefit if infected. Sotrovimab currently appears to be most likely to retain activity against the Omicron variant. (According to CDCR/CCHCS, this was already the protocol as of January 2022.)

Recommendation 13.7: Preemptively identify individuals who may benefit from oral antiviral medications and plan to operationalize their delivery. The oral antiviral treatments nirmatrelvir/ritonavir (Paxlovid) and molnupiravir have been granted EUA by the FDA. Both will likely retain activity against Omicron. While molnupiravir and nirmatrelvir/ritonavir have not been compared head-to-head, data for nirmatrelvir/ritonavir are more encouraging. (According to CDCR/CCHCS, this was done in November 2021.)

2. Context of Report

2.1. Contractual context

In December 2017, the California Prison Receivership (CPR) engaged Dr. Brie Williams's organization, Amend at University of California, San Francisco (UCSF) (formerly the Criminal Justice & Health Program at UCSF), to conduct an independent assessment of specified systems, policies, and practices in the California Correctional Health Care Services (CCHCS) to:

1. Assess whether CCHCS systems conform to community standard policy and practice in federal and/or California state ("community") integrated health care systems, and
2. Develop recommendations to optimize CCHCS' systems of care

The initial project scope included an assessment of four systems:

1. CCHCS Mortality Review Policy and Practice (1)
2. CCHCS Systems for Maintaining a Qualified Workforce (including peer review systems)(2)
3. CCHCS Patient Safety Program (3), and
4. A pending assessment of the Medical Inspection Program of the Office of the Inspector General (OIG) and other potential mechanisms for longer term medical oversight.

In early 2020, as the threat that coronavirus disease 2019 (COVID-19) posed to prisons became apparent, the Receivership expanded its contract with Amend at UCSF to assess pressing policy-relevant questions related to COVID-19 transmission and mitigation efforts in California's state prisons. For this scope of work, Dr. Williams brought together a multidisciplinary team across the UCSF School of Medicine and the University of California, Berkeley (UC Berkeley) Schools of Public Health and Public Policy. Together, this team launched an initiative called CalPROTECT (California Prison Roadmap for Targeting Efforts to Address the Ecosystem of COVID Transmission), which was designed to provide in-the-moment and longer-range analysis of pressing questions that have arisen over the course of the COVID-19 pandemic. This report details many of our findings and analyses over the past 21 months (March 2020 – December 2021).

2.2. What is the goal of this report and who is the intended audience?

This report aims to document our findings and provide recommendations to stakeholders regarding COVID-19 transmission and some of the mitigation efforts undertaken in California prisons between March 2020 and December 2021. Our primary audiences are the CPR, the California Department of Corrections and Rehabilitation (CDCR), and the CCHCS. However, as

COVID-19's threat to the health and wellbeing of residents and staff in prisons is extreme, we hope additional stakeholders find the information in this report of use, including politicians, state and local public health officials, union leaders, and community advocacy groups.

Our overarching goal is to highlight opportunities for stakeholders to improve living and working conditions for residents and staff in California prisons and aid CCHCS's ongoing advancement towards achieving what we have termed a "healthy health care system" (4). Such a health care system is self-examining, responsive to evolving community standards, and rooted in a systems-driven culture of patient safety, quality improvement, and ongoing learning. We have derived this definition from the Institute of Medicine's seminal report on health care quality, "Crossing the Quality Chasm," which defines quality as "the degree to which health care services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge."(5)

Our recommendations throughout this report are based on the current state of knowledge about the pandemic, and several references and supplements produced earlier in the pandemic by CalPROTECT were based on the state of knowledge at the time those documents were created. In this report, we also aim to inform responses to emerging variants of concern (such as Omicron) and future respiratory pandemics. Following the original severe acute respiratory syndrome coronavirus (SARS-CoV) outbreak in 2003, the emergence of the Middle East respiratory syndrome–related coronavirus (MERS-CoV) in 2012, and now the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic, carceral settings will undoubtedly face the threat of a novel coronavirus or another respiratory pathogen in the future. The only way to avoid compounding the tragedy that has unfolded during the last two years at the nexus of two epidemics—COVID-19 and mass incarceration—is to learn from both the successes and challenges faced by California's prison system during this period of immense stress. We hope that this report will contribute to this goal.

2.3 Methodology

This report draws upon the sources listed below. Methods are explained in greater detail within each relevant section of the report.

- Review of the evolving scientific literature and expert guidance on COVID-19 prevention, mitigation, and treatment
- Analysis of anonymized night-level resident and day-watch-level staff data regarding COVID-19 infection and risk factors obtained from CCHCS

- Evaluation of statewide policies and guidance regarding COVID-19 from CDCR and CCHCS (Note: in this report, we describe policies when they are contextually relevant; a more comprehensive list of policies can be found in Supplemental Text S3)
- Primary quantitative and qualitative data collected during site visits to 10 CDCR institutions (Figure 2.1):
    - Semi-structured interviews and questionnaires with key stakeholders before and during visits, including:
        - Facility CDCR and CCHCS leadership
        - Facility healthcare, custody, and plant/engineering leadership
    - On-site data collection:
        - Focus groups and conversations with residents, front-line staff, and facility (correctional and healthcare) leadership
            - Conducted at 8 of the 10 institutions visited
        - Indoor air quality assessments
            - Conducted at 6 of the 10 institutions visited
        - Review of site-specific announcements and policies
    - Departure and post-visit debriefings with institutional leadership, in which we shared many of the recommendations in this report as preliminary findings

Figure 2.1. CDCR prisons visited by the CalPROTECT team

2.4 Organization of this report

This report comprises multiple, interrelated mini reports presented together. Each section can be read on its own or as part of the whole.

2.5 A note on the dynamic nature of SARS-CoV-2 and COVID-19

Our CalPROTECT team has done its best to continuously update our findings based on evolving data, policies, and scientific knowledge up until December of 2021. However, given the rapidly evolving understanding of SARS-CoV-2 (virus) and COVID-19 (disease and pandemic), and changes in CDCR and CCHCS policies, some of the recommendations in this report may become outdated following its release. This report is not intended to be a living document, therefore the CalPROTECT team and its partners may not revise all publications and resources included in this report as new information becomes available.

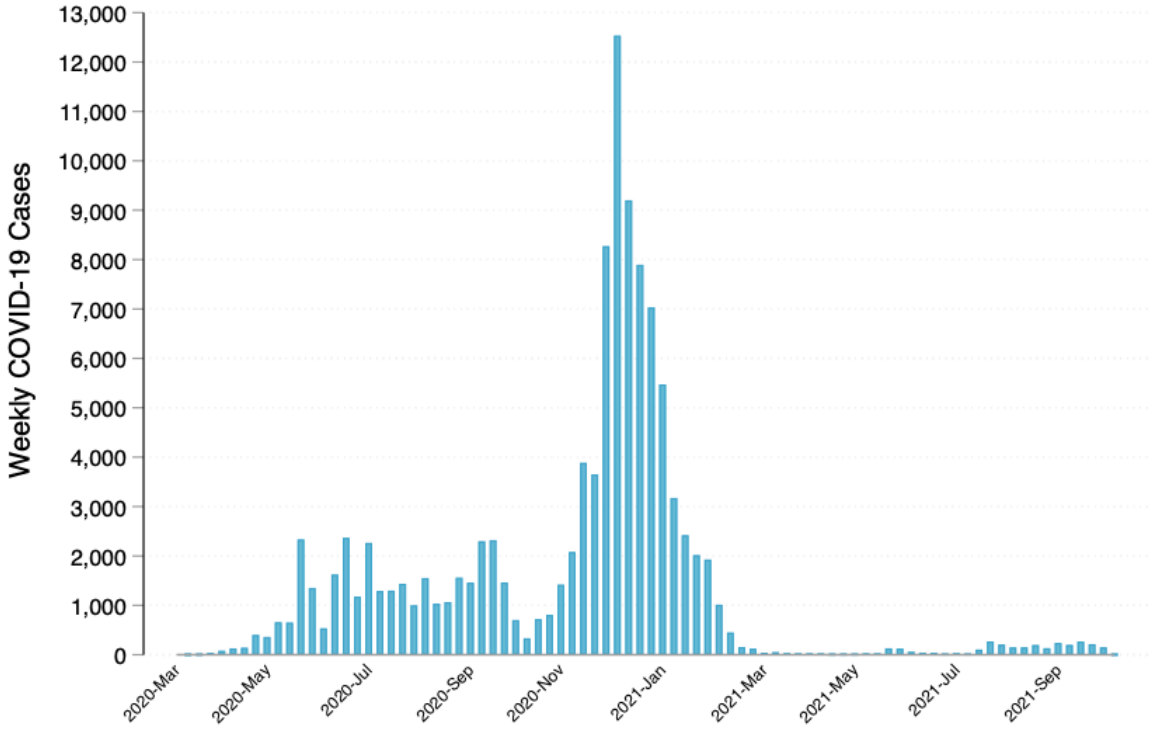
Many of our team's findings and recommendations have been communicated to CPR and CCHCS throughout the year. Consequently, in this report, we focus on two main areas:

- Providing a more in-depth analysis of the findings informing our recommendations throughout the year
- Highlighting new recommendations in areas that remain relevant in the current moment

3. Background on COVID-19 in Correctional Settings, Including CDCR Prisons

The COVID-19 pandemic has repeatedly exposed the profound public health dangers posed by carceral settings, which imprison some of society's most medically vulnerable people.(1-5) In the United States (U.S.), which holds a quarter of the world's incarcerated population, nearly half of state prisons reported that confirmed cases among incarcerated people were 4 or more times (and up to 15 times) higher than the rate found in the state's general population.(6) Nationally, COVID-19 deaths among incarcerated people have been three times those in the general population.(7) Prison staff are also at disproportionately high risk, with reported infection rates at least three times higher than in the general population.(6,7)

Figure 3.1. Weekly totals of new COVID-19 cases at CDCR institutions



CDCR houses the second largest U.S. state prison population, and each of its 35 prisons experienced at least one outbreak of COVID-19 over the past two years. As of October 9, 2021, 15,259 total infections had been reported among prison staff and 50,575 infections among incarcerated people over the course of the pandemic. Among those who were continuously incarcerated in a CDCR prison or employed by CDCR without interruption throughout the pandemic, respective infection rates were 2.6 times higher (prison residents)

and 1.6 times higher (prison staff) than the rate of laboratory-confirmed infections among adults in the general California population,(8,9) although when interpreting these differences, it is important to note that frequent testing in California's state prisons may be driving some of the differences in infection rates between the prison and the community. Cases were highest over the 2020-2021 winter season, peaking at over 12,000 weekly new resident cases in late December 2020 (**Figure 3.1**).

The COVID-19 outbreaks by magnitude were unevenly distributed across CDCR prisons. Some institutions experienced fast-spreading outbreaks resulting in significant morbidity and mortality. Others experienced smaller, more rapidly controlled outbreaks, and a few institutions did not have a single day free from new active cases for 9 to 10 months.

Optimal control of COVID-19 transmission in correctional institutions requires population reduction (through decarceration), high levels of vaccination (among both people who are incarcerated and prison staff), early outbreak detection, and optimization of ventilation and air filtration systems in shared air spaces. Making strides in each of these areas requires the mobilization of significant resources and—in the case of decarceration—profound political will. In addition, prisons and other correctional institutions do not exist in isolation – the walls of prisons are porous, allowing the virus to pass back and forth from prison to community and back again. This, in turn, presents risk to surrounding communities, including the possibility of additional pressure on local healthcare system capacity. For example, one study conducted in early 2020 traced nearly 1 in 6 COVID-19 cases in Illinois to an outbreak at Chicago's Cook County Jail.(10) With 2.1 million adults living in 5,000 carceral facilities nationwide, the number of prison residents, staff and surrounding community members at persistent risk of adverse health effects, poor wellbeing and increased mortality due to COVID-19 is profound. Adoption of aggressive measures to depopulate our correctional facilities, vaccinate incarcerated people and prison staff (including booster shots), detect outbreaks early, and improve prison ventilation and air filtration is essential.

4. Incarcerated People in CDCR Prisons throughout COVID-19: Population Demographics and Epidemiology of SARS-CoV-2 Infection and Disease

This section describes the demographics of incarcerated people at CDCR institutions during the COVID-19 pandemic. It then examines the epidemiology of SARS-CoV-2 infection and disease among people incarcerated in CDCR institutions from March 1, 2020 to October 9, 2021.

4.1. Demographics

4.1.1. Cohort Definitions

For the purpose of this section, we present data according to several cohort definitions, including:

- **Full Cohort** (residents): all residents who were incarcerated at any CDCR institution for any duration of time between March 1, 2020 and October 9, 2021; (n=148,488)
    - Among the full cohort:
        - 17,249 individuals spent an average of 5.2 nights (SD: 9.7; range: 1–205) out to medical
        - 2,180 individuals spent an average of 1.1 nights (SD: 3.5; range: 1-144) out to court
- **Continuous Cohort** (residents): all residents who were incarcerated in any CDCR institution continuously between March 1, 2020 and October 9, 2021 (n=73,318; 49.4% of the full cohort)
    - This definition includes anyone who spent any night out to court or out to medical, as long as they were captured in CDCR/CCHCS' nightly housing each night during the 588-day study period. This cohort does not include people who were paroled, discharged, or died from COVID-19 according to CCHCS during this period.
    - Among the continuous cohort:
        - 11,664 number of individuals spent an average of 4.4 nights (SD: 7.4; range: 1-205) out to medical
        - 113 number of individuals spent an average of 1.4 nights (SD: 1.4; range: 1-11) out to court

- **Recent Cohort** (residents): all residents who were incarcerated in any CDCR institution as of October 9, 2021 (n=97,740; 65.8% of the full cohort and 75.0% of the continuous cohort)

We also describe data among the following subpopulations:

- **Cases**: all those who ever tested positive for *or* who died due to COVID-19 between March 1, 2020 and October 9, 2021 (n=50,575)
- **Deaths**: all those who died as a resident of a CDCR facility due to COVID-19 according to CCHCS between March 1, 2020 and October 9, 2021 (n=240)

4.1.2. Resident Demographics

The 148,488 individuals in the full cohort resided at an average of 1.41 institutions (range: 1-7) for an average of 400 days in the entire 588-day period between March 1, 2020 and October 9, 2021. In the full cohort, 95.3% were male, approximately half were younger than age 40 (52.1%), and 5.2% were 65 years or older (**Table 4.1**).

Data Considerations – Demographic Variables

Sex: The measure "sex" was one of the data elements provided to us for analyses related to residents. This measure has been defined by CDCR/CCHCS as "resident's phenotypic sex (M or F)" and does not allow for nonbinary identities. The data dictionary further defines the variable "sex" as follows: "Startdate for this value is the first day of the resident's birth year, which is a known limitation in the case of sex reassignment." We report on this measure ("sex") noting these 'limitations and have referred to "M" as male and "F" as female. Notably, the CDCR data used in this report do not include the gender of residents.

Race and Ethnicity: CDCR/CCHCS data elements include two separate variables: "Race" and "Ethnicity". In this report, we use the "race" variable which is defined as a "resident's race/ethnicity" and contains 9 values: Asian or Pacific Islander, Black, Cuban, Hispanic, American/Indian/Alaskan Native, Mexican, Other, Unknown, and white with missing values left blank. We have attempted to maintain these categories as closely as possible to ensure adequate cell size for analysis, and since CDCR is a primary audience for this report, we endeavored to create a report that maintains consistency with internal CDCR classifications. Since CDCR defines people who are Latino(a)/Hispanic according to whether or not they are of Mexican descent, we have termed these variables "Hispanic/Latino(a) - non-Mexican" and "Hispanic/Latino(a) - Mexican" to differentiate these two groupings in the data and

emphasize that the terms Hispanic and Latino refer to a multiracial, pan-ethnic group of people. Similarly, we refer to people who have been classified as "Black" in CDCR's data as "Black/African American."

Table 4.1. Characteristics of people incarcerated in CDCR facilities during the COVID-19 pandemic, including demographics and comorbidities. Five cohorts are described: (1) full cohort, (2) continuous cohort, (3) recent cohort, (4) all COVID-19 cases, and (5) all COVID-19 deaths (see **Section 4.1** for description of each cohort).

	Full Cohort N = 148,488		**Continuous Cohort N = 73,318**		**Recent Cohort N = 97,740**		**Cases N = 50,575**		**Deaths N = 240**	
	Freq	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*
Residency										
Average no. institutions during period		1.41		1.37		1.49		1.37		1.08
Average no. days during period (of 588)		400		588		496		527		250
Always resident during period	73,318	49.4%	73,318	100.0%	73,318	75.0%	36,388	71.9%	N/A	N/A
Recent resident (October 2021)	97,740	65.8%	73,318	100.0%	97,740	100.0%	40,006	79.1%	N/A	N/A
Demographics										
Sex										
Female	6,998	4.7%	2,086	2.9%	3,541	3.6%	1,385	2.7%	2	0.8%
Male	141,490	95.3%	71,232	97.2%	94,199	96.4%	49,190	97.3%	238	99.2%
Age Group										
Younger than 30	29,747	20.0%	10,662	14.5%	18,447	18.9%	7,539	14.9%	0	0.0%
30 to 39	47,711	32.1%	20,929	28.6%	29,637	30.3%	14,092	27.9%	3	1.3%
40 to 49	33,494	22.6%	17,758	24.2%	22,390	22.9%	11,994	23.7%	15	6.3%
50 to 64	29,861	20.1%	18,743	25.6%	21,517	22.0%	13,173	26.0%	96	40.0%
65 or older	7,675	5.2%	5,226	7.1%	5,749	5.9%	3,777	7.5%	126	52.5%
Race / Ethnicity										
Asian or Pacific Islander	2,151	1.5%	967	1.3%	1,385	1.4%	704	1.4%	4	1.7%
Black/African American	40,273	27.1%	22,198	30.3%	27,884	28.5%	12,474	24.7%	63	26.3%
Latino(a)/Hispanic (non-Mexican)	50,021	33.7%	21,341	29.1%	31,405	32.1%	16,318	32.3%	43	17.9%
Latino(a)/Hispanic (Mexican)	16,681	11.2%	11,128	15.2%	12,614	12.9%	7,199	14.2%	43	17.9%
American Indian/Alaskan Native	1,761	1.2%	877	1.2%	1,193	1.2%	668	1.3%	6	2.5%
White	32,023	21.6%	13,500	18.4%	19,333	19.8%	10,973	21.7%	72	30.0%
Other or Unknown	5,578	3.8%	3,307	4.5%	3,926	4.0%	2,239	4.4%	9	3.8%
Comorbidity										
COVID Risk Score	140,609	1.21	73,229	1.60	97,644	1.44	50,542	1.58	231	5.79
Any mental health condition	73,089	49.2%	38,422	52.4%	49,832	51.0%	25,613	50.6%	150	62.5%
Any cognitive impairment	1,934	1.3%	1,106	1.5%	1,341	1.4%	551	1.1%	7	2.9%
Any mobility impairment	13,978	9.4%	9,057	12.4%	10,362	10.6%	5,748	11.4%	126	52.5%
Any speech, hearing, vision impairment	5,194	3.5%	3,543	4.8%	3,985	4.1%	2,324	4.6%	43	17.9%

Note: Race/ethnicity categories are defined by CDCR; non-Mexican and Mexican are mutually exclusive in the Latino(a)/Hispanic category. **Supplemental Text S4.1** provides detailed descriptions of the COVID Risk Score. A COVID risk score was assigned to each resident at a CDCR institution on April 2020, and scoring was updated on July 2020. The score is a sum of weights associated for different COVID risk scores.

In the full cohort, 33.7% were Latino(a)/Hispanic (non-Mexican), 27.1% Black/African American, 21.6% White, 11.2% Latino(a)/Hispanic (Mexican), 1.5% Asian or Pacific Islander, 1.2% American Indian or Alaskan Native, and the remaining 3.8% were of other or unknown race. In **Table 4.1**, statistics for age, sex, race, and other characteristics are summarized for the full, continuous, and recent cohorts.

The demographic makeup of people incarcerated in California state prisons differs substantially from the state's population as a whole. Compared to California's population in 2019, people incarcerated in CDCR during the pandemic (full cohort) were more likely to be male (CDCR: 95.3% vs. California population: 49.7%), Black/African American (27.1% vs. 6.5%), and one of CDCR's Latino(a)/Hispanic categories (44.9% vs. 36.5%).(1) Overall, 7,675 (5.2%) people incarcerated in CDCR during the pandemic were 65 years or older, compared to 14.8% of California's general population.

4.1.3. Crowding in CDCR Institutions

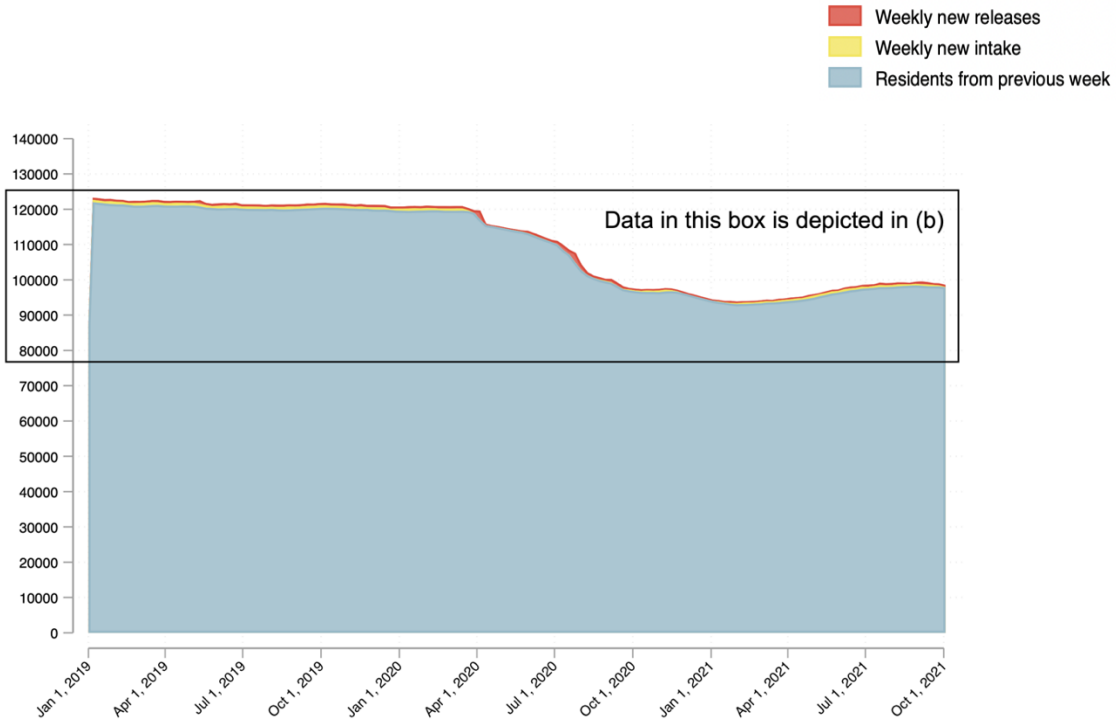
The resident population of CDCR prisons changed over the course of the pandemic with a 17% overall reduction (from 117,344 in March 2020 to 97,740 in October 2021). This population reduction meant that CDCR prisons went from being at 131% of the architectural design capacity (on average) at the outset of the pandemic, to 113% architectural design capacity in October of 2021.(2) The effect that CDCR's population reduction had on crowding was likely reduced by the closure of one institution (Deuel Vocational Institute) on September 30, 2021, the recent deactivations of parts of two other prisons (California Correctional Institution and Correctional Training Facility), and the impending closure of portions of another (California Correctional Center). These closures, planned prior to the pandemic and outlined in the California state Governor's 2020-2021 budget, have resulted in the reassignment of residents and staff to other CDCR institutions.(3,4)

Between 2016 and early 2020, the total number of people residing in CDCR facilities was fairly consistent (approximately 120,000). On March 24, 2020, California Governor Gavin Newsom issued an executive order for CDCR to halt county jail intake and transfers.(5) The results of this order are depicted in **Figure 4.1**, which shows a decline in average occupancy rates across CDCR facilities beginning in March 2020 (**Figure 4.1a**). CDCR resumed intake on a limited basis in May 2020 and again in August 2020, and halted it twice (June 2020 and November 2020). Intake resumed the week of January 11, 2021.(6) The changes these policies had on population levels can be seen in **Figure 4.1b**, which portrays the population range between 80,000 and 125,000.

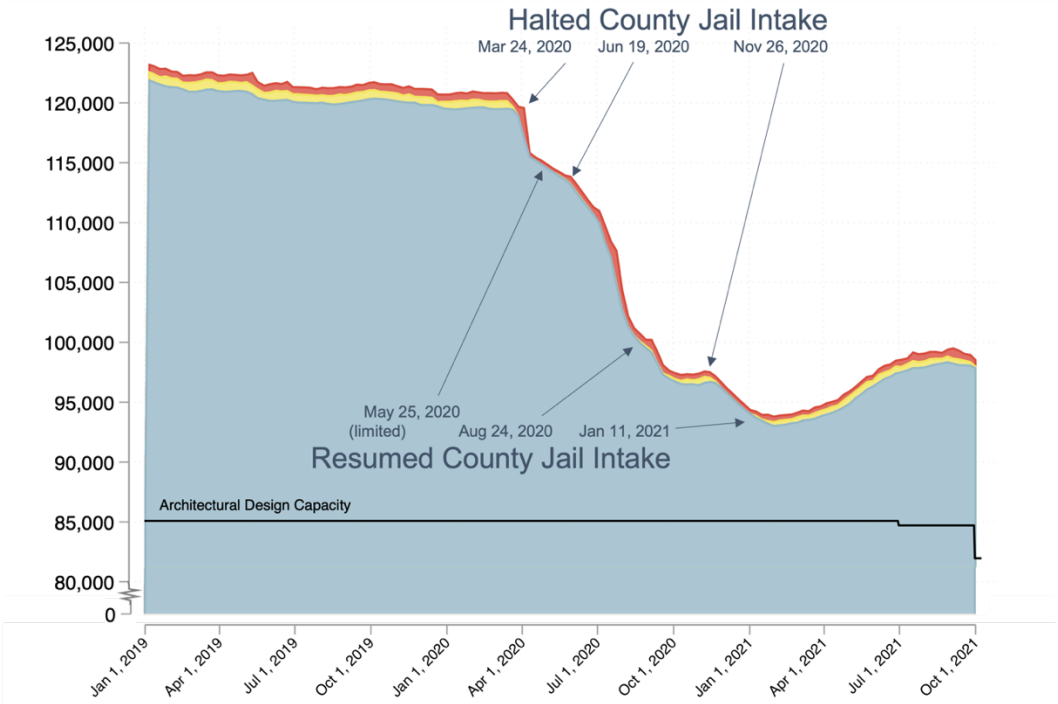
As a vital public health response to the COVID-19 pandemic, multiple healthcare societies and professionals issued calls to reduce overcrowding in correctional facilities—with a focus on releasing older, medically vulnerable residents to less crowded living situations where possible.(7-11) Most of the decrease in California's prison population was a result of the pause in the intake of people from jails as described above, rather than any sustained acceleration in early release or furlough.

Figure 4.1. CDCR's total resident population was fairly constant before the pandemic, and declined beginning in March 2020, primarily due to reductions in new intake from jails.

(a) with y-axis ranging from 0 to 140,000



(b) with y-axis ranging from 80,000 to 125,000



Note: Weekly new releases (red), weekly new intake (yellow) and incarcerated individuals who were residents from the previous week (blue) at all CDCR institutions between January 2019 and October 2021.

Figure 4.2 shows the total monthly intake and monthly releases / transfers out from CDCR institutions between 2019 and 2021. We defined monthly intake as total number of incarcerated people who were not incarcerated at a CDCR institution in the previous month; similarly, "monthly releases / transfers out" refers to the total number of incarcerated people who were incarcerated at a CDCR institution at any time in the month but are not incarcerated at a CDCR institution at any time in the following month. We did not differentiate between "releases" and "transfers out", and the monthly releases / transfers out does not include people who were sent out to court or sent out for medical care/hospitalizations, but it does include people who were on parole or discharged as long as they were not incarcerated at any CDCR institution in the next month.

The increase in releases in July and August of 2020 corresponds to Governor Newsom's order to accelerate the release of up to 8,000 residents at that time,(12) but it is then offset by lower levels of releases in subsequent months as compared to pre-pandemic levels. Evidence that a halt in intake drove the reduction in prison population during the pandemic can be demonstrated by comparing the 20-month period during the pandemic to the 14-month period prior to the pandemic. The pandemic period had a significantly lower average number of residents than the pre-pandemic period (101,449 vs. 120,627, p-value < 0.001). However, although average monthly intakes during the pandemic were significantly lower (1,182 vs. 2,950, p-value < 0.001), there was no statistical difference between average monthly releases during these two periods (2,537 vs 2,776, p-value = 0.502; Table 4.2).

Figure 4.2. Total monthly intake and monthly releases / transfers out of CDCR institutions between 2019 and 2021. The dashed vertical line represents March 2020 when COVID-19 mitigation measures began.

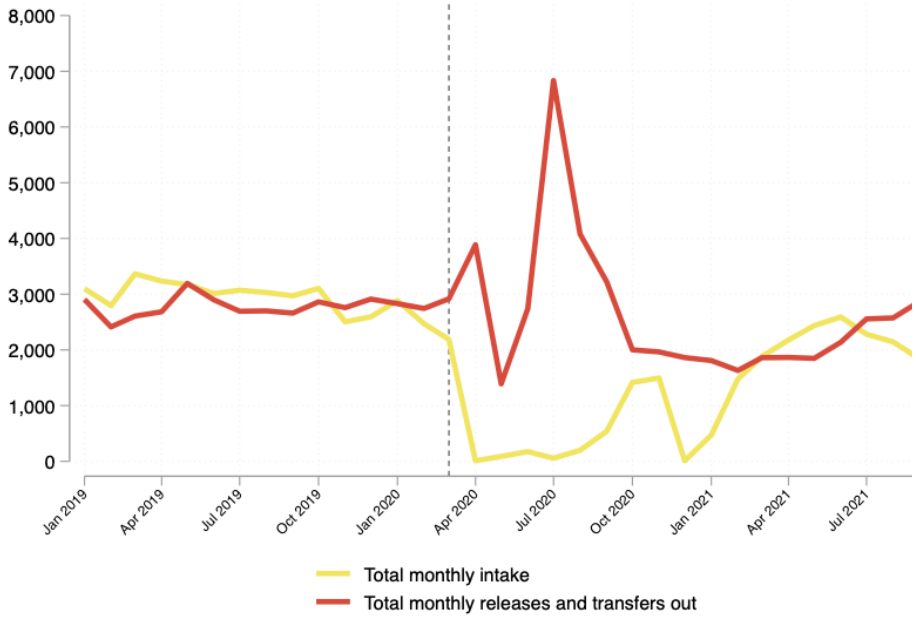


Table 4.2. Differences in monthly occupancy means before versus during COVID-19 time periods.

	Jan 2019 - Feb 2020 (14 months)		Mar 2020 - Oct 2021 (20 months)		
	Mean	*95% CI*	*Mean*	*95% CI*	*p-value*
Monthly Residents	120,627	(120,178 - 121,076)	101,449	(97,322 - 105,577)	0.000
Monthly Intake / Transfers In	2,950	(2,794 - 3,107)	1,182	(727 - 1,638)	0.000
Monthly Releases / Transfers Out	2,776	(2,671 - 2,881)	2,537	(1,930 - 3,145)	0.502
	Freq	*Mean or %*	*Freq*	*Mean or %*	*p-value*
Total Residents	167,365		153,991		
Male	158,879	94.9%	146,525	95.2%	0.004
Age	167,365	41.4	153,991	41.0	0.000
55 or older	29,472	17.6%	26,405	17.1%	0.001
Age Group					
Younger than 30	31,105	18.6%	30,919	20.1%	0.000
30 to 39	54,294	32.4%	49,669	32.3%	0.260
40 to 49	38,717	23.1%	34,767	22.6%	0.000
50 to 64	34,535	20.6%	30,803	20.0%	0.000
65 or older	8,714	5.2%	7,833	5.1%	0.124
Race / Ethnicity					
Asian or Pacific Islander	2,402	1.4%	2,234	1.5%	0.712
Black/African American	45,404	27.1%	41,695	27.1%	0.738
Latino(a)/Hispanic (non-Mexican)	55,704	33.3%	52,021	33.8%	0.003
Latino(a)/Hispanic (Mexican)	18,644	11.1%	17,096	11.1%	0.734
American Indian/Alaskan Native	1,996	1.2%	1,821	1.2%	0.792
White	36,878	22.0%	33,357	21.7%	0.011
Other or Unknown	6,337	3.8%	5,767	3.7%	0.539

Note: Rightmost column reports two-sided p-values from t-tests used to test the null hypothesis that the difference in means between the 14-month period before the pandemic (January 2019 – February 2020) and the 20-month period during the pandemic (March 2020 – October 2021) was equal to zero. If p-value < 0.05, we reject the null and conclude a significant difference does exist at the 5% significance level; p-value < 0.001, at the 0.1% significance level.

While the drop in the prison population eased some of the crowding within CDCR prisons, accomplishing this reduction by halting intake from county jails likely blunted the overall public health impact of prison population reduction for the state, since more people remained in jails where COVID-19 was able to spread just as efficiently.(13) Furthermore, our analyses do not suggest a significant focus on expediting release for those at highest risk of severe COVID-19 disease, a focus which would have had the greatest potential to avoid hospitalizations and deaths from COVID-19 among the CDCR population. When we compare the residents who left CDCR prisons between March 2020 and October 2021 to those who were incarcerated continuously (continuous cohort) we find that those who left CDCR prisons likely had a *lower* risk of developing severe COVID-19 if infected as evidenced by the following:

- The proportion of residents who were 55 or older who left CDCR prisons between March 2020 and October 2021 was 13.5%, which was significantly lower than the proportion who were in the continuous cohort (22.9%, p-value < 0.001).
- The average COVID risk score (a marker of the risk of severe disease with higher numbers describing higher risk) of those who left CDCR prisons between March 2020 and October 2021 was (0.93, n=42,965), which was significantly lower than those who were in the continuous cohort (1.60, n=73,229; difference in means p-value <0.001).

Key finding: Population reduction was modest and was primarily accomplished by expediting planned paroles and halting intake from county jails, where residents also faced a high risk of contracting COVID-19.

Key finding: Population reduction did not significantly prioritize the release of older adults or those with higher COVID-19 risk scores.

Recommendation 4.1: In the setting of ongoing COVID-19 risk, CDCR prisons remain overcrowded and decarceration remains a vital tool for safeguarding individual and public health. Policymakers should focus on the expedited release of older adults and people with high COVID-19 risk scores. Such a focus will necessitate considering a second look to evaluate appropriate people for the possibility of early release or parole to people serving three strikes or life without the possibility of parole sentences since these populations are overrepresented with older adults. Guidance might become available shortly as California has commissioned the California Committee on the Revision of the Penal Code to provide state leadership with consensus, evidence-based recommendations that are designed to improve public safety and reduce unnecessary incarceration across the state. However, it is also critical to improve metrics related to safe decarceration during a respiratory pandemic.

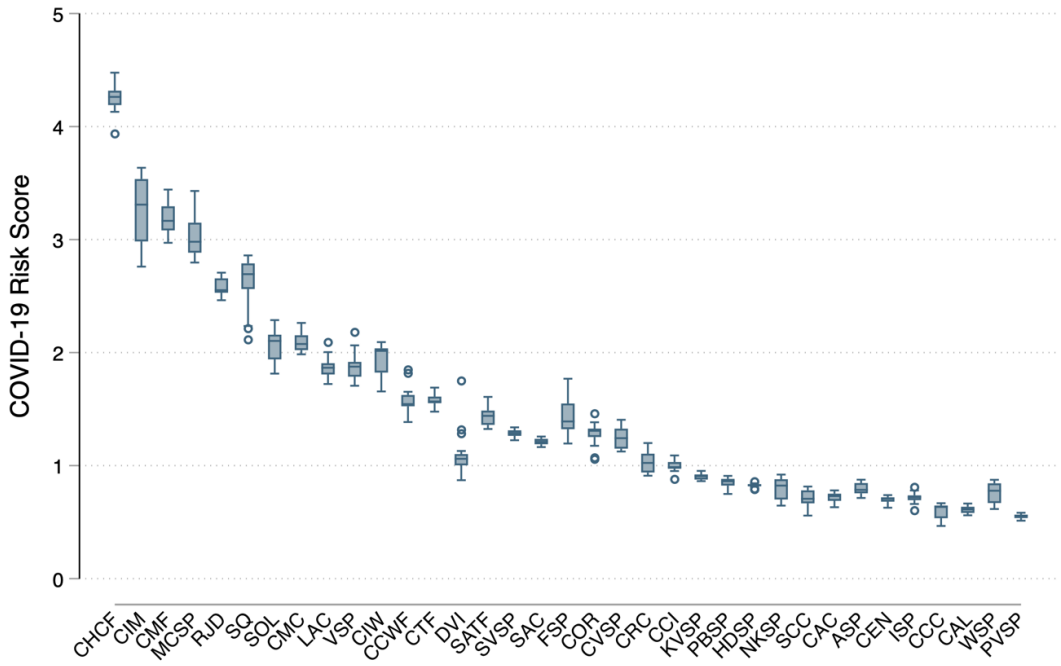
Recommendation 4.2: For the population remaining in CDCR prisons, physical distancing is exceedingly difficult; overcrowding undoubtedly contributed to the explosive COVID-19 transmission experienced in the last year and a half. If the pandemic continues with new, more transmissible variants, we recommend that population reduction be prioritized and that planned prison closures be delayed until after the pandemic has reached an endemic state to reduce population crowding.

4.1.4. Comorbidities and Risk for Severe COVID-19

At the outset of the pandemic, CCHCS developed a COVID-19 risk score using health care conditions drawn from each person's medical records. The COVID-19 risk score was based on

guidelines from the Centers for Disease Control and Prevention (CDC): higher scores indicate increased risk of poor outcomes from infection and a score of zero indicates no increased risk from documented health care conditions. (**Supplemental Text S4.1** contains more details on CDCR's COVID-19 risk score.) The average COVID-19 risk score among patients at CDCR institutions was 1.21 (range: 0 to 18) among the 140,609 (95%) individuals in the full cohort for whom we have COVID-19 risk score data. The average COVID-19 risk score was 1.60 (range: 0 to 18) for the 99.9% of residents in the continuous cohort for whom we have COVID-19 risk score data. As a result of the different missions of CDCR facilities (some are more likely to house residents of older age or in need of specialized medical care), the risk scores of residents are not distributed evenly across CDCR institutions (**Figure 4.3**). The institution with the highest average monthly COVID-19 risk score (4.25) was the California Health Care Facility (CHCF), which is designed to provide "medical care and mental health treatment to inmates who have the most severe and long-term needs."(14)

Figure 4.3. Resident populations across CDCR institutions by COVID-19 risk score shows large variation in the risk of severe COVID-19 outcomes across institutions.



Note: Boxplot of average monthly COVID risk scores by institution throughout the COVID-19 pandemic (20 months: March 2021 – October 2021) demonstrates that the patients with highest average medical risk are housed in the following 10 prisons (from leftmost to right): CHCF (California Health Care Facility, Stockton), CIM (California Institution for Men), CMF (California Medical Facility), MCSP (Mule Creek State Prison), RJD (Richard J. Donovan Correctional Facility), SQ (San Quentin), SOL (California State Prison, Solano), CMC (California Men's Colony), LAC (California State Prison, Los Angeles County), and VSP (Valley State Prison).

Comorbidities and risk factors for severe COVID-19 are described below in reference to the full cohort and can also be found in greater detail within **Supplemental Table 4.1**. High frequency comorbid medical conditions among CDCR patients that are known to result in a higher risk of severe COVID-19 include: obesity as defined by a body mass index (BMI) ≥30 (61,796, 41.6%), diabetes (11,169, 7.5%), advanced liver disease (3,938, 2.7%), asthma (17,198, 11.6%), cancer (3,817, 2.6%), chronic kidney disease (18,776, 12.6%), chronic obstructive pulmonary disease (3,384, 2.3%), hypertension (30,132, 20.3%), cardiovascular disease other than hypertension (6,676, 4.5%), and HIV (1,206, 0.8%). Medical vulnerability in the CDCR patient population was further underscored by high rates of any mental health condition (73,089, 49.2%), cognitive impairment (1,934, 1.3%), mobility impairment (13,978, 9.4%), and any speech, hearing or vision impairment (n=5,194, 3.5%). **Table 4.1** includes the rates of these conditions across the resident cohorts, and **Supplemental Table S4.1** contains the rates of different levels of mental health conditions and cognitive and/or development impairments.

Key Finding: CDCR residents have high rates of medical comorbidities that are known to increase the risk for severe COVID-19. Medically high-risk individuals are disproportionately housed in select prisons.

4.2. Epidemiology of SARS-CoV-2 infection

4.2.1. Quarantine, Medical Isolation, and Testing

To examine the epidemiology of SARS-CoV-2 infection, we focused on the 588-day period between March 1, 2020 and October 9, 2021. First, we examined outcomes for quarantine (defined as housing used to separate people from the general population who have been exposed to COVID-19) and medical isolation (defined as housing used to separate people from the general population who have tested positive for COVID-19 or who are suspected of having COVID-19). Among the full cohort, 125,677 residents (85%) were quarantined at least once due to exposure to suspected or confirmed COVID-19 infection (94% were ever quarantined* in the continuous cohort) (**Table 4.3**). Those quarantined in the full cohort spent an average of 41 days (IQR: 16-57) in quarantine during the study period. In the full cohort, 58,323 residents (39%) were medically isolated at least once due to suspected or confirmed COVID-19 infection (57% were ever isolated in the continuous cohort) (**Table 4.3**). Those isolated in the full cohort spent an average of 15 days (IQR: 11-16) in medical isolation during the study period.

In the full cohort, 94% of CDCR residents were ever tested for COVID-19 (99% in the continuous cohort), and those who were ever tested were tested an average of 16 times (IQR 7-23) (the continuous cohort received an average of 21 tests), as shown in **Table 4.3**. Since the

start of the pandemic, CCHCS has conducted a total of 2,269,897 COVID-19 tests for the full cohort, of which 12% (232,998) we are able to distinguish as antigen tests and 76% (1,725,997) we are able to distinguish as PCR tests.

Table 4.3. Experiences of quarantine, medical isolation, testing, and community healthcare use among the following groups of CDCR residents: (1) full cohort, (2) continuous cohort, (3) recent cohort, (4) all cases, (5) all deaths.

	Full Cohort N = 148,488		Continuous Cohort N = 73,318		Recent Cohort N = 97,740		Cases N = 50,575		Deaths N = 240	
	Freq	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*
COVID-19 outcomes										
Ever quarantined	125,677	84.6%	68,676	93.7%	92,979	95.1%				
Number of days quarantined (non-zero)	125,677	41.1	68,676	47.7	92,979	44.1				
Ever isolated	58,323	39.3%	41,695	56.9%	46,071	47.1%				
Number of days isolated (non-zero)	58,323	14.8	41,695	14.7	46,071	14.5				
Ever tested	138,806	93.5%	72,849	99.4%	97,257	99.5%				
Number of times tested (non-zero)	138,806	16.4	72,849	21.3	97,257	19.2				
Ever infected	50,575	34.1%	36,388	49.6%	40,006	40.9%				
Ever had ED visit due to COVID-19	1,661	1.1%	1,077	1.5%	1,198	1.2%	1,661	3.3%	182	75.8%
Ever hospitalized due to COVID-19	1,049	0.7%	627	0.9%	710	0.7%	1,049	2.1%	168	70.0%
Ever in ICU due to COVID-19	152	0.1%	29	<0.1%	33	<0.1%	152	0.3%	105	43.8%
Died due to COVID-19	240	0.2%	N/A	N/A	N/A	N/A	240	0.5%	240	100.0%
Ever vaccinated against COVID-19	89,153	60.0%	60,593	82.6%	77,478	79.3%	38,257	75.6%	10	4.2%

Note: All intensive care unit (ICU) were coded as hospitalized; all hospitalized had emergency department (ED) visit. ED and hospitalizations due to COVID-19 are classified as a visit/admission that happened 2 days before through 14 days after a positive test. ICU due to COVID-19 is an ICU admission 2 days before and 21 days after a positive COVID-19 test.

Key finding: Irrespective of infection status, most CDCR residents had been tested, quarantined, and isolated for COVID-19 symptoms or exposures during the study period.

Methodological Limitation: In this section, we examine whether a COVID-19 outcome ever occurred (e.g., "ever infected" or "ever hospitalized") and how many times they occurred (e.g., "number of times tested") during the pandemic, typically between March 2020 and October 2021. Although our purpose in doing this was to provide a description of what occurred, the limitation of this approach is that it does not account for characteristics that vary with time over the study period. The findings in this section can only be interpreted – without additional information – as outcomes that occurred at any time or for a certain number of times during the pandemic. For example, that 34% of the full cohort was ever infected between March 2020 and October 2021 alone does not tell us how risk varied over time (e.g., whether these infections occurred in the first two months or if they were uniformly spread across the entire period). For another analytic approach that accounts for several time-variant characteristics related to COVID-19 transmission at CDCR institutions during the pandemic, we direct the reader to **Sections 10 and 11** in this report.

Data Limitation: According to CCHCS leadership, quarantine data reported in this report are likely to underrepresent actual time in quarantine. This is because individual quarantine orders required time-consuming manual entry processes such that some might have been skipped during busy outbreak periods. Additionally, a different data entry protocol exists for documenting the quarantine of entire housing units, a process that is less likely to be included in the dataset we analyzed.

4.2.2. Emergence and Spread of COVID-19 Variants

Beginning in December 2020, CCHCS partnered with the California Department of Public Health (CDPH) to perform whole genome sequencing (WGS) of 524 isolates from cases in 25 prisons. Overall, the predominant variants circulating in the community largely matched what was seen in CDCR prisons. A simplified timeline of the emergence of variants is below (adapted from CCHCS data):

- December 2020 – March 2021: Multiple variants identified (among 309 samples sequenced, 42% were Epsilon, and 58% were other variants that were not classified variants of concern)
- May – June 2021: Alpha was the predominant variant (81% of 72 samples sequenced) with the first Delta cases detected in June 2021
- July – August 2021: All 143 samples sequenced were Delta
- December 10, 2021: The first positive specimens genotyped as Omicron (SARS CoV-2 B.1.1.529 lineage) were collected from three staff

4.2.3. Documented COVID-19 Infection

Overall, COVID-19 infections were diagnosed in 50,575 residents, translating to an attack rate of 34% in the full cohort. The attack rate was 50% in the continuous cohort (n=36,388) and 41% in the recent cohort (n=40,006). Following the deployment of effective COVID-19 vaccines for staff and residents beginning in December 2020, case rates had been maintained at much lower levels, and large institution-wide outbreaks had been avoided. As of the date of this report, this was expected to change with the introduction of the emerging Omicron variant.

Data Limitation: A number of CDCR residents refused COVID-19 tests at times during the pandemic (often motivated by concerns about being separated from personal property or removal from preferred housing locations). It is very likely that this has resulted in an underestimation of the true number of cases. While reliable data on testing refusal are not available, there were minimal differences in the proportion of residents who were tested (or the number of tests they received) among demographic groups. While case numbers

reported here may reflect an underestimation of total cases, CDCR residents were subjected to testing protocols that far exceeded the testing done in community settings and thus likely detected a significantly higher proportion of total cases (particularly mild and asymptomatic cases) than the proportion of cases detected in the community.

Table 4.4 displays the COVID-19 case rates per 1,000 and the relative risk of COVID-19 infection in the full cohort according to demographic characteristics. We used generalized linear models to compute both unadjusted and adjusted risk ratios for cases accounting for certain resident characteristics at the individual level to examine the risks of COVID-19 outcomes within each cohort. Subsequent investigations would benefit from more in-depth analyses, such as with individual day-level data.

Table 4.4. COVID-19 case rates per 1,000 and associations with resident characteristics as measured by risk ratios (unadjusted and adjusted for sex, age group, race/ethnicity, mental health conditions, and health-related impairments).

	Full Cohort (N = 148,488)							
	Total Cases N = 50,575	*Cases per 1,000 for category*	*Unadj. Risk Ratio*	*95% CI*	*p-value*	*Adj. Risk Ratio*	*95% CI*	*p-value*
Sex								
Female	1,385	198	*Ref*			*Ref*		
Male	49,190	348	1.8	(1.7 - 1.8)	0.000	1.7	(1.6 - 1.8)	0.000
Age Group								
Younger than 40	21,631	279	*Ref*			*Ref*		
40 to 49	11,994	358	1.3	(1.3 - 1.3)	0.000	1.3	(1.2 - 1.3)	0.000
50 to 64	13,173	441	1.6	(1.6 - 1.6)	0.000	1.6	(1.6 - 1.6)	0.000
65 or older	3,777	492	1.8	(1.7 - 1.8)	0.000	1.8	(1.7 - 1.8)	0.000
Race / Ethnicity								
White	10,973	343	*Ref*			*Ref*		
Asian or Pacific Islander	704	327	1.0	(0.9 - 1.0)	0.150	1.0	(1.0 - 1.1)	0.130
Black/African American	12,474	310	0.9	(0.9 - 0.9)	0.000	0.9	(0.9 - 1.0)	0.000
Latino(a)/Hispanic (non-Mexican)	16,318	326	1.0	(0.9 - 1.0)	0.000	1.1	(1.1 - 1.1)	0.000
Latino(a)/Hispanic (Mexican)	7,199	432	1.3	(1.2 - 1.3)	0.000	1.2	(1.2 - 1.3)	0.000
American Indian/Alaskan Native	668	379	1.1	(1.0 - 1.2)	0.001	1.1	(1.1 - 1.2)	0.000
Other or Unknown	2,239	401	1.2	(1.1 - 1.2)	0.000	1.2	(1.1 - 1.2)	0.000
No mental health condition	24,962	331	*Ref*			*Ref*		
Mental health condition	25,613	350	1.1	(1.0 - 1.1)	0.000	1.0	(1.0 - 1.1)	0.000
No cognitive impairment	50,024	341	*Ref*			*Ref*		
Cognitive impairment	551	285	0.8	(0.8 - 0.9)	0.000	0.7	(0.7 - 0.8)	0.000
No mobility impairment	44,827	333	*Ref*			*Ref*		
Mobility impairment	5,748	411	1.2	(1.2 - 1.3)	0.000	1.0	(0.9 - 1.0)	0.000
No speech, hearing, vision impairment	48,251	337	*Ref*			*Ref*		
Speech, hearing, vision impairment	2,324	447	1.3	(1.3 - 1.4)	0.000	1.1	(1.0 - 1.1)	0.001

Note: Unadjusted and adjusted risk ratios estimated from generalized linear models among full cohort; adjusted relative risk accounts for sex, age group, race/ethnicity, any mental health condition, any cognitive impairment, any mobility impairment, and any speech, hearing, or vision impairment.

The case rate per 1,000 was 348 among males and 198 among females. The case rate rose progressively with age, from 279 cases per 1,000 in those younger than 40, to 492 cases per 1,000 in those 65 years or older. For race/ethnicity, those classified by CDCR as Latino(a)/Hispanic (Mexican) had the highest case rate at 432 per 1,000, while Black/African American residents had the lowest rate at 310 per 1,000. When adjusting for sex, age group,

race/ethnicity, mental health conditions, and health-related impairments (cognitive, mobility, or sensory), male residents were at higher risk than female residents of being infected. Risk of infection also increased with older age. Compared to White residents, Black/African American residents had slightly lower rates of infection while slightly higher rates of infection were found among residents whom CDCR classified as Latino(a)/Hispanic, American Indian/Alaska Native, and other or unknown race/ethnicity.

Despite efforts to protect the most medically vulnerable residents from COVID-19 infection, the attack rate in the continuous cohort (including the 240 residents who died from COVID-19, n=73,558) among those with an elevated COVID-19 risk score of ≥7 (5.4% of the population in this cohort) was higher than the rate among those with a risk score of <7 (54% vs 50%, p<0.001). Participation in labor (or housing with others who are participating in labor) has been associated with an increased risk of acquiring COVID-19.(15)

When considering raw case numbers, it is important to note that a proportion of patients will not make a full recovery following acute COVID-19 and will instead experience prolonged symptoms and potentially a higher rate of adverse health outcomes in the post-acute setting. More research is needed to better understand post-COVID conditions and how these conditions affect CDCR residents and staff.

Reinfections with COVID-19 were rare during the study period. Using the definition of reinfection as a positive test result more than 90 days after the first positive test result, 451 residents (0.3%) had an initial COVID-19 infection and a re-infection in a CDCR facility. Some of these cases, however, may be from patients with prolonged PCR positivity from a single infection rather than a reinfection.

Key finding: Despite efforts to protect the most vulnerable residents from COVID-19, the 5% of residents with the highest COVID-19 risk scores were more likely to have a documented COVID-19 infection than those with lower risk scores.

4.2.4. Use of Community Healthcare Services: COVID-19-Related Emergency Department Visits, Hospitalizations, and ICU Admissions

Data Limitation: Community hospital visits and admissions were derived from the CCHCS data set which required tracking and manual entry of admissions to community hospitals and levels of care (e.g., ICU admission). According to CCHCS, "Due to the manual process involved in tracking this data element, not all levels of care for a given hospital visit may be recorded." As a result, the findings reported here may be an underestimation, particularly of

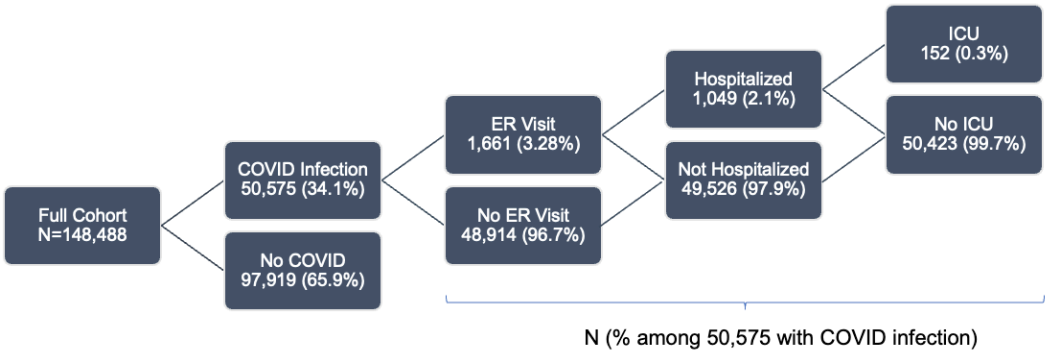
brief hospitalizations and intensive care unit (ICU) admission. However, such underestimation is not likely to favor reporting of any particular subgroup.

Among those ever diagnosed with COVID-19, we examined COVID-19-related health care utilization, including visiting a community emergency department (ED) or being admitted to a community hospital or an intensive care unit (ICU). The data provided general hospitalization information but no definitive information on cause of hospitalization. To classify hospital visits and admissions as related to COVID-19, we used time from positive test to hospital visit/admission as a proxy. COVID-19-related ED visits or hospital admissions were defined as visiting an ED or being admitted to a hospital between two days before and 14 days following a positive COVID-19 test (antigen or PCR). Given that ICU admission may occur as a late sequela of COVID-19, we considered any ICU admission to be COVID-19-related if it occurred 21 days after or two days before a positive COVID-19 test for those ever infected.

In the full cohort, 1,661 residents (1.1%) visited an ED in a community hospital between 2 days before and 14 days following their first positive COVID-19 test (**Figure 4.4**). In the continuous cohort, 1,077 residents (1.5%) visited an ED associated with a positive COVID-19 test. Among all known COVID-19 cases in CDCR patients, 3.3% resulted in at least one community ED visit.

Overall, 1,049 residents (0.7%) in the full cohort were hospitalized with COVID-19 for a rate of 706 hospitalizations per 100,000 residents. In the continuous cohort there were 627 hospitalizations (0.9%) with COVID-19 for a rate of 855 per 100,000 residents. In total, 2.1% of all CDCR patients with COVID-19 were hospitalized in the community. Overall, there were 152 COVID-19 ICU admissions (0.1%) in the full cohort and 29 (<0.1%) in the continuous cohort. Among all resident COVID-19 cases, 152 (0.3%) resulted in an ICU admission, of these 152 ICU cases, 105 (69%) died.

Figure 4.4. Resident COVID-19 infections, ER visits, hospitalizations, and ICU admissions.



Note: Numbers of ER visits, hospitalizations, and ICU admissions do not reflect the 58 CDCR residents who died of COVID-19 without a documented ER visit or hospital admission.

Table 4.5a displays the COVID-19 hospitalization rates per 100,000 people and unadjusted and adjusted relative risk of COVID-19 hospitalization in the full cohort according to demographic characteristics. The hospitalization rate per 100,000 was 329 among females and 725 among males. The hospitalization rate rose progressively with age, from 108 cases per 100,000 in those younger than 40 to 4,534 cases per 100,000 in those 65 years or older. The highest hospitalization rates were found among those classified by CDCR as American Indian or Alaska Native (1,306 per 100,000) and Latino(a)/Hispanic (Mexican) (1,259 per 100,000), while the lowest rate was among those classified as Latino(a)/Hispanic (non-Mexican) (504 per 100,000). Advanced age remained a powerful, independent risk factor for hospitalization, even after accounting for sex, race/ethnicity, mental health conditions, and health-related impairments (cognitive, mobility, or sensory). Non-white residents also experienced a higher risk of hospitalization compared to white residents in the adjusted analysis as did individuals with a mobility impairment or any speech, hearing, or vision impairment.

When limiting the analysis to only those who were infected with COVID-19 (Table 4.5b), the adjusted risk of hospitalization still rose with advancing age and non-white residents still had higher rates of hospitalization compared to white residents. Mobility impairment and any speech, hearing, or vision impairment were also still associated with higher rates of hospitalization even independent of age.

Table 4.5. Hospitalizations due to COVID-19 per 100,000 people according to demographic characteristics as measured by risk ratios (unadjusted and adjusted for sex, age group, race/ethnicity, mental health conditions, and health-related impairments).

(a) Among full cohort

	Full Cohort (N = 148,488)							
	Total Hospitalizations N = 1,049	*Hospitalizations per 100,000 for category*	*Unadj. Risk Ratio*	*95% CI*	*p-value*	*Adj. Risk Ratio*	*95% CI*	*p-value*
Sex								
Female	23	329	*Ref*			*Ref*		
Male	1,026	725	2.2	(1.5 - 3.3)	0.000	1.6	(1.1 - 2.4)	0.028
Age Group								
Younger than 40	84	108	*Ref*			*Ref*		
40 to 49	160	478	4.4	(3.4 - 5.7)	0.000	4.3	(3.3 - 5.6)	0.000
50 to 64	457	1,530	14.1	(11.2 - 17.8)	0.000	13.2	(10.3 - 16.8)	0.000
65 or older	348	4,534	41.8	(33.0 - 53.0)	0.000	31.0	(23.9 - 40.2)	0.000
Race / Ethnicity								
White	229	715	*Ref*			*Ref*		
Asian or Pacific Islander	17	790	1.1	(0.7 - 1.8)	0.690	2.0	(1.2 - 3.3)	0.005
Black/African American	263	653	0.9	(0.8 - 1.1)	0.313	1.2	(1.0 - 1.5)	0.022
Latino(a)/Hispanic (non-Mexican)	252	504	0.7	(0.6 - 0.8)	0.000	2.1	(1.7 - 2.5)	0.000
Latino(a)/Hispanic (Mexican)	210	1,259	1.8	(1.5 - 2.1)	0.000	2.0	(1.7 - 2.5)	0.000
American Indian/Alaskan Native	23	1,306	1.8	(1.2 - 2.8)	0.006	2.1	(1.4 - 3.3)	0.000
Other or Unknown	55	986	1.4	(1.0 - 1.8)	0.032	1.7	(1.2 - 2.2)	0.001
No mental health condition	472	626	*Ref*			*Ref*		
Mental health condition	577	789	1.3	(1.1 - 1.4)	0.000	1.0	(0.9 - 1.1)	0.601
No cognitive impairment	1,021	697	*Ref*			*Ref*		
Cognitive impairment	28	1,448	2.1	(1.4 - 3.0)	0.000	0.9	(0.6 - 1.3)	0.482
No mobility impairment	630	468	*Ref*			*Ref*		
Mobility impairment	419	2,998	6.4	(5.7 - 7.2)	0.000	2.1	(1.8 - 2.4)	0.000
No speech, hearing, vision impairment	891	622	*Ref*			*Ref*		
Speech, hearing, vision impairment	158	3,042	4.9	(4.1 - 5.8)	0.000	1.3	(1.1 - 1.5)	0.009

Note: Unadjusted and adjusted risk ratios estimated from generalized linear models among full cohort; adjusted relative risk accounts for sex, age group, race/ethnicity, any mental health condition, any cognitive impairment, any mobility impairment, and any speech, hearing, or vision impairment.

(b) Among COVID-19 cases

	Cases (N = 50,575)							
	Total Hospitalizations N = 1,049	*Hospitalizations per 100,000 for category*	*Unadj. Risk Ratio*	*95% CI*	*p-value*	*Adj. Risk Ratio*	*95% CI*	*p-value*
Sex								
Female	23	1,661	*Ref*			*Ref*		
Male	1,026	2,086	1.3	(0.8 - 1.9)	0.276	0.8	(0.5 - 1.2)	0.264
Age Group								
Younger than 40	84	388	*Ref*			*Ref*		
40 to 49	160	1,334	3.4	(2.6 - 4.5)	0.000	3.3	(2.6 - 4.3)	0.000
50 to 64	457	3,469	8.9	(7.1 - 11.3)	0.000	8.1	(6.4 - 10.3)	0.000
65 or older	348	9,214	23.7	(18.7 - 30.0)	0.000	17.3	(13.4 - 22.4)	0.000
Race / Ethnicity								
White	229	2,087	*Ref*			*Ref*		
Asian or Pacific Islander	17	2,415	1.2	(0.7 - 1.9)	0.557	2.0	(1.3 - 3.3)	0.003
Black/African American	263	2,108	1.0	(0.8 - 1.2)	0.909	1.3	(1.1 - 1.5)	0.003
Latino(a)/Hispanic (non-Mexican)	252	1,544	0.7	(0.6 - 0.9)	0.001	1.8	(1.5 - 2.2)	0.000
Latino(a)/Hispanic (Mexican)	210	2,917	1.4	(1.2 - 1.7)	0.000	1.7	(1.4 - 2.0)	0.000
American Indian/Alaskan Native	23	3,443	1.6	(1.1 - 2.5)	0.020	2.0	(1.3 - 3.0)	0.001
Other or Unknown	55	2,456	1.2	(0.9 - 1.6)	0.272	1.4	(1.1 - 1.9)	0.012
No mental health condition	472	1,891	*Ref*			*Ref*		
Mental health condition	577	2,253	1.2	(1.1 - 1.3)	0.004	1.0	(0.9 - 1.1)	0.971
No cognitive impairment	1,021	2,041	*Ref*			*Ref*		
Cognitive impairment	28	5,082	2.5	(1.7 - 3.6)	0.000	1.3	(0.9 - 1.8)	0.170
No mobility impairment	630	1,405	*Ref*			*Ref*		
Mobility impairment	419	7,289	5.2	(4.6 - 5.9)	0.000	2.2	(1.9 - 2.5)	0.000
No speech, hearing, vision impairment	891	1,847	*Ref*			*Ref*		
Speech, hearing, vision impairment	158	6,799	3.7	(3.1 - 4.3)	0.000	1.2	(1.0 - 1.5)	0.014

Note: Unadjusted and adjusted risk ratios estimated from generalized linear models among cases in full cohort; adjusted relative risk accounts for sex, age group, race/ethnicity, any mental health condition, any cognitive impairment, any mobility impairment, and any speech, hearing, or vision impairment.

Key finding: COVID-19 placed a significant strain on the health systems of prisons and surrounding communities, leading to at least 1,661 community ED visits, 1,049 hospital admissions, and 152 ICU admissions related to COVID-19. Many of these cases occurred over short periods of time during rapidly spreading outbreaks.

Key finding: Non-white residents had a higher risk of COVID-19 hospitalization than white residents when adjusting for sex, age group, mental health conditions, and health-related impairments.

4.2.5. Deaths Due to COVID-19

As of October 9, 2021, 240 CDCR residents had died of COVID-19, accounting for a case fatality rate of 0.5% among residents who ever tested positive in the full cohort. Among the 240 who died, 238 (99%) were male, 96 (40%) were between ages 50 and 64, and 126 (53%) were 65 years or older. Overall, 72 (30%) were white, 63 (26%) were Black/African American, 43 (18%) were Latino/Hispanic (non-Mexican); 43 (18%) were Latino(a)/Hispanic (Mexican); 6 (3%)

were American Indian or Alaska Native, 4 (2%) were Asian or Pacific Islander, and 9 (4%) were of another race or unknown race. Table 4.6 shows when the 240 deaths occurred by month and the average age, COVID risk score, and vaccination status of the deceased according to month (note: vaccine efficacy is discussed in greater detail elsewhere).

Among the 240 COVID-19 deaths, 182 (76%) had visited an ED with COVID-19, 168 (70%) had been hospitalized in the community with COVID-19, and 105 (44%) were known to have been in the ICU during their hospitalization. These data suggest that 58 residents were never transported to the ED prior to dying with COVID-19. While CCHCS appropriately cautions that the manual data entry required to collect these data may represent a slight underestimation (particularly of brief hospitalizations and ICU admission), the cases of these 58 residents warrant additional investigation to determine whether this number of deaths did indeed occur prior to transfer to a community hospital, whether patients were offered but declined transport, and if any early warning signs of clinical deterioration were missed that could improve care quality in the future.

Table 4.6. Number of deaths due to COVID-19 according to month.

Month	No. Deaths due to COVID-19	Average Age	Average COVID Risk Score	No. Deaths Not Fully Vaccinated	No. Deaths Fully Vaccinated
Apr 2020	1	62.0	N/A	N/A	N/A
May 2020	9	67.3	N/A	N/A	N/A
Jun 2020	13	62.9	3.3	N/A	N/A
Jul 2020	25	67.0	4.6	N/A	N/A
Aug 2020	15	66.3	5.6	N/A	N/A
Sep 2020	9	62.3	5.4	N/A	N/A
Oct 2020	9	62.2	4.8	N/A	N/A
Nov 2020	9	65.6	5.3	N/A	N/A
Dec 2020	55	63.2	5.4	N/A	N/A
Jan 2021	65	65.0	6.5	N/A	N/A
Feb 2021	18	66.8	6.8	18	0
Mar 2021	5	66.2	6.6	5	0
Apr 2021	2	73.5	10.5	2	0
May 2021	3	71.7	12.3	2	1
Jun 2021	1	46.0	5.0	0	1
Jul 2021	0	N/A	N/A	0	0
Aug 2021	1	82.0	12.0	0	1
Total	240	65.0	5.8	27/30	3/30

Note: Average age and average COVID risk score are by month. COVID risk scores were not available for individuals who died due to COVID-19 in April and May of 2020. Beginning February 2021, "fully vaccinated" is defined here as 2 or more doses of mRNA-1273 (Moderna), 2 or more doses of BNT162b2 (Pfizer), or 1 or more doses of Ad26.COV2.S (Janssen/Johnson & Johnson) as of October 9, 2021.

Using generalized linear models, we computed the risk ratio (RR) for death while adjusting for sex, age group, race/ethnicity, mental health condition, and health-related impairments (cognitive, mobility, or sensory) in the full cohort (Table 4.7a) and among cases in the full cohort (Table 4.7b). Among all cases, the adjusted risk ratio (aRR) was 1.9 for males relative to females a difference that did not reach statistical significance (95% confidence interval (CI) 0.5 - 7.7, p=0.355). Compared to those younger than 40, there was a significant elevation in risk of death among infected residents in older age groups (aRR = 161.5 for those 65 years or older compared to those under 40; 95% CI 50.4 - 517.4, p<0.001). While those classified by CDCR as Latino(a)/Hispanic (non-Mexican) had the lowest crude case fatality rate (264 per 100,000), in the adjusted analysis, the only significant difference according to race/ethnicity was a higher risk of death among Latino(a)/Hispanic (non-Mexican) residents (aRR 1.5, 95% CI 1.0 - 2.2, p=0.037) relative to those who were white. Among residents who were infected with COVID-19, those with a mental health condition were more likely to die than those who did not have a mental health condition (aRR 1.3, 95% CI 1.0 - 1.8, p=0.036) and those with a mobility impairment were more likely to die from COVID-19 than infected residents who did not have a mobility impairment (aRR 2.5, 95% CI 1.9 - 3.2, p<0.001).

Table 4.7. Deaths due to COVID-19 per 100,000 people according to demographic characteristics as measured by risk ratios (unadjusted and adjusted for sex, age group, race/ethnicity, mental health conditions, and health-related impairments)

(a) Among full cohort

	Full Cohort (N = 148,488)							
	Total Deaths N = 240	*Deaths per 100,000 for category*	*Unadj. Risk Ratio*	*95% CI*	*p-value*	*Adj. Risk Ratio*	*95% CI*	*p-value*
Sex								
Female	2	29	*Ref*			*Ref*		
Male	238	168	5.9	(1.5 - 23.7)	0.013	4.1	(1.0 - 16.6)	0.046
Age Group								
Younger than 40	3	4	*Ref*			*Ref*		
40 to 49	15	45	11.6	(3.3 - 39.9)	0.000	10.9	(3.1 - 37.6)	0.000
50 to 64	96	321	83.0	(26.3 - 261.9)	0.000	71.1	(22.3 - 226.6)	0.000
65 or older	126	1,642	423.9	(134.9 - 1,331.7)	0.000	291.8	(90.9 - 936.3)	0.000
Race / Ethnicity								
White	72	225	*Ref*			*Ref*		
Asian or Pacific Islander	4	186	0.8	(0.3 - 2.3)	0.711	1.8	(0.7 - 5.0)	0.231
Black/African American	63	156	0.7	(0.5 - 1.0)	0.035	1.0	(0.7 - 1.4)	0.996
Latino(a)/Hispanic (non-Mexican)	43	86	0.4	(0.3 - 0.6)	0.000	1.6	(1.1 - 2.4)	0.013
Latino(a)/Hispanic (Mexican)	43	258	1.1	(0.8 - 1.7)	0.478	1.5	(1.1 - 2.3)	0.025
American Indian/Alaskan Native	6	341	1.5	(0.7 - 3.5)	0.327	1.9	(0.8 - 4.3)	0.128
Other or Unknown	9	161	0.7	(0.4 - 1.4)	0.348	0.9	(0.5 - 1.8)	0.815
No mental health condition	90	119	*Ref*			*Ref*		
Mental health condition	150	205	1.3	(1.1 - 1.4)	0.000	1.2	(0.9 - 1.6)	0.113
No cognitive impairment	233	159	*Ref*			*Ref*		
Cognitive impairment	7	362	2.3	(1.1 - 4.8)	0.032	0.7	(0.3 - 1.5)	0.342
No mobility impairment	114	85	*Ref*			*Ref*		
Mobility impairment	126	901	10.6	(8.3 - 13.7)	0.000	2.3	(1.7 - 3.0)	0.000
No speech, hearing, vision impairment	197	137	*Ref*			*Ref*		
Speech, hearing, vision impairment	43	828	6.0	(4.3 - 8.4)	0.000	1.0	(0.7 - 1.5)	0.865

Note: Unadjusted and adjusted risk ratios estimated from generalized linear models among full cohort; adjusted relative risk accounts for sex, age group, race/ethnicity, any mental health condition, any cognitive impairment, any mobility impairment, and any speech, hearing, or vision impairment.

(b) Among COVID-19 cases

	Cases (N = 50,575)							
	Total Deaths N = 240	*Deaths per 100,000 in category*	*Unadj. Risk Ratio*	*95% CI*	*p-value*	*Adj. Risk Ratio*	*95% CI*	*p-value*
Sex								
Female	2	144	*Ref*			*Ref*		
Male	238	484	3.4	(0.8 - 13.5)	0.088	1.9	(0.5 - 7.7)	0.355
Age Group								
Younger than 40	3	14	*Ref*			*Ref*		
40 to 49	15	125	9.0	(2.6 - 31.1)	0.001	8.4	(2.4 - 29.0)	0.001
50 to 64	96	729	52.5	(16.7 - 165.8)	0.000	43.4	(13.6 - 138.4)	0.000
65 or older	126	3,336	240.5	(76.6 - 755.5)	0.000	161.5	(50.4 - 517.4)	0.000
Race / Ethnicity								
White	72	656	*Ref*			*Ref*		
Asian or Pacific Islander	4	568	0.9	(0.3 - 2.4)	0.779	1.9	(0.7 - 5.0)	0.216
Black/African American	63	505	0.8	(0.5 - 1.1)	0.128	1.1	(0.8 - 1.5)	0.746
Latino(a)/Hispanic (non-Mexican)	43	264	0.4	(0.3 - 0.6)	0.000	1.5	(1.0 - 2.2)	0.037
Latino(a)/Hispanic (Mexican)	43	597	0.9	(0.6 - 1.3)	0.625	1.3	(0.9 - 1.9)	0.159
American Indian/Alaskan Native	6	898	1.4	(0.6 - 3.1)	0.458	1.8	(0.8 - 4.0)	0.169
Other or Unknown	9	402	0.6	(0.3 - 1.2)	0.165	0.8	(0.4 - 1.6)	0.579
No mental health condition	90	361	*Ref*			*Ref*		
Mental health condition	150	586	1.6	(1.3 - 2.1)	0.000	1.3	(1.0 - 1.8)	0.036
No cognitive impairment	233	466	*Ref*			*Ref*		
Cognitive impairment	7	1,270	2.7	(1.3 - 5.8)	0.008	1.1	(0.5 - 2.2)	0.882
No mobility impairment	114	254	*Ref*			*Ref*		
Mobility impairment	126	2,192	8.6	(6.7 - 11.1)	0.000	2.5	(1.9 - 3.2)	0.000
No speech, hearing, vision impairment	197	408	*Ref*			*Ref*		
Speech, hearing, vision impairment	43	1,850	4.5	(3.3 - 6.3)	0.000	1.0	(0.7 - 1.5)	0.867

Note: Unadjusted and adjusted risk ratios estimated from generalized linear models among cases in full cohort; adjusted relative risk accounts for sex, age group, race/ethnicity, any mental health condition, any cognitive impairment, any mobility impairment, and any speech, hearing, or vision impairment.

Recommendation 4.3: CCHCS's mortality review process should examine the cases of residents who died of COVID-19 prior to transfer to a community hospital with the aim of determining whether opportunities exist to improve the early detection of clinical deterioration among patients with COVID-19 and/or whether care in these cases reflected the wishes of patients who declined to transfer to the community hospital/ED setting.

Key finding: Older age, mental health conditions, and mobility impairments were associated with a higher adjusted risk of COVID-19 death among people diagnosed with COVID-19.

4.2.6. Measuring the Disproportionate Burden of COVID-19 on CDCR Residents

COVID-19 case rates inside CDCR prisons have exceeded the case rates in surrounding communities. At the institution level, the case rate per 1,000 people in each prison (excluding DVI since it closed during the pandemic) alongside the case rate per 1,000 people in the surrounding county is displayed in **Table 4.8**. As of October 9, 2021, every CDCR prison had a COVID-19 case rate that exceeded its county case rate. Case rates of the institutions exceeded their county case rates by an average of 3.34 times, ranging from 1.05 times (135 per 1,000 at

Wasco State Prison (WSP) vs. 128 per 1,000 in Kern County) to 9.30 (545 per 1,000 at San Quentin (SQ) vs. 59 per 1,000 in Marin County). The true magnitude of the difference in case rates, however, is likely smaller than what is displayed in **Table 4.8**, given CDCR's extensive testing protocols in comparison to testing in the surrounding communities. Furthermore, case rates in many CDCR institutions since the spring of 2021—following the widespread deployment of vaccines to residents and staff—have been lower than in many institutions compared to their surrounding communities.

Table 4.8. Institutional case rate per 1,000 people in each prison, in comparison with county where the CDCR institution is located.

Institution	County	Institutional cases per 1000	County cases per 1000	Ratio of institution to county case rate
WSP, Wasco State Prison	Kern	135	128	1.05
NKSP, North Kern State Prison	Kern	141	128	1.10
PBSP, Pelican Bay State Prison	Del Norte	176	123	1.42
CEN, California State Prison, Centinela	Imperial	244	164	1.48
SAC, California State Prison, Sacramento	Sacramento	161	97	1.67
CAL, Calipatria State Prison	Imperial	295	164	1.79
KVSP, Kern Valley State Prison	Kern	245	128	1.90
COR, California State Prison, Corcoran	Kings	312	160	1.95
CCWF, Central California Women's Facility	Madera	244	124	1.98
CIW, California Institution for Women	Riverside	312	141	2.21
SVSP, Salinas Valley State Prison	Monterey	241	99	2.44
CHCF, California Health Care Facility, Stockton	San Joaquin	316	122	2.59
CIM, California Institution for Men	San Bernardino	423	155	2.72
RJD, Richard J. Donovan Correctional Facility	San Diego	304	108	2.82
CCC, California Correctional Center	Lassen	423	143	2.96
CRC, California Rehabilitation Center	Riverside	420	141	2.97
CCI, California Correctional Institution	Kern	395	128	3.07
CAC, California City Correctional Facility	Kern	400	128	3.11
LAC, California State Prison, Los Angeles County	Los Angeles	442	138	3.21
ISP, Ironwood State Prison	Riverside	479	141	3.39
SATF, Substance Abuse Treatment Facility and State Prison, Corcoran	Kings	564	160	3.52
CMF, California Medical Facility	Solano	353	96	3.69
PVSP, Pleasant Valley State Prison	Fresno	471	127	3.71
HDSP, High Desert State Prison	Lassen	532	143	3.72
ASP, Avenal State Prison	Kings	618	160	3.86
FSP, Folsom State Prison	Sacramento	389	97	4.02
SOL, California State Prison, Solano	Solano	396	96	4.14
SCC, Sierra Conservation Center	Tuolumne	438	100	4.39
VSP, Valley State Prison	Madera	572	124	4.63
CVSP, Chuckawalla Valley State Prison	Riverside	661	141	4.68
MCSP, Mule Creek State Prison	Amador	458	90	5.10
CTF, Correctional Training Facility	Monterey	559	99	5.66
CMC, California Men's Colony	San Luis Obispo	686	94	7.33
SQ, San Quentin State Prison	Marin	545	59	9.30
			Average	3.34

Note: County population and cases do not include CDCR residents or cases, and CDCR has higher testing rates.

We compared COVID-19 cases and deaths in CDCR (using the continuous cohort) to those in the general U.S. and California populations (**Table 4.9**). We selected this cohort to demonstrate the true risk of being infected with or dying from COVID-19 across the study period by removing people who left prison early in the pandemic or who were newly incarcerated at CDCR near the end of the study period. Despite having a smaller proportion of older adults compared to the general population (5.2% vs 14.8% aged 65 years or older), the COVID-19 death rate of 326.3 per 100,000 CDCR residents is 9.0% higher than California's death rate (299.4 per 100,000 residents) and 8.3% higher than the U.S. death rate (301.4 per 100,000 residents) (**Table 4.9**).(16-18) The COVID-19 case fatality rate in the continuous cohort (0.66%), however, is substantially lower than the estimated case fatality rate in California and in the US general population (1.61% and 1.53%). This is likely, in part, driven by the smaller proportion of older adults in CDCR prisons as well as extensive testing, which can detect mild and asymptomatic infections that may not have otherwise come to medical attention in the community. The higher per population death rate in the setting of a lower case fatality rate is best explained by the significantly higher number of cases in CDCR institutions.

Table 4.9. Comparison of cases and deaths across United States, California, and CDCR.

	U.S. General Population	California General Population	CDCR Continuous Cohort + Deaths
N (18+)	258,300,000	24,621,819	73,558
Cases	48,377,531	4,806,510	36,628
Deaths	778,489	73,712	240
Case Fatality Rate	1.61%	1.53%	0.66%
Cases per 1,000	187.3	195.2	497.9
Deaths due to COVID-19 per 100,000	301.4	299.4	326.3

Note: US general population data from: https://covid.cdc.gov/covid-data-tracker/#trends_dailydeaths. California general population data from: https://covid19.ca.gov/state-dashboard/.

Key finding: The COVID-19 case rate is over three times higher among CDCR residents than among residents of the counties in which CDCR prisons are located. Every CDCR prison exceeded the case rate in its surrounding county, although true differences between the two populations may be smaller given higher levels of testing in CDCR prisons.

Key finding: Despite having a smaller proportion of older adults compared to the general population, COVID-19 deaths per population among CDCR residents has exceeded the death rate in California and the United States as a whole.

Recommendation 4.4: Policymakers should respond to the disproportionate burden of COVID-19 infections, hospitalizations, and deaths experienced within CDCR prisons by both removing as many medically vulnerable people as possible from congregate living facilities with shared air spaces, and greatly increasing the resources available to mitigate the effects of COVID-19 (described in **Section 7**) for those who remain incarcerated.

4.2.7. Performance of the CDCR COVID-19 Risk Score

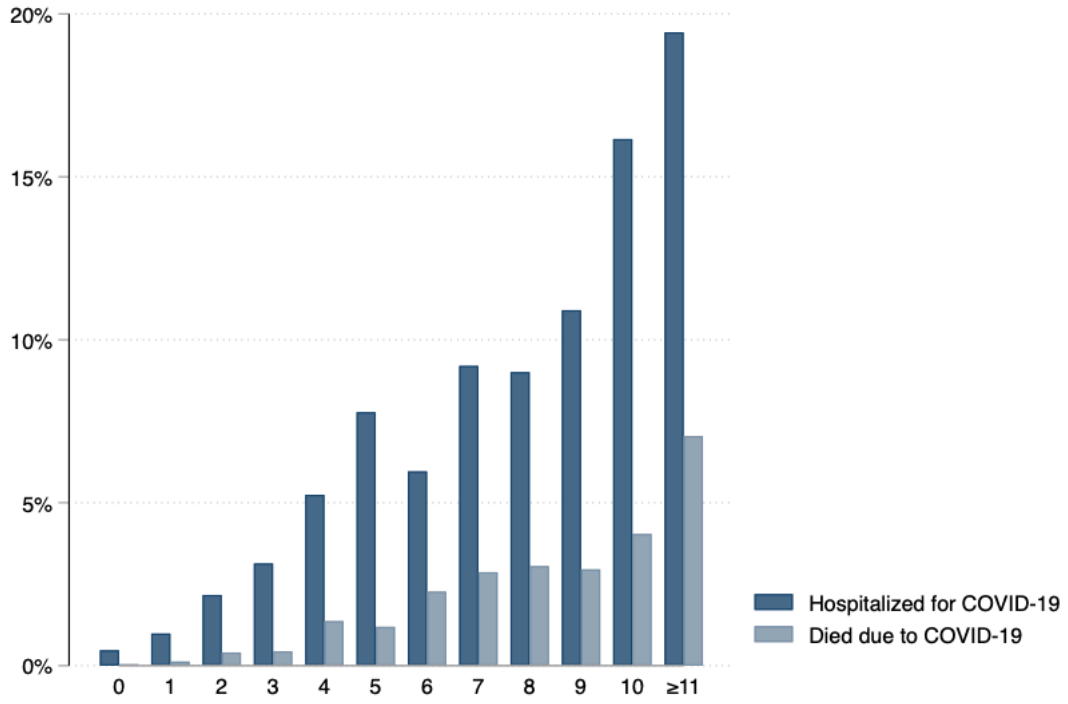
CCHCS's COVID-19 risk score was developed to stratify residents based on their risk for severe complications from COVID-19 infection, with higher scores indicating increased risk. The scoring is described in detail in **Supplemental Text S4.1**. The average COVID-19 risk score was 1.21 in the full cohort, 1.58 among those who were ever positive for COVID-19, and 5.79 among those who died from COVID-19 (**Table 4.1**).

The distribution of risk scores across CDCR residents and the proportion of residents with each risk score who were ever infected is described in **Table 4.10**. The risk score that we report is the one updated in August 2020. Among those who were infected in the full cohort, the proportions of patients who were hospitalized or died is displayed in **Figure 4.5**. The graph displays an association between rising risk scores, hospitalizations, and deaths that is less strongly correlated at the higher risk scores where case rates and severe outcomes are smaller in number. The distribution of hospitalizations and deaths suggests that the risk scores could reasonably categorize patients into risk tiers for operational planning purposes. According to CDCR/CCHCS, when cutoffs were needed, they considered 0-2 low risk, 3-5 medium risk, and 6 or higher as highest risk. The outcomes across these risk tiers and those with unknown risk scores for the full cohort are described in **Table 4.11**.

Table 4.10. Distribution of COVID-19 risk scores and infections across the full and continuous cohorts from August 2020 onward.

	Full Cohort				Continuous Cohort			
			Ever Infected				Ever Infected	
COVID-19 Risk Score	*N*	*% of Cohort*	*Freq*	*% of Score*	*N*	*% of Cohort*	*Freq*	*% of Score*
0	65,177	43.9%	19,968	39.5%	28,774	39.3%	13,439	36.9%
1	37,723	25.4%	13,706	27.1%	19,397	26.5%	9,704	26.7%
2	16,046	10.8%	6,687	13.2%	9,937	13.6%	5,106	14.0%
3	7,785	5.2%	3,446	6.8%	5,238	7.1%	2,734	7.5%
4	4,032	2.7%	1,831	3.6%	2,804	3.8%	1,468	4.0%
5	2,555	1.7%	1,260	2.5%	1,803	2.5%	1,022	2.8%
6	2,045	1.4%	1,057	2.1%	1,494	2.0%	872	2.4%
7	1,625	1.1%	838	1.7%	1,187	1.6%	677	1.9%
8	1,255	0.9%	655	1.3%	913	1.3%	520	1.4%
9	893	0.6%	441	0.9%	655	0.9%	353	1.0%
10	611	0.4%	297	0.6%	448	0.6%	233	0.6%
11	381	0.3%	160	0.3%	272	0.4%	121	0.3%
12	242	0.2%	105	0.2%	164	0.2%	77	0.2%
13	127	0.1%	52	0.1%	78	0.1%	38	0.1%
14	68	0.1%	23	0.1%	37	0.1%	16	0.0%
15	30	0.0%	12	0.0%	19	0.0%	6	0.0%
16	11	0.0%	3	0.0%	7	0.0%	1	0.0%
17	1	0.0%	1	0.0%	1	0.0%	1	0.0%
18	2	0.0%	0	0.0%	1	0.0%	0	0.0%
Unknown Risk Score	7,879	5.3%	33	0.1%	89	0.1%	0	0.0%
Total	148,488	1	50,575	0	73,318	1	36,388	100.0%

Figure 4.5. Percentage of CDCR residents with COVID-19 from the full cohort (starting August 2020) who were hospitalized or died due to COVID-19 by risk score.



Note: Hospitalized for COVID-19 and died due to COVID-19 are non-mutually exclusive categories. Based on our definitions, 168 people who died due to COVID-19 were hospitalized and 72 people who died due to COVID-19 were not hospitalized with COVID-19.

Table 4.11. Risk score categories and frequency of hospitalizations and deaths among those infected in the full cohort.

	Full Cohort				Positive Cases				
CDCR Categories for COVID-19 Risk Score	*N*	*% of Cohort*	Ever Infected *Freq*	Ever Infected *Row %*	*N*	Ever Hospitalized due to COVID-19 *Freq*	Ever Hospitalized due to COVID-19 *Row %*	Ever Died due to COVID-19 *Freq*	Ever Died due to COVID-19 *Row %*
Low Risk: 0-2	118,946	80.1%	40,361	33.9%	40,361	374	0.9%	54	0.1%
Medium Risk: 3-5	14,372	9.7%	6,537	45.5%	6,537	302	4.6%	56	0.9%
Highest Risk: 6 and higher	7,291	4.9%	3,644	50.0%	3,644	364	10.0%	121	3.3%
Unknown Risk Score	7,879	5.3%	33	0.4%	33	9	27.3%	9	27.3%

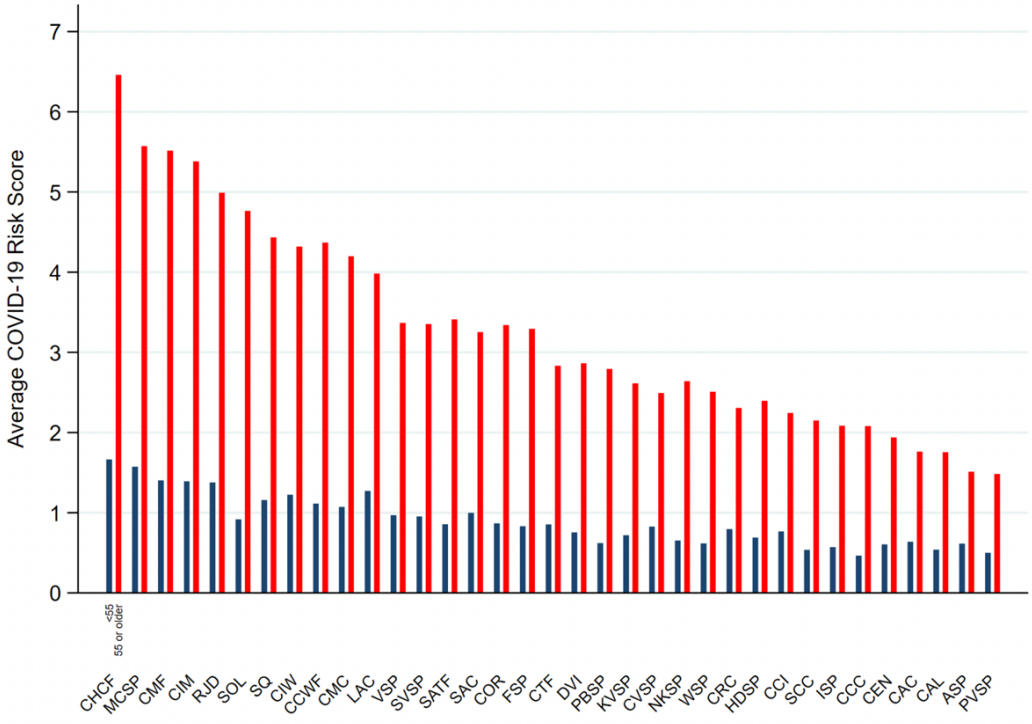
Recommendation 4.5: CCHCS's COVID-19 risk score can reasonably categorize patients into three tiers to predict the likelihood of hospitalization and death if infected with COVID-19. Individuals at intermediate and high risk could benefit from enhanced mitigation efforts (e.g.,

housing in buildings that are less conducive to the spread of COVID-19) and access to therapeutics that can reduce the risk of severe COVID-19 (e.g., antiviral medications as they become available and monoclonal antibody treatment).

4.3 COVID-19 outcomes among adults age 55 or older

The burden of SARS-CoV-2 on CDCR residents of older age are summarized in this section. While CDCR residents, on average, are younger than California's population, residents of correctional facilities are known to have higher rates and earlier onset of chronic medical conditions and geriatric syndromes (19). For this reason, the age group including individuals 55 years or older has been used to describe "older adults" in correctional settings, rather than the community norm of 65 years or older. Overall, 25,697 (17.3%) of adults incarcerated in CDCR in the full cohort were age 55 or older. **Figure 4.6** depicts a stratification of the average COVID-19 risk score by institution among residents who are younger than age 55 and among those who are 55 or older. The findings demonstrate the outsized risk of severe COVID-19 complications that is borne by older adults in CDCR and how this risk is distributed across CDCR prisons.

Figure 4.6. Average COVID risk score by institution and by residents who are younger than 55 years (blue) and 55 years or older (red).



Note: COVID risk score graphed is the average of all COVID risk scores for residents by age category in each institution for every month between March 2020 and October 2021.

Table 4.12 describes summary statistics for people incarcerated between March 1, 2020 and October 9, 2021 according to age (55 years or older versus younger than 55 years). Overall, incarcerated people who were age 55 years or older had higher rates of multiple comorbidities that are associated with more severe COVID-19, including mental health conditions, health-related impairments (cognitive, mobility or sensory), and average COVID-19 risk scores (55 years or older: 3.6 vs. younger than 55 years: 0.7).

Table 4.12. Descriptive statistics of age differences among CDCR residents 55 years or older vs. those younger than 55 years across demographics, housing characteristics, and comorbidities including COVID-19 risk score.

	Full Cohort N = 148,488				
	Younger than 55 N = 122,791		55 years or older N = 25,697		
	Freq.	*Mean or %*	*Freq.*	*Mean or %*	*p*-value
Demographics					
Sex					
Female	6,172	5.0%	826	3.2%	0.000
Male	116,619	95.0%	24,871	96.8%	0.000
Race					
Asian or Pacific Islander	1,885	1.5%	266	1.0%	
Black/African American	31,992	26.1%	8,281	32.2%	
Latino(a)/Hispanic (non-Mexican)	46,789	38.1%	3,232	12.6%	
Latino(a)/Hispanic (Mexican)	13,037	10.6%	3,644	14.2%	0.000
American Indian/Alaskan Native	1,391	1.1%	370	1.4%	
White	23,321	19.0%	8,702	33.9%	
Other or Unknown	4,376	3.6%	1,202	4.7%	
Resident Characteristics					
Number of institutions	122,791	1.4	25,697	1.3	0.000
Total days during period (of 588)	122,791	385.4	25,697	471.1	0.000
Always resident	56,521	46.0%	16,797	65.4%	0.000
Recent resident	78,892	64.2%	18,848	73.3%	0.000
Comorbidity					
COVID Risk Score	122,791	0.72	25,697	3.59	0.000
Any mental health condition	57,810	47.1%	15,279	59.5%	0.000
Any cognitive impairment	1,179	1.0%	755	2.9%	0.000
Any hearing impairment	1,566	1.3%	2,761	10.7%	0.000
Any mobility impairment	5,556	4.5%	8,422	32.8%	0.000
Any speech impairment	85	0.1%	93	0.4%	0.000
Any vision impairment	445	0.4%	540	2.1%	0.000

Note: For binary covariates, two-sided p-values are reported from t-tests used to test the null hypothesis that the difference in means or percentages between younger than 55 group and 55 years or older group was equal to zero. For categorical covariates, two-sided p-values are reported from one-way analysis of variances (ANOVA), which was used to test the null hypothesis that the mean or percentage is equal for all the groups between younger than 55 group and 55 years or older group. If p-value < 0.05, we reject the null and conclude a significant difference does exist at the 5% significance level; p-value < 0.001, at the 0.1% significance level.

Data Limitation: The levels of cognitive impairment recorded are lower than those found in some other studies of older adults who are incarcerated and are also lower than estimates of cognitive impairment in older adults in the community. Several factors may be contributing to this difference. For example, (i) the rates of cognitive impairment presented in this report were derived from medical records; it is possible that prison healthcare professionals are not sufficiently assessing or documenting cognitive impairment in older patients, and (ii) the average age of the 'older adult' prison population is markedly younger than it is in the community such that a lower average rates of cognitive impairment and dementia in prison populations can be expected.

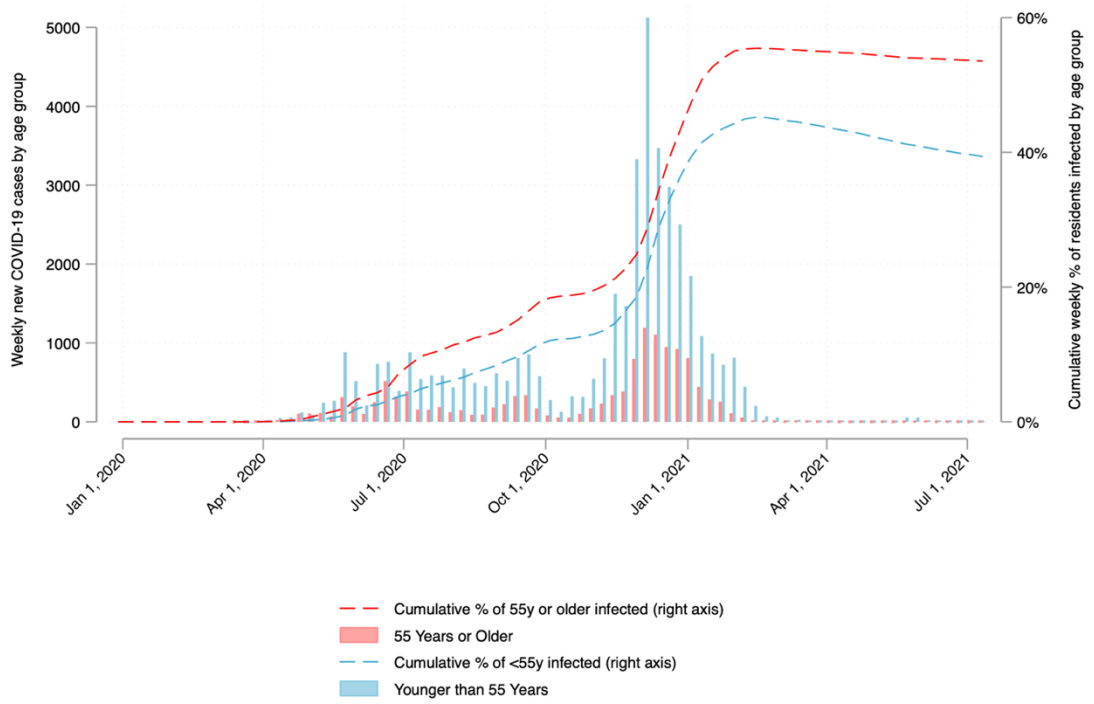
Table 4.13 describes the burden of COVID-19 on incarcerated residents in the full cohort who were 55 years or older, compared to those who were younger than 55 years. Older adults were more likely to be quarantined (89% vs. 84%, $p<0.001$), spend more days in quarantine (41.4 vs. 33.4, $p<0.001$), be placed in medical isolation (54% vs. 36%, $p<0.001$), spend more days in medical isolation (8.3 vs. 5.3, $p<0.001$), get tested more times (19.8 vs. 15.6, $p<0.001$), become infected with COVID-19 (47% v. 31%, $p<0.001$), get hospitalized for COVID-19 (2.7% vs. 0.3%, $p<0.001$), and die due to COVID-19 (0.8% vs. <0.1%, $p<0.001$). Although more young people than older people were infected with COVID-19, the proportion of older adults who were ever infected was greater than the proportion of younger adults ever infected at all times between April 2020 and October 2021 (**Figure 4.7**).

Table 4.13. Descriptive statistics of age differences among CDCR residents 55 years or older compared to those younger than 55 years across COVID-19 outcomes ever experienced during March 1, 2020 and October 9, 2021.

	Full Cohort N = 148,488				
	Younger than 55 N = 122,791		55 years or older N = 25,697		
	Freq.	*Mean or %*	*Freq.*	*Mean or %*	*p* -value
COVID-19 outcomes					
Ever quarantined	122,791	83.7%	25,697	89.2%	0.000
Number of days quarantined	122,791	33.4	25,697	41.4	0.000
Ever isolated	122,791	36.2%	25,697	53.8%	0.000
Number of days isolated	122,791	5.3	25,697	8.3	0.000
Ever tested	114,339	93.1%	24,467	95.2%	0.000
Number of times tested (non-zero)	114,339	15.6	24,467	19.8	0.000
Ever infected	38,605	31.4%	11,970	46.6%	0.000
Ever had ER visit due to COVID-19	727	0.6%	934	3.6%	0.000
Ever hospitalized due to COVID-19	360	0.3%	689	2.7%	0.000
Ever in ICU due to COVID-19	28	<0.1%	124	0.5%	0.000
Died due to COVID-19	34	<0.1%	206	0.8%	0.000
Ever vaccinated against COVID-19	70,088	57.1%	19,065	74.2%	0.000

Note: For binary covariates, two-sided p-values are reported from t-tests used to test the null hypothesis that the difference in means or percentages between younger than 55 group and 55 years or older group was equal to zero. If p-value < 0.05, we reject the null and conclude a significant difference does exist at the 5% significance level; p-value < 0.001, at the 0.1% significance level.

Figure 4.7. Percentage of population younger than 55 years vs. 55 years or older who had a confirmed positive COVID-19 test over time. Although more young people than older people were infected with COVID-19, the proportion of older adults who were ever infected was far greater than the proportion of younger adults who were ever infected throughout the pandemic.

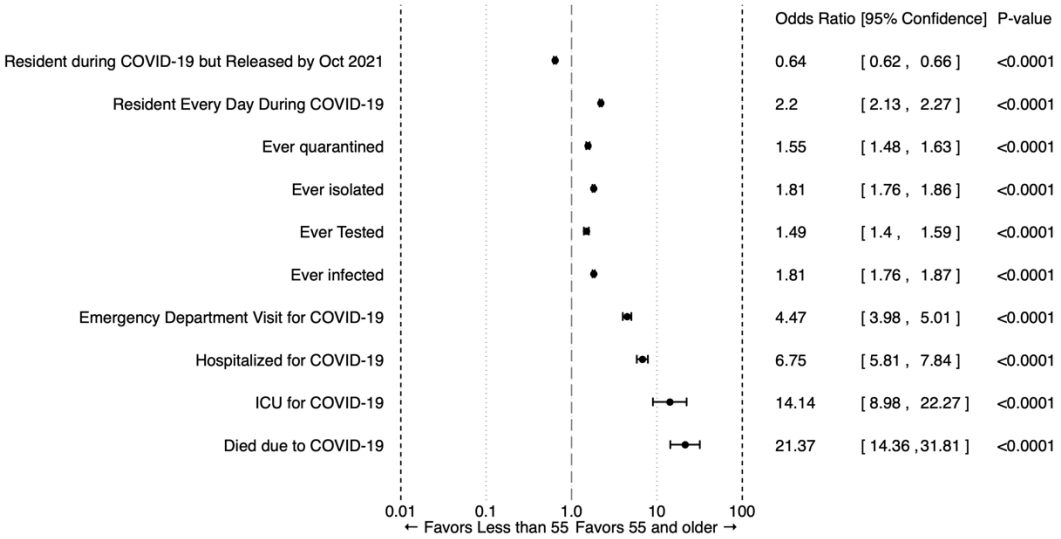


To examine the association between COVID-19 outcomes and older age (age 55 or older) among CDCR residents, we calculated odds ratios adjusting for sex, race/ethnicity, mental health conditions, and health-related impairments as shown in **Figure 4.8**. Residents who were 55 years or older experienced higher odds of all adverse COVID-19 outcomes compared to younger residents. The adjusted odds of COVID-19 infection for the older group was 1.8 times the odds of infection for the younger group (which is in contrast to community settings where older adults had lower rates of infection compared to younger adults). For older adults, the adjusted odds of hospitalization was 6.8 times the odds of hospitalization compared to the younger group, and the adjusted odds of dying due to COVID-19 was 21.4 times the odds compared to younger adults (all p-values <0.001).

Key finding: Compared to younger CDCR residents, those age 55 years or older spent more time in quarantine and medical isolation and had dramatically higher rates of COVID-19 infection, hospitalization, and death.

Recommendation 4.6: We recommend that future research compare the general population by age to the incarcerated population. Making a direct comparison to the general population solely on proportions is difficult because people who were incarcerated during the pandemic, especially in California state prisons, were tested with markedly higher frequency than the general population. We note that nearly half of state prisons reported that confirmed cases of COVID-19 among incarcerated people were 4 to 15 times higher than rates found in the community. COVID-19 deaths among incarcerated people have been three times those in the general population. This is, in large part, because it is incredibly challenging to provide the same level of protection from infection in crowded prisons compared to the community (where many older adults can shelter in place).

Figure 4.8. Adjusted odds ratios of residents who are younger than 55 years versus those 55 years or older across COVID-19 outcomes.



Note: Logistic regression was used to compute odds ratios by age group adjusted by sex, race/ethnicity, percent of days spent of all days at CDCR between March 1, 2020 and October 9, 2021 in a cell, dorm, or other room type, any mental health condition, any health-related impairment (cognitive, mobility, or sensory).

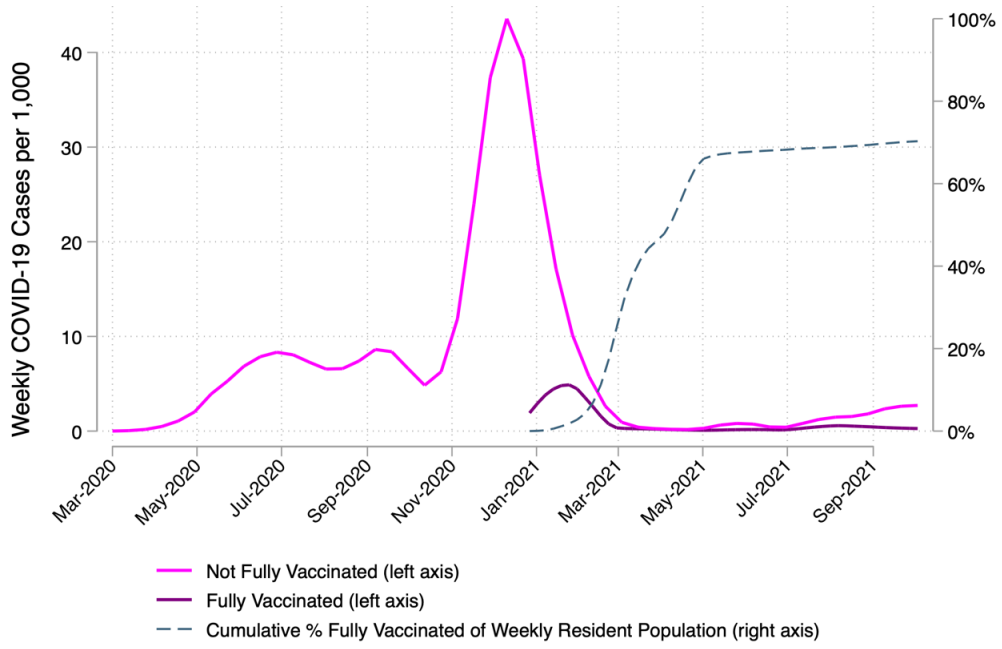
4.4. Impact of COVID-19 Vaccination

COVID-19 vaccinations first became available to select groups of CDCR residents and staff beginning in December of 2020 and by February 2021 nearly every resident and staff member had been offered vaccination against COVID-19. This vaccination has had a dramatic impact on COVID-19 case rates, hospitalizations, and deaths in CDCR, including protective effects for unvaccinated residents and staff.

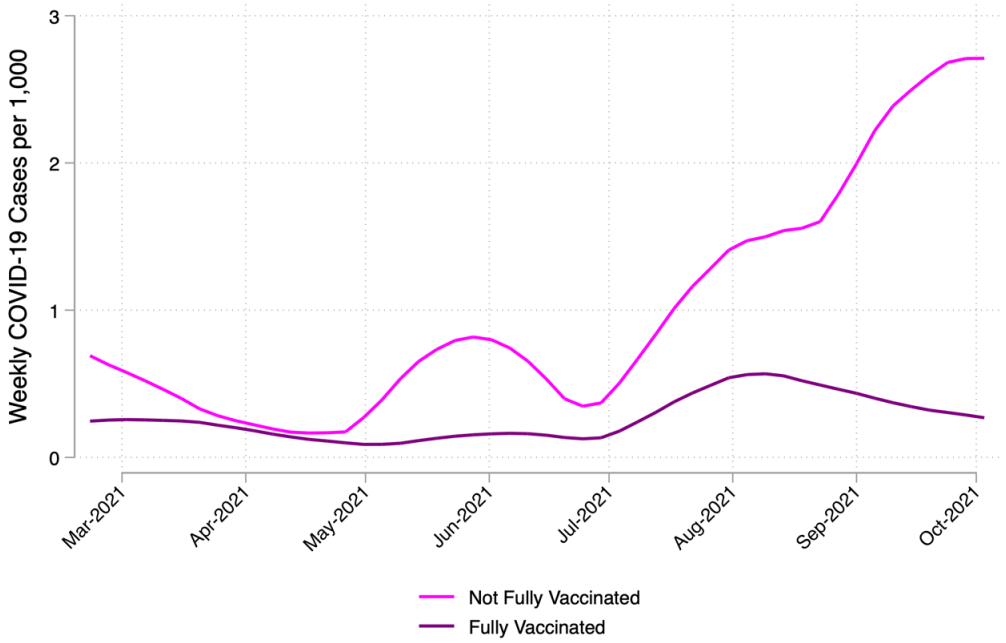
The weekly COVID-19 case rate among residents according to vaccination status is shown in **Figure 4.9** (fully vs. not fully vaccinated is shown overlying the vaccination rate across all CDCR residents). Since the spring of 2021, the highest number of active cases CDCR reported at any given time was 353 cases on November 8, 2021. Following large-scale vaccination, the largest outbreak in any institution peaked at 180 active cases at North Kern State Prison in September of 2021 and only four institutions had outbreaks exceeding 100 cases (the others being California State Prison Corcoran, Central California Women's Facility, and Sierra Conservation Center) by December 31, 2021.

Figure 4.9. Weekly cases per 1,000 by fully vaccinated and not fully vaccinated (displayed with local polynomial smoothing regression)

(a) Weekly cases per 1,000 by full vaccination status (Mar 1, 2020–Oct 9, 2021)



(b) Weekly cases per 1,000 by full vaccination status (Feb 23, 2021–Oct 9, 2021)

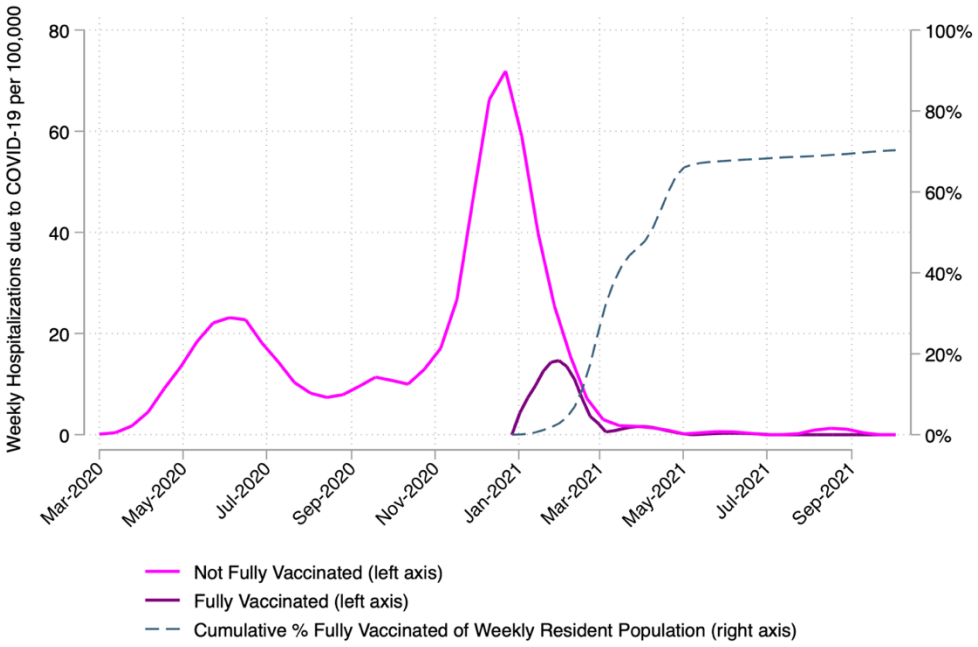


Note: Fully vaccinated is defined as 2 or more doses of mRNA-1273 (Moderna), 2 or more doses of BNT162b2 (Pfizer), or 1 or more of Ad26.COV2.S (Janssen/Johnson & Johnson) as of October 9, 2021.

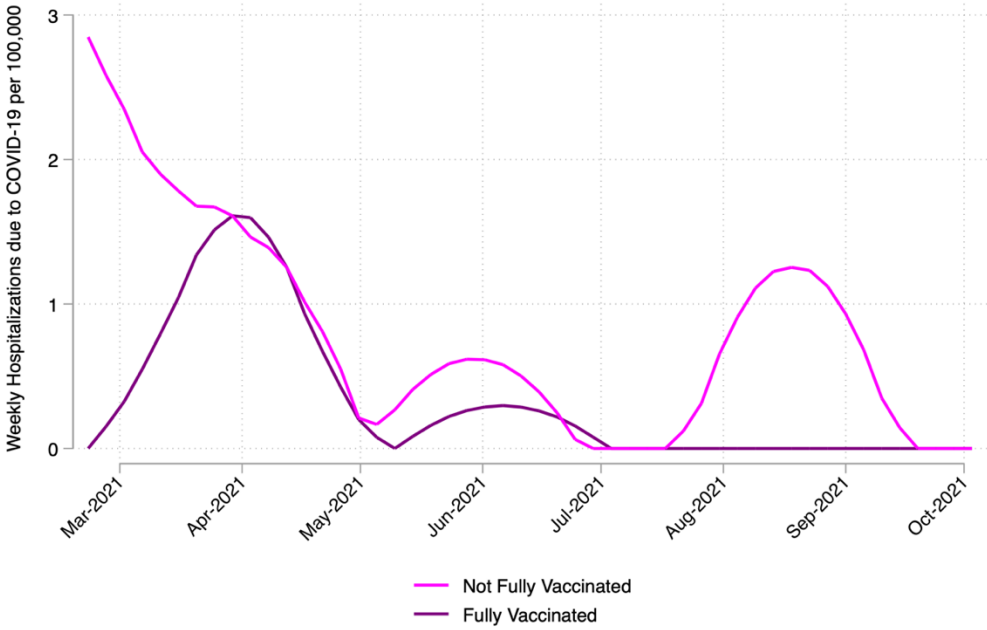
Resident hospitalization rates also improved dramatically following the deployment of COVID-19 vaccines. As cases became rare and the number of unvaccinated and uninfected residents dropped, hospitalization rates dropped for both vaccinated and unvaccinated residents, with the weekly hospitalization rate remaining in the range of 0-2 hospitalizations per 100,000 residents among both groups (**Figure 4.10**) by October 9, 2021. When compared to the weekly hospitalization rate among the general adult population in the United States (**Figure 4.11**), fully vaccinated CDCR residents had low rates of COVID-19 associated hospitalization which were similar to rates among fully vaccinated adults in the U.S. population (both <5 hospitalizations per 100,000 people). In contrast, CDCR residents who were not fully vaccinated had much lower rates of hospitalization than unvaccinated adults in the U.S. population (0-2 weekly hospitalizations per 100,000 people in CDCR vs 40-60 weekly hospitalizations per 100,000 people in the adult U.S. population during the summer and fall months).(20) We hypothesize that this stark difference is a product of the younger age of CDCR residents, higher rates of prior infection in unvaccinated CDCR residents, and protection from infection due to higher rates of vaccination among the CDCR resident population as a whole.

Figure 4.10. Weekly hospitalizations due to COVID-19

(a) Weekly hospitalizations due to COVID-19 per 100,000 by full vaccination status (Mar 1, 2020–Oct 9, 2021)

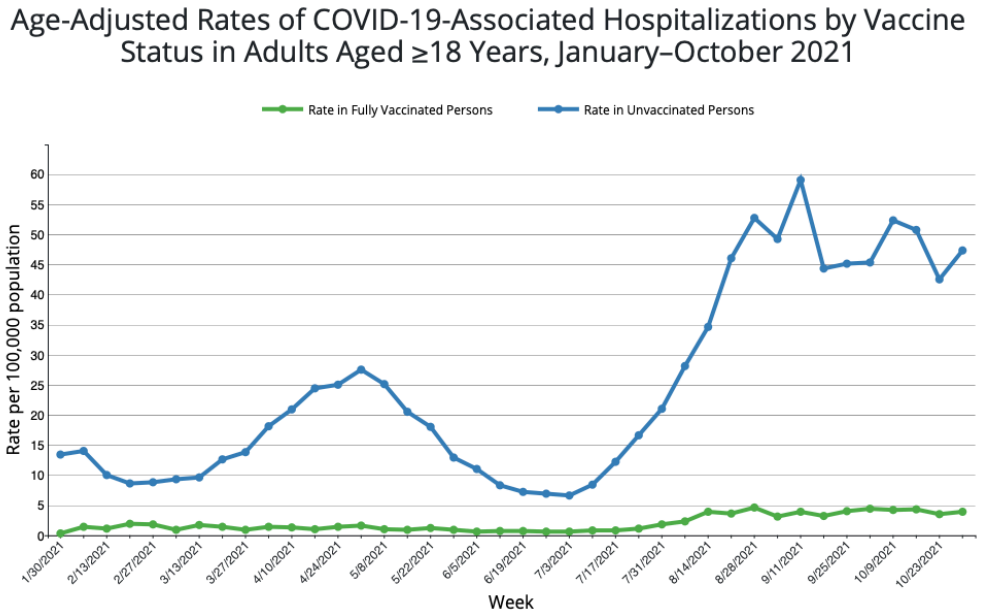


(b) Weekly hospitalizations per 100,000 by full vaccination status (Feb 23, 2021–Oct 9, 2021)



Note: Fully vaccinated is 2 or more doses of mRNA-1273 (Moderna), 2 or more doses of BNT162b2 (Pfizer), or 1 or more of Ad26.COV2.S (Janssen/Johnson & Johnson) as of October 9, 2021. Otherwise, an individual is considered not fully vaccinated. Hospitalizations were determined to be related to COVID-19 if an individual was reported as being admitted between two days before and 14 days following a positive COVID-19 test (antigen or PCR).

Figure 4.11. Weekly hospitalizations in the general adult population of the United States, stratified by vaccination status.



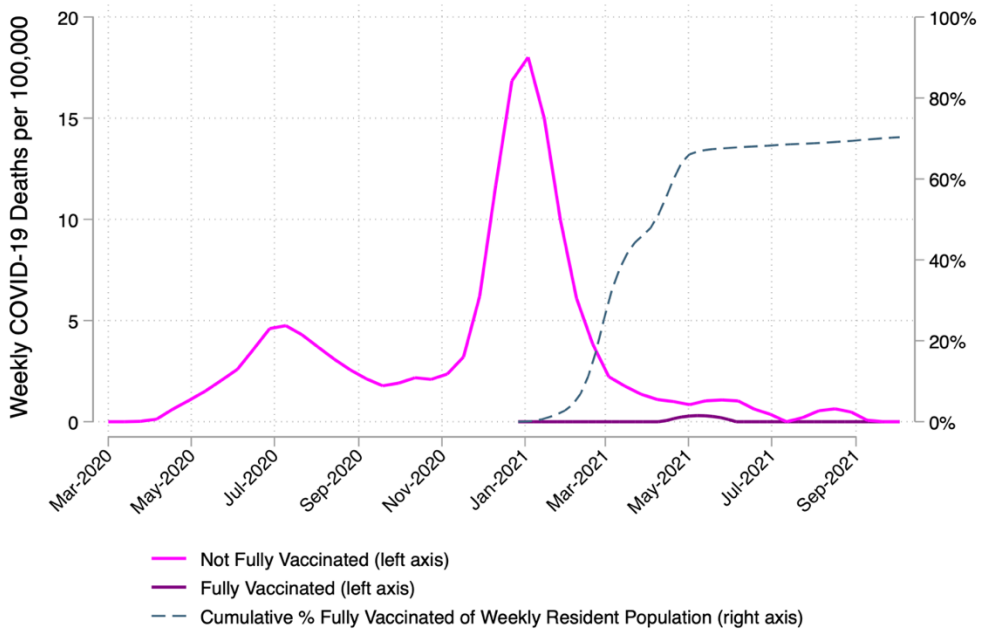
Source: https://covid.cdc.gov/covid-data-tracker/#covidnet-hospitalizations-vaccination

There were 30 COVID-19 deaths between February 1, 2021 (when vaccines became widely available to CDCR residents) and October 9, 2021, compared to 210 COVID-19 deaths in the 11 months prior. Among these 30 deaths, 3 were in fully vaccinated residents and 27 were in residents who were not fully vaccinated. Weekly death rates remained below 2 deaths per 100,000 people from March of 2021 through October 9 2021, compared to rates that exceeded 15 weekly deaths per 100,000 people during the winter surge of 2020-2021 (**Figure 4.12**).

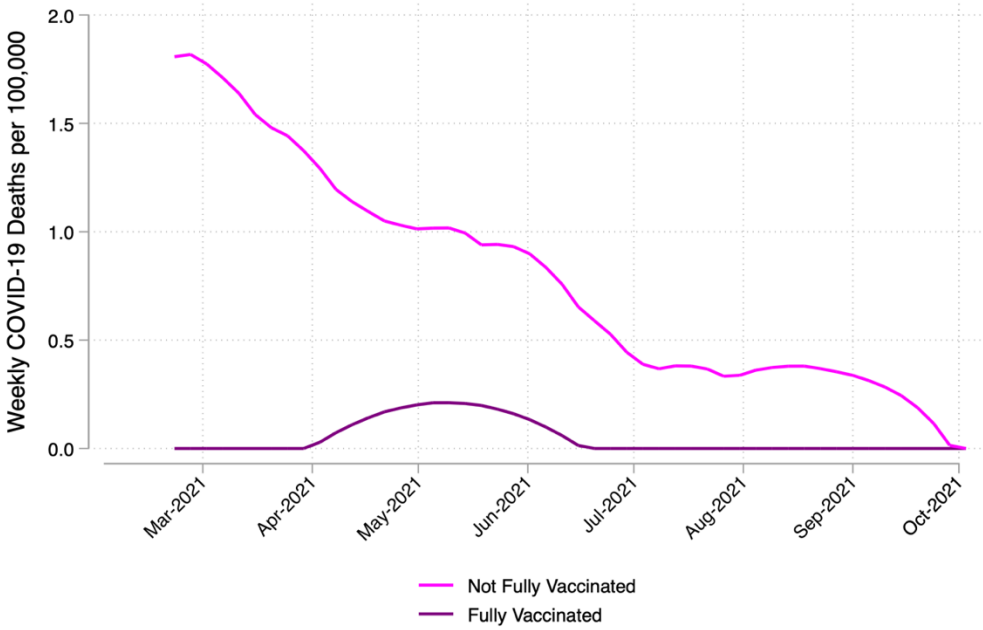
Key finding: Vaccination has had a dramatic impact on COVID-19 case rates, hospitalizations, and deaths in CDCR, including protective effects for unvaccinated residents.

Figure 4.12. Weekly deaths due to COVID-19 according to CCHCS

(a) Weekly deaths due to COVID-19 per 100,000 by full vaccination status (Mar 1, 2020–Oct 9, 2021)



(b) Weekly deaths per 100,000 by full vaccination status between Mar 1, 2020 – Oct 9, 2021



Note: Fully vaccinated is 2 or more doses of mRNA-1273 (Moderna), 2 or more doses of BNT162b2 (Pfizer), or 1 or more of Ad26.COV2.S (Janssen/Johnson & Johnson) as of October 9, 2021. All others are considered to be not fully vaccinated.

5. Staff at CDCR Prisons during COVID-19: Demographics and Epidemiology of SARS-CoV-2 Infection and Disease

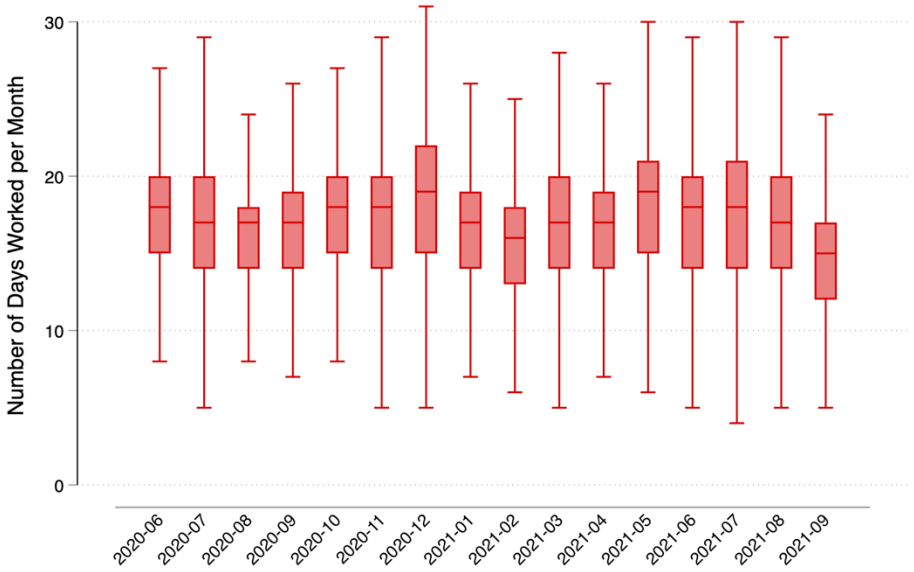
5.1. Staff demographics

Cohort Definitions

For the purpose of this report, we present data based on different cohort definitions. The three most common cohorts are:

- **Full Cohort (staff):** all staff who worked at a CDCR institution for any duration of time between May 1, 2020 and October 9, 2021 (n=69,144)
- **Continuous Cohort (staff):** all staff who worked at a CDCR institution for at least one shift for 16 months between May 2020 and October 2021 (n=30,608; 44% of the full cohort)
    - We utilize this definition because the CCHCS data provide a roster of active staff in any given month for all CDCR employees who are not on long-term leave and have not stopped working; however, due to delays in changes in personnel status, active status month-to-month may still appear in a month during which a staff member is not active.
- **Recent Cohort (staff):** all staff who worked at a CDCR institution during October 1-9, 2021 (n= 56,858; 82% of the full cohort and 53% of the continuous cohort)
    - This cohort includes any staff who was in the roster of active staff or worked a shift in October 2021. Staffing levels fluctuated very minimally over the course of the pandemic. Changes in total numbers of staff employed by CDCR from May 2020 to October 2021 (<1% reduction) contrast with the 18.3% reduction in resident population over this same time period. Such high staffing ratios likely were quite fortuitous as many staff were required to miss work for quarantine and/or isolation over the course of the pandemic. December 2020 (when COVID-19 cases were at their highest) was the month with the peak number of days worked, with the top 50th percentile of staff working just under 20 days in the month, a frequency that exceeded the top 25th percentile in the month of September 2021 (see **Figure 5.1**).

Figure 5.1. Boxplots of the average number of days worked per month between June 2020 and September 2021 for nurses, healthcare, and custody staff (not all staff).



Note: For each month, a boxplot without outliers is shown to demonstrate the spread of number of days worked per month across staff. The bottom mark of each month's boxplot represents the minimum number of days worked per month by staff in the shift-level dataset, and the top mark represents the maximum for that month. Between the bottom mark and the bottom of the shaded box is the first quartile; between the bottom of the shaded box and the middle mark (the median) of the shaded box is the second quartile; between the median and the top part of the shaded box is the third quartile, and between the top of the shaded box and the top mark is the fourth quartile.

Data Limitation: CDCR staff can be captured in the dataset from two possible sources:
1) A roster of active staff by month (December 2020 – October 2021): this includes all CDCR employees "who are not on long-term leave and have not stopped working for CDCR"
2) A shift-level dataset for any nursing, custody, or healthcare staff member (May 13, 2020 – October 9, 2021): this includes all CDCR employees who worked a shift irrespective of if they were included on the monthly staff roster

The number of staff from the active staff roster and shift-level datasets are shown for each month (**Supplemental Table S5.1**). Most staff members are captured in both datasets. In December 2020 (the first month of available anonymized staff roster data), the 35 CDCR institutions were staffed by 52,254 "active staff" on the roster; however, from the shift-level data, 56,101 staff from nursing, custody, and healthcare worked at least one shift. In October 2021, there were 54,837 staff on the active roster at the 35 CDCR institutions, though 56,858 individuals from nursing, custody, and healthcare worked at least one shift.

Since staff in both datasets had data captured regarding demographics, job type, COVID-19 infection, and vaccination, we elected to include any staff member who was captured in either dataset in our analysis. Some individuals, however, were not affiliated with any CDCR institution in either dataset as they were classified as having a primary work location that was not a CDCR prison. These staff members were excluded from our analysis which may have implications on the interpretation and generalizability of our results.

Data Considerations – Demographic Variables

Ethnicity: The measure "ethnicity" was provided to us for staff and was defined as the "self-reported ethnicity of staff member" with the following values: American Indian or Alaskan Native, Asian, Black, Filipino, Hispanic, Others, Pacific Islander, White, and NULL which "indicates ethnicity is unknown." The data dictionary noted that "self-reported ethnicity may change for an individual over time. We referred to this variable as "Race/Ethnicity". We referred to the Black group of individuals as "Black / African American" and the Hispanic group of individuals as "Hispanic/Latino(a)."

Gender: The measure "gender" was another data element provided to us for staff. This measure has been defined by CDCR/CCHCS as "self-reported gender of staff member" with values "Male, Female, NULL." The data dictionary notes that "to safeguard against potential identification of individuals, cases where gender is not male or female are set to a null value. Also, self-reported gender may change for a given individual over time." We report on this measure ("gender") and have referred to "Male" as men and "Female" as women as we believe that is the intention of this variable's definition.

Table 5.1 provides descriptive statistics of the three cohorts of staff. Among the full cohort, 56% were men (72% of the continuous cohort). The bulk of staff (74%) were between the ages of 30 and 59 in the full cohort (84% of the continuous cohort), while 9.1% (5.3% in continuous cohort) were 60 years or older and 7.2% (1.2% in continuous cohort) were of an unknown age. The racial/ethnic composition of the prison workforce is not known as 83% of the data we were given had missing race/ethnicity data (87% in the recent cohort). Overall, 40% of the full cohort work in custody, 17% work in healthcare, and 17% work in operations; 76% have jobs which entail direct resident care. While data related to the medical conditions of staff were not available to our team, correctional staff—particularly those working in custody—are known to

have higher rates of mental and physical health disorders compared to the general population.(1) From May 1, 2020 through October 9, 2021 (526 days), the average number of days worked among staff in the full cohort (n=69,144) was 139 days, with an average of 166 watches (shifts) (see Table 5.1).

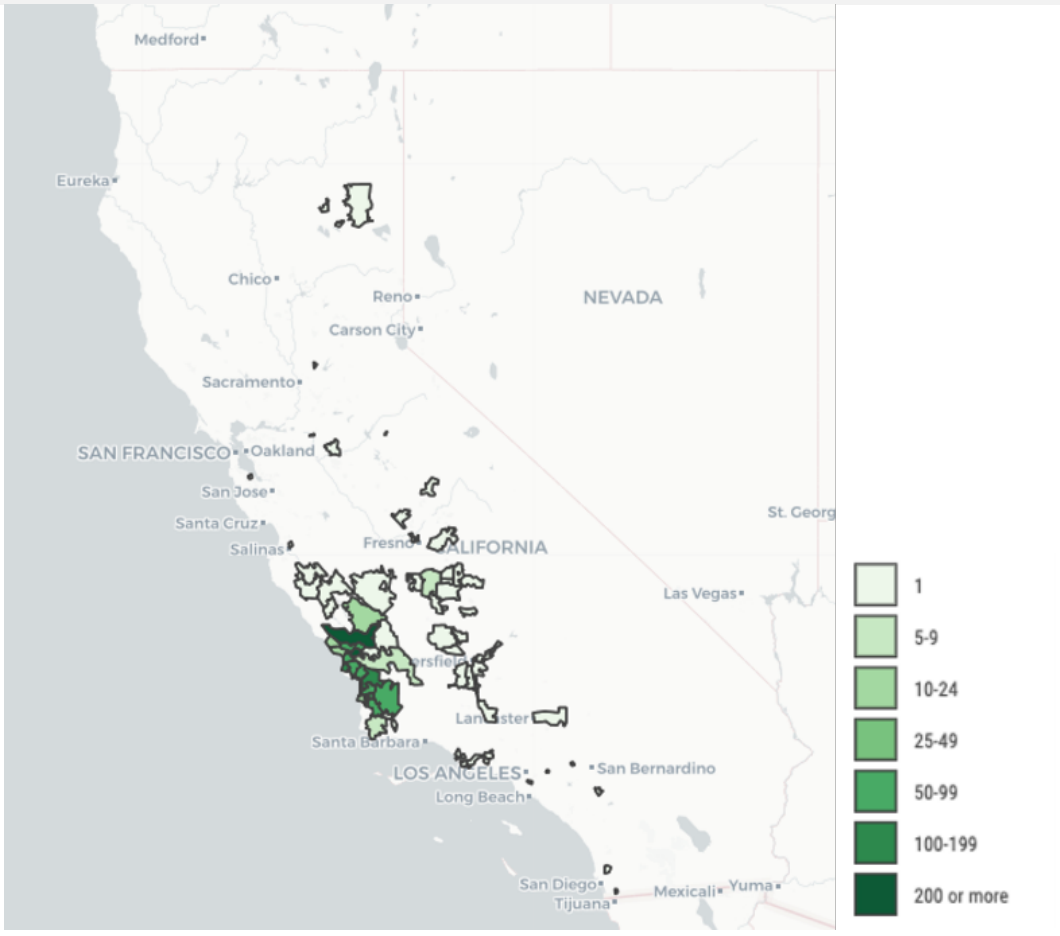
Table 5.1. Descriptive statistics of staff in full, continuous, and recent staff cohorts

	Full Cohort (N = 69,144)		Continuous Cohort (N = 30,608)		Recent Cohort (N = 56,858)	
	Freq	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*
In any cohort						
Full cohort	69,144	100.0%	30,608	100.0%	56,858	100.0%
Continuous Cohort	30,608	44.3%	30,608	100.0%	16,168	53.3%
Recent Cohort	56,858	82.2%	30,035	99.1%	56,858	100.0%
Demographics						
Gender						
Women	30,553	44.2%	53,242	27.9%	49,513	41.2%
Men	38,591	55.8%	15,902	72.1%	19,631	58.8%
Age Group						
20 to 29	6,525	9.4%	2,852	9.3%	5,701	10.0%
30 to 39	17,521	25.3%	9,494	31.0%	15,372	27.0%
40 to 49	18,751	27.1%	10,155	33.2%	16,535	29.1%
50 to 59	15,092	21.8%	6,114	20.0%	12,011	21.1%
60 or older	6,257	9.1%	1,629	5.3%	4,691	8.3%
Unknown age	4,998	7.2%	364	1.2%	2,548	4.5%
Race / Ethnicity				0.0%		0.0%
White	5,187	7.5%	0	0.0%	3,187	5.6%
Asian	611	0.9%	0	0.0%	354	0.6%
Pacific Islander	83	0.1%	0	0.0%	42	0.1%
Filipino	474	0.7%	0	0.0%	295	0.5%
Black / African American	1,211	1.8%	0	0.0%	677	1.2%
Hispanic / Latino(a)	3,722	5.4%	0	0.0%	2,453	4.3%
American Indian/Alaskan Native	117	0.2%	0	0.0%	87	0.2%
Other	298	0.4%	0	0.0%	169	0.3%
Unknown	57,441	83.1%	30,608	100.0%	49,594	87.2%
Job characteristics						
Job Type						
Custody	27,626	40.0%	18,298	77.3%	12,232	46.4%
Healthcare	11,940	17.3%	1,492	22.1%	2,013	18.8%
Operations	12,072	17.5%	0	0.0%	1,978	18.7%
Education	1,316	1.9%	0	0.0%	25	2.1%
Contractor	6,836	9.9%	1	0.4%	783	11.7%
Job Unknown	9,688	14.0%	0	0.3%	47	2.9%
Position involves contact with residents	52,330	75.7%	30,361	99.6%	42,171	86.1%
Number of institutions	69,144	1.9	30,608	2.0	56,858	2.0
Total CDCR watches	69,144	165.9	30,608	338.6	56,858	192.1
Total CDCR days	69,144	138.6	30,608	281.6	56,858	160.0

Many staff commute long distances to work, some by carpool and vanpool. These staff members have community COVID-19 exposures that differ from transmission in the community immediately surrounding the prison where they work. Figure 5.2 shows the number of staff from California Men's Colony (CMC, located in San Luis Obispo) and how their zip codes of

residence are mapped across California (data provided by CMC leadership, from June 2020). In our conversations with staff during site visits, we found that ridesharing often occurs without masks and may involve traveling long distances with the windows rolled up. While we could not verify if ridesharing increased the risk of COVID-19 acquisition, it is a distinct possibility that could be an opportunity for education.

Figure 5.2. Staff from the CalPROTECT California Men's Colony (CMC) site visit. Located in San Luis Obispo, the prison employs staff who list their home address zip codes from throughout California. This suggests that correctional staff may commute from far away and that risk for infection should not be based solely on rates in the surrounding community but should instead account for the likelihood of a large range of commuting distances.



Key Finding: CDCR staff are more likely to be men and younger compared to the general California population. At least three quarters have jobs that entail direct resident contact.

Recommendation 5.1: Investigate ridesharing as a source of COVID-19 transmission between staff members. Reinforce (particularly for unvaccinated staff) the COVID-19 mitigation measures that can be taken when ridesharing (masking, traveling with the windows down, not eating or drinking.).

5.2. Epidemiology of SARS-CoV-2 among staff

Among the full staff cohort, 61,333 (89%) of CDCR staff were ever tested for COVID-19 (93% among the recent staff cohort). Laboratory-confirmed COVID-19 infections were identified in 5,259 (22%) of staff in the full cohort (25% in the recent cohort). Among the 52,330 (75.6%) of the full cohort whose jobs entailed direct resident care, 13,030 (25%) ever tested positive (compared to 13% of those who do not provide direct resident care, p<0.001), and this group had significantly higher numbers of tests conducted when compared to the staff who do not have a position that involves contact with residents (36.7 vs. 19.7, p-value<0.001). In the continuous cohort, the infection rate was 321 infections per 1,000 staff compared to 195 infections per 1,000 adults in California. This 64% increase in the rate of infection is likely an overestimate of the true difference as CDCR staff are tested far more frequently than the average Californian. COVID-19 testing, infections, and attack rates among subgroups of staff are described in Table 5.2.

Table 5.2. COVID-19 testing and attack rates among staff

	Full Cohort (N = 69,144)			**Continuous Cohort (N = 30,608)**			**Recent Cohort (N = 56,858)**		
		Freq	*Mean or %*		*Freq*	*Mean or %*		*Freq*	*Mean or %*
Ever tested		61,333	88.7%		30,177	98.6%		52,623	92.6%
Number of tests (non-zero)		61,333	36.8		30,177	47.1		56,858	40.2
	n	*Cases*	*Attack Rate*	*n*	*Cases*	*Attack Rate*	*n*	*Cases*	*Attack Rate*
Ever positive	69,144	15,259	22.1%	30608	9814	32.1%	56,858	13,991	24.6%
Position involves contact with residents									
No	16,814	2,229	13.3%	124	10	8.1%	7,891	1,455	18.4%
Yes	52,330	13,030	24.9%	30,484	9,804	32.2%	48,967	12,536	25.6%
Job Type									
Custody	27,626	9,379	33.9%	23,666	8,546	36.1%	26,372	9,125	34.6%
Healthcare	11,940	1,950	16.3%	6,758	1,260	18.6%	10,698	1,808	16.9%
Operations	12,072	2,552	21.1%	13	4	30.8%	10,605	2,355	22.2%
Education	1,316	207	15.7%	0	0	0.0%	1,187	194	16.3%
Contractor	6,836	433	6.3%	130	22	16.9%	6,674	429	6.4%
Job Unknown	9,688	815	8.4%	102	3	2.9%	1,634	154	9.4%

We used logistic regression models to estimate the unadjusted and adjusted odds describing the association between select staff characteristics and COVID-19 infection (Table 5.3). Our adjusted model included age group, gender, job type, having a position that involves contact

with residents, minimal education required for job, and number of institutions at which staff worked. Compared to those age 60 years or older, every age group had higher odds of infection with the odds higher among progressively younger groups: younger than 30, adjusted odds ratio (aOR) = 1.63; 30 to 39 years, aOR = 1.51; 40 to 49 years, aOR = 1.41; 50 to 59 years, aOR = 1.18; all p-values<0.001). After adjusting for the covariates listed above, there was no statistically significant difference in the odds of infection among men compared to women (p-value = 0.427); staff who have a position that involves contact with residents were more likely to get infected than those who did not (aOR = 1.14, p-value = 0.004); and working at multiple institutions (range: 2-5) during the time period did not increase the odds of getting infected. Instead, relative to working at a single institution, the odds of working at two institutions significantly decreased the odds of infection (aOR = 0.86, p-value = 0.002) while no significant decreases in the odds of infection were observed for staff who worked at a 3, 4, or 5 total institutions during the study period. Supplemental Table S5.2 contains an extended version of Table 5.3 with models including staff and ethnicity, where 17% of non-missing staff-reported race/ethnicity data.

According to public data,(2) 46 staff across 35 CDCR prisons have died from COVID-19 as of November 2021, accounting for 150 COVID-19 deaths per 100,000 staff in the continuous cohort. By comparison, the COVID-19 death rate in California is 299 per 100,000 adult residents. The younger age of CDCR staff (when compared to the general California population) likely explains some of this difference.

Table 5.3. Associations between staff characteristics and COVID-19 infection.

	Full Cohort (N = 69,144)					
	(1) Unadjusted Estimates			(2) Adjusted Estimates		
	Unadj. Odds Ratio	*95% CI*	*p-value*	Adj. Odds Ratio	*95% CI*	*p-value*
60 or older	**1.00**			**(Ref)**		
Younger than 30	2.21	(2.02 - 2.41)	0.000	1.63	(1.48 - 1.78)	0.000
30 to 39	2.09	(1.93 - 2.26)	0.000	1.51	(1.39 - 1.63)	0.000
40 to 49	1.94	(1.79 - 2.09)	0.000	1.41	(1.30 - 1.52)	0.000
50 to 59	1.44	(1.32 - 1.55)	0.000	1.18	(1.08 - 1.27)	0.000
Unknown	0.00	(0.00 - 0.00)	0.000	0.00	(0.00 - 0.01)	0.000
Women	**1.00**			**(Ref)**		
Men	1.82	(1.75 - 1.89)	0.000	0.98	(0.93 - 1.02)	0.427
Healthcare	**1.00**			**(Ref)**		
Custody	2.64	(2.49 - 2.78)	0.000	1.57	(1.41 - 1.73)	0.000
Operations	1.38	(1.28 - 1.46)	0.000	1.78	(1.58 - 2)	0.000
Education	0.96	(0.82 - 1.12)	0.605	1.33	(1.12 - 1.58)	0.001
Contractor	0.35	(0.31 - 0.38)	0.000	0.57	(0.50 - 0.65)	0.000
Unknown	0.47	(0.43 - 0.51)	0.000	1.13	(0.96 - 1.31)	0.131
Position w/o contact w/ residents	**1.00**			**(Ref)**		
Provides direct care	2.17	(2.06 - 2.27)	0.000	1.14	(1.04 - 1.24)	0.004
Graduate degree required for job	**1.00**			**(Ref)**		
Less than a college degree equivalent	2.71	(2.50 - 2.92)	0.000	1.61	(1.43 - 1.81)	0.000
College degree or equivalent	0.87	(0.79 - 0.95)	0.002	1.43	(1.28 - 1.58)	0.000
Unknown	0.59	(0.52 - 0.64)	0.000	-	-	-
Works at 1 institution	**1.00**			**(Ref)**		
Works at 2nd institution	3.57	(3.32 - 3.82)	0.000	0.86	(0.77 - 0.94)	0.002
Works at 3rd institution	4.48	(4.05 - 4.95)	0.000	0.95	(0.83 - 1.08)	0.449
Works at 4th institution	4.31	(3.08 - 6.01)	0.000	0.95	(0.66 - 1.35)	0.758
Works at 5th institution	2.76	(0.58 - 13.00)	0.200	0.68	(0.13 - 3.39)	0.638

Note: Unadjusted and adjusted odds ratio with robust standard errors clustered at institution level estimated with logistic regression. Adjusted odds ratio includes institution fixed effects and all covariates shown in that column. (Ref) refers to reference group.

Key finding: Compared to the adult population of California, CDCR staff have higher rates of COVID-19 infection and lower rates of COVID-19 death. These findings likely relate to: (i) the higher rates of testing of people with asymptomatic infections, (ii) the increased occupational risk of COVID-19 infection, (iii) the relatively younger age of CDCR staff compared to the population at large, and (iv) the possibility that CDCR staff may be less likely to be vaccinated and/or less likely to engage in safer behaviors in the community (definitive data are not available regarding the last point). Further research on these topics may be illuminating.

Key finding: Staff characteristics associated with COVID-19 infection were: being of younger age, working in custody, education or operations (compared to healthcare), having a position that involves contact with residents, and having a job that does not require a college degree or equivalent.

Recommendation 5.2: Policymakers should respond to the disproportionate burden of COVID-19 infections among staff by greatly increasing the resources available to mitigate the risk of COVID-19 faced by staff. Recommendations for reducing the risk to staff are described in **Section 7.6**.

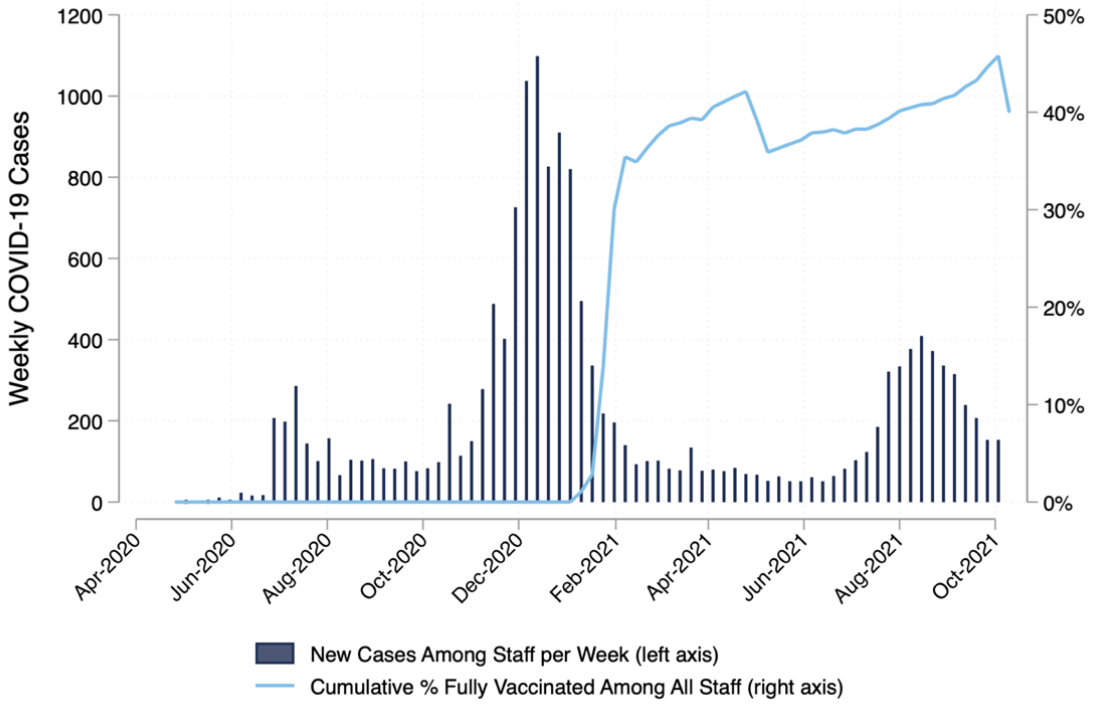
5.3. Impact of vaccination

As of December 15, 2021, at least 68% of current CDCR staff had been fully vaccinated against COVID-19, compared to 77% of California residents ages 18 years or older.(3) Since it is likely that some staff who received vaccination outside of CDCR have not been captured in the staff database, this number may be an underestimation. Among vaccinated CDCR staff in the recent cohort (as of October 9, 2021), 49% were fully vaccinated (including 8% who had received a booster), and 5% were partially vaccinated. Regarding vaccine types, 6% in the recent cohort had received the 2-dose BNT162b2 (Pfizer) vaccine, 39% had received the 2-dose mRNA-1273 (Moderna) vaccine, and 4% had received the 1-dose Ad26.COV2.S (Janssen/Johnson & Johnson (J&J)) vaccine. **Table 5.4** provides summary statistics of the vaccination statuses for the three staff cohorts as of October 9, 2021. The reduction in staff COVID-19 cases following the vaccination of residents and staff is depicted in **Figure 5.3**.

Table 5.4. Descriptive statistics of vaccination status for full, continuous, and recent cohorts.

	Full Cohort (N = 69,144)		Continuous Cohort (N = 30,608)		Recent Cohort (N = 56,858)	
	Freq	*Mean or %*	*Freq*	*Mean or %*	*Freq*	*Mean or %*
Total Staff						
Not vaccinated	35,787	51.8%	13,966	45.6%	26,466	46.5%
Partially vaccinated	3,046	4.4%	1,550	5.1%	2,750	4.8%
Fully vaccinated without booster	**25,977**	**37.6%**	**10,974**	**35.9%**	**23,319**	**41.0%**
Fully vaccinated with booster	**4,334**	**6.3%**	**4,118**	**13.5%**	**4,323**	**7.6%**
Ever refused a COVID-19 vaccine	35,787	51.8%	6,372	45.6%	12,319	46.5%
Number of vaccines of type						
BNT162b2 (Pfizer) vaccine						
2 or more	**3,571**	**5.2%**	**2,265**	**7.4%**	**3,182**	**5.6%**
0	64,186	92.8%	27,507	89.9%	52,369	92.1%
1	1,387	2.0%	836	2.7%	1,307	2.3%
2	2,883	4.2%	1,603	5.2%	2,495	4.4%
3	510	0.7%	489	1.6%	509	0.9%
4	177	0.3%	172	0.6%	177	0.3%
5	1	<0.1%	1	<0.1%	1	<0.1%
mRNA-1273 (Moderna)						
2 or more	**24,579**	**35.5%**	**11,480**	**37.5%**	**22,372**	**39.3%**
0	42,892	62.0%	18,407	60.1%	33,029	58.1%
1	1,673	2.4%	721	2.4%	1,457	2.6%
2	21,191	30.6%	8,267	27.0%	18,994	33.4%
3	2,553	3.7%	2,405	7.9%	2,543	4.5%
4	826	1.2%	800	2.6%	826	1.5%
5	9	<0.1%	8	<0.1%	9	<0.1%
Ad26.COV2.S (Janssen/J&J) vaccine						
1 or more	**2,163**	**3.1%**	**1,349**	**4.4%**	**2,090**	**3.7%**
0	66,981	96.9%	29,259	95.6%	54,768	96.3%
1	1,905	2.8%	1,106	3.6%	1,832	3.2%
2	258	0.4%	243	0.8%	258	0.5%

Figure 5.3. Weekly case rates for staff in the full cohort



Note: Fully vaccinated is 2 or more doses of mRNA-1273 (Moderna), 2 or more doses of BNT162b2 (Pfizer), or 1 or more of Ad26.COV2.S (Janssen/Johnson & Johnson) as of October 9, 2021. Vaccination rate is a lower bound, since data do not include staff who may have received vaccinations outside of CDCR. Cumulative percentage of fully vaccinated fluctuates due to changing weekly cohorts of staff working shifts and individuals who are considered active staff.

We used logistic regression models to estimate the unadjusted and adjusted odds that describe the association between select staff characteristics and not having been vaccinated as of October 9, 2021 (**Table 5.5**). When accounting for gender, job classification, having a position that involved contact with residents, minimum education required for one's job, and the number of institutions at which an individual worked during the pandemic, staff younger than age 30 (aOR = 2.52, $p<0.001$) and between the ages of 30 and 39 (aOR = 1.69, $p<0.001$) have significantly higher odds of never having been vaccinated relative to the odds of staff who are age 60 or older. Staff who are men have significantly lower odds of not getting vaccinated compared to women (aOR = 0.78, $p<0.001$). Staff with unknown job classifications, contractors, and custody had 3.9, 2.5, and 2.2 times the odds of being unvaccinated compared to those working in healthcare ($p<0.001$ for all comparisons). Having a position that did not require a college degree or equivalent was also associated with being unvaccinated. Finally, having been diagnosed with COVID-19 infection was also associated with being unvaccinated (aOR = 1.40, $p<0.001$; column (3) in **Table 5.5**). We also find that the direction and significance across these

covariates are robust to controlling for those who were infected. Supplemental Table S5.3 contains an extended version of Table 5.5 with models including staff and race/ethnicity, where 17% of non-missing staff-reported race/ethnicity data.

Key finding: CDCR staff, as a whole, appear to be less likely to be vaccinated than other adults in California. Staff who work in custody or operations, or who are contractors or have unknown job classifications have the highest odds of being unvaccinated.

Recommendation 5.3: Efforts to address vaccine refusal should be delivered by messengers who are more likely to be trusted by unvaccinated staff who are disproportionately younger in age, men, have a work type that is not in healthcare or education, and have a job that involves contact with residents.

Table 5.5. Associations between staff characteristics and having never been vaccinated against SARS-CoV-2 as of October 9, 2021.

	Full Cohort (N = 69,144)								
	(1) Unadjusted Estimates			(2) Adjusted Estimates (without Ever Positive covariate)			(3) Adjusted Estimates (with Ever Positive covariate)		
	Unadj. Odds Ratio	*95% CI*	*p-value*	Adj. Odds Ratio	*95% CI*	*p-value*	Adj. Odds Ratio	*95% CI*	*p-value*
60 or older	**1.00**			**(Ref)**			**(Ref)**		
Younger than 30	2.85	(2.65 - 3.06)	0.000	2.52	(2.33 - 2.72)	0.000	2.46	(2.27 - 2.66)	0.000
30 to 39	1.73	(1.63 - 1.83)	0.000	1.69	(1.58 - 1.79)	0.000	1.65	(1.54 - 1.76)	0.000
40 to 49	1.13	(1.06 - 1.20)	0.000	1.08	(1.01 - 1.15)	0.015	1.06	(0.99 - 1.13)	0.066
50 to 59	1.03	(0.96 - 1.08)	0.422	0.97	(0.91 - 1.03)	0.390	0.96	(0.90 - 1.02)	0.272
Unknown	2.27	(2.10 - 2.45)	0.000	0.40	(0.36 - 0.44)	0.000	0.42	(0.37 - 0.46)	0.000
Women	**1.00**			**(Ref)**			**(Ref)**		
Men	1.01	(0.97 - 1.03)	0.697	0.83	(0.79 - 0.86)	0.000	0.83	(0.79 - 0.86)	0.000
Healthcare	**1.00**			**(Ref)**			**(Ref)**		
Custody	2.80	(2.67 - 2.92)	0.000	2.24	(2.05 - 2.44)	0.000	2.18	(1.99 - 2.37)	0.000
Operations	1.87	(1.76 - 1.96)	0.000	1.43	(1.30 - 1.57)	0.000	1.38	(1.25 - 1.52)	0.000
Education	1.08	(0.95 - 1.22)	0.222	0.83	(0.72 - 0.95)	0.007	0.82	(0.71 - 0.93)	0.003
Contractor	4.15	(3.89 - 4.42)	0.000	2.41	(2.21 - 2.62)	0.000	2.45	(2.24 - 2.66)	0.000
Unknown	5.42	(5.10 - 5.74)	0.000	3.99	(3.56 - 4.45)	0.000	3.94	(3.52 - 4.4)	0.000
Position w/o contact w/ residents	**1.00**			**(Ref)**			**(Ref)**		
Provides direct care	0.72	(0.69 - 0.74)	0.000	1.54	(1.43 - 1.65)	0.000	1.53	(1.42 - 1.64)	0.000
Graduate degree required for job	**1.00**			**(Ref)**			**(Ref)**		
Less than a college degree equivalent	3.17	(2.97 - 3.36)	0.000	1.76	(1.59 - 1.93)	0.000	1.72	(1.56 - 1.89)	0.000
College degree or equivalent	3.05	(2.85 - 3.26)	0.000	1.50	(1.37 - 1.63)	0.000	1.48	(1.35 - 1.6)	0.000
Unknown	7.05	(6.55 - 7.58)	0.000	-	-	-	-	-	-
Works at 1 institution	**1.00**			**(Ref)**			**(Ref)**		
Works at 2nd institution	0.30	(0.28 - 0.31)	0.000	0.20	(0.18 - 0.21)	0.000	0.20	(0.18 - 0.21)	0.000
Works at 3rd institution	0.23	(0.21 - 0.25)	0.000	0.15	(0.13 - 0.16)	0.000	0.14	(0.12 - 0.16)	0.000
Works at 4th institution	0.25	(0.18 - 0.33)	0.000	0.16	(0.11 - 0.22)	0.000	0.16	(0.11 - 0.22)	0.000
Works at 5th institution	0.22	(0.06 - 0.77)	0.019	0.16	(0.04 - 0.64)	0.010	0.17	(0.04 - 0.64)	0.010
Never positive	**1.00**			-			**(Ref)**		
Ever positive	1.40	(1.34 - 1.44)	0.000	-	-	-	1.40	(1.34 - 1.44)	0.000

Note: Unadjusted and adjusted odds ratio with robust standard errors clustered at institution level estimated with logistic regression.
Adjusted odds ratio includes institution fixed effects and all covariates shown in that column. (Ref) refers to reference group.

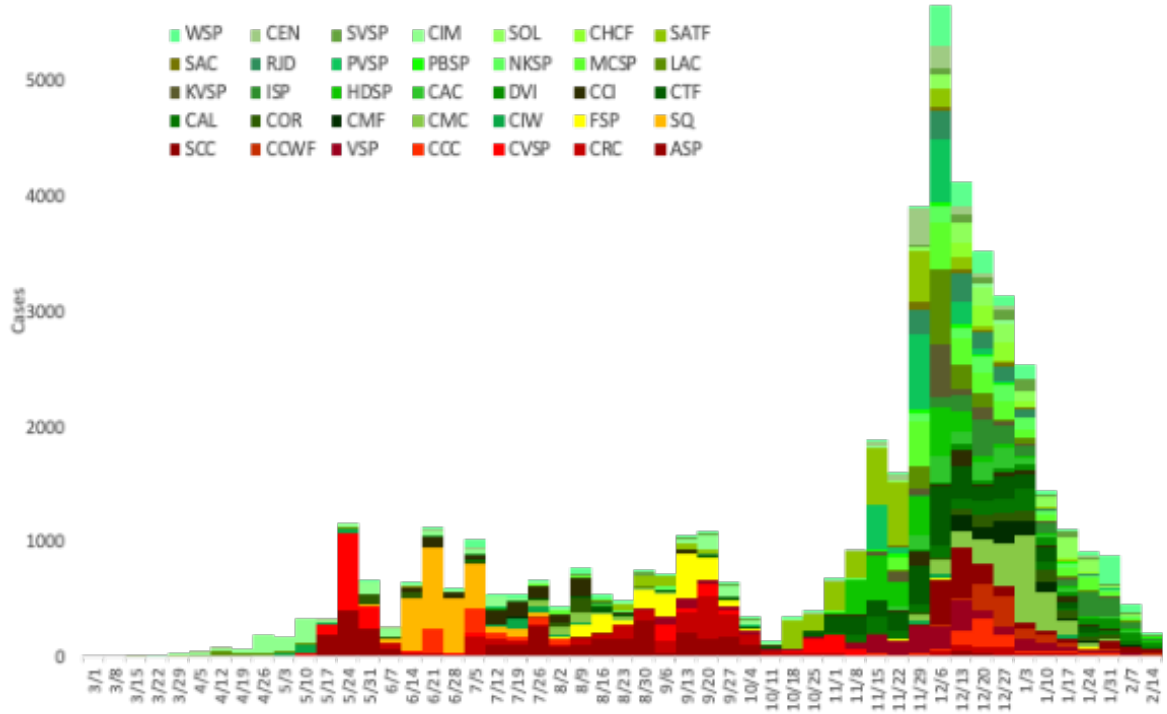
6. The Built Environment

Prisons are built for security, and many of these spaces and their architectural features are in conflict with protecting people in crowded living spaces during a respiratory pandemic. Since the built environment of a prison can be largely incompatible with respiratory pandemic mitigation measures, prisons require unique and additional precautions and engineering to reduce pathogen introduction and transmission risks. This section focuses on architectural features and the built environment across CDCR institutions specifically, and in the context of the COVID-19 pandemic, we characterize the types of buildings and physical spaces that need to be better understood to improve infection control and the safety of the environment across CDCR institutions.

One example of how the built environment is relevant in the context of a respiratory pandemic is the way aerosol transmission of SARS-CoV-2 caused outbreaks in institutions throughout the COVID-19 pandemic. Across CDCR, COVID-19 outbreaks in summer 2020 predominantly occurred in institutions that consisted mostly of dormitories ("dorms") and pods (a "pod" is a structure that includes multiple smaller dorms on a single shared floor which may or may not have a shared air space). Beginning in mid-October 2020, large outbreaks also occurred in institutions that were comprised mainly of cells with solid walls and doors (**Figure 6.1**). From this figure, we hypothesize that as outdoor temperatures dropped and heating systems were turned on in the fall of 2020, significant decreases in outside air entry—paired with recirculation of indoor air containing infectious aerosol—may have contributed to the fall and winter spread of COVID-19 in all housing units (including in celled housing, places we thought were more protected from COVID-19) in 2020-2021.

This section is organized as follows. First, we describe the history of buildings and the built environment in CDCR prisons, based on publicly available data, CCHCS administrative data and infection rates, and observations of housing characteristics collected during CalPROTECT site visits. We then investigate how the built environment may have influenced the spread of COVID-19 by reporting the ratio of cases found in each housing unit type over the number of people who lived in that housing unit for at least 30 days during the pandemic. We use this analysis as one way to determine which CDCR housing units may be lower risk to the spread of COVID-19, as such buildings may be best used for quarantine purposes or the long-term housing of residents who are particularly vulnerable to COVID-19 infection.

Figure 6.1. Aerosol transmission has caused outbreaks in institutions that are majority dormitories and pods (red), majority barred cells (orange and yellow), and majority cells with solid walls (green) through different seasons.



Note: Image provided by Heidi Bauer and Justine Nicholson (CCHCS). Figure shows CCHCS statewide COVID-19 cases (N=48,984) by institution and by week for March 1, 2020 – February 27, 2021.

6.1. History of CDCR buildings

Across its more than 150-year history, the infrastructure of the California State Prison System has evolved in response to a changing population and state administrations. The history of the CDCR prisons can be broadly summarized into different eras:

- **Pre-1920s & 1920s to 1960s:** The California prison system was comprised of what is now referred to as the "Original 12" prisons: SQ, FSP, CCC, CCI, CIM, CIW, CMC, SCC, CMF, CRC, CTF, DVI. The oldest prisons that remain in use tend to have unique building types and campuses, such as the multi-story "closed dormitory" cellblocks of San Quentin and "Old" Folsom State Prison, which are the two oldest California state prisons and were constructed as early as the 1850s.

- **1980s and 1990s:** A significant proportion of the currently active state prisons was constructed in the 1980s and 1990s as part of a national increase in harsher sentencing

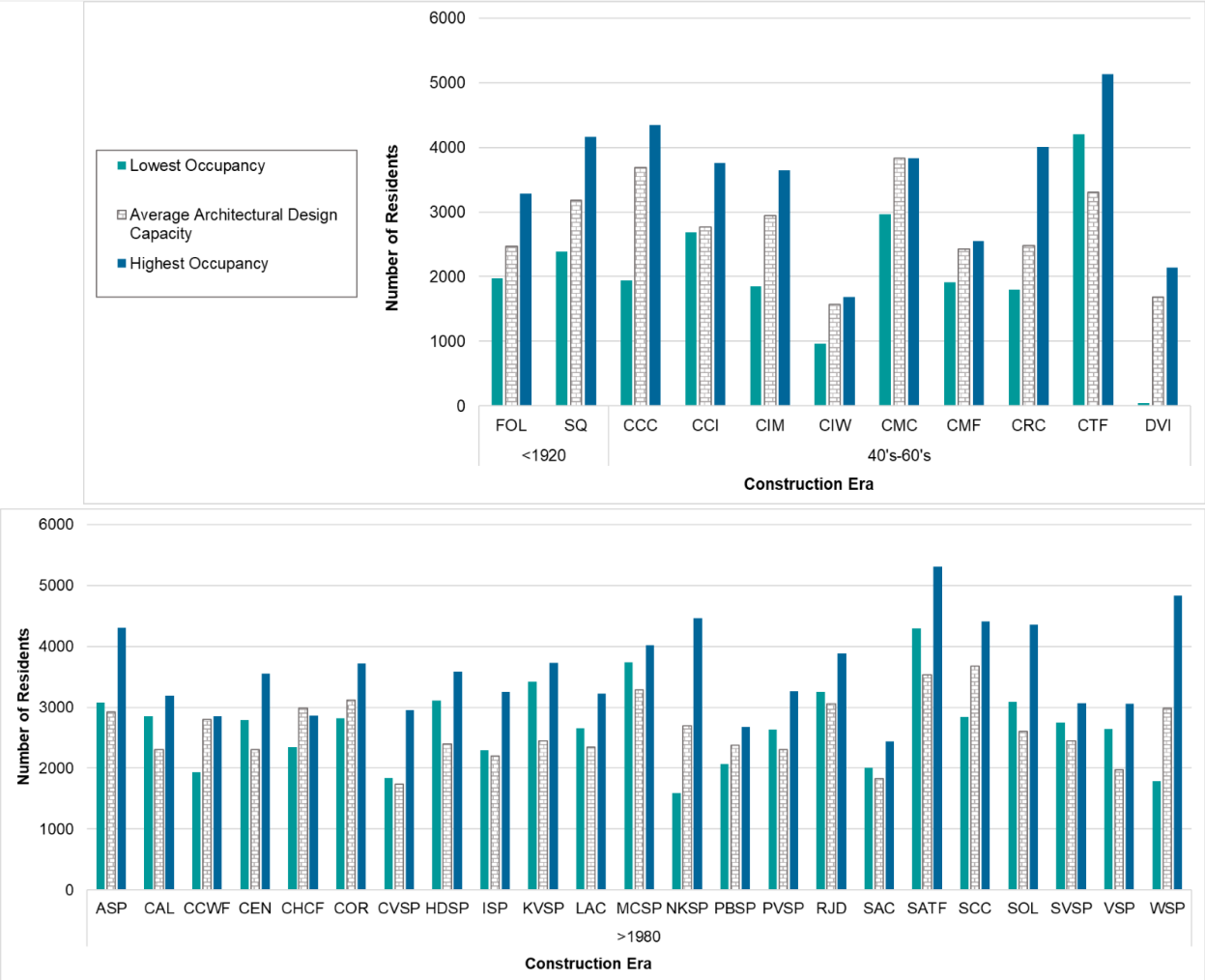
laws that resulted in a surging prison population. This time period was met with a construction boom when new design standards were being adopted. For example, instead of one big yard or dining hall, prisons began to be broken up into smaller, more semi-autonomous yards to enhance security.

For the prisons constructed in this later period, construction and building types were more standardized, though some prison-by-prison differences in construction occurred. Additionally, several of these building types were constructed as additions to older prisons to accommodate overcrowding and special housing needs (e.g., "270s" and "E-Type" Dormitories). Named for the degrees that could be seen from the correctional officers' central control, buildings with 270(-degree) designs were constructed either as two-tier open dorms or two-tier celled housing units. Similarly named for the degrees that can be seen from central control, other building units with celled housing constructed during this era were "180s" (with 180-degree design), which were higher-level security units that allowed for movement to be more controlled through design.

Figure 6.2 depicts CDCR institutions grouped by the era of construction date. Using CDCR Population Reports, we extracted weekly occupancy figures (number of residents) to display the maximum and minimum institution occupancy from January 2020 through October 2021 and compared those numbers to the average architecturally specified design capacity of each institution. This figure shows that the majority of California's active institutions are of relatively recent construction. While occupancy and design capacity vary across the system, many prisons have remained above design capacity throughout the pandemic, particularly those constructed from the 1980s onward.

Key finding: CDCR institutions were constructed at different times over more than a century. The oldest institutions were more likely to have had occupancy levels below their architectural design capacities at some point during the pandemic.

Figure 6.2. Weekly Occupancy of Institutions During the Study Period (January 2020-October 2021), with Minimum, Maximum, Architecturally Specified Design Capacity, grouped on Construction Era



6.2. Physical Infrastructure

A key prevention and mitigation question is the role of different housing types in COVID-19 transmission. To better characterize the building types beyond "cell" or "dormitory", our team used a combination of observation during site visits, information available from CDCR, and the use of satellite images available in the public domain.

Data Limitation: CalPROTECT's access to CCHCS administrative data contains anonymized yard, building, and room identifications with classification of room types (i.e., 270 cell, 270 dorm, 180 cell, other cell, other dorm, room, etc.). Having identified housing data would provide an opportunity to link observations and data collected from CalPROTECT site visits

to CDCR administrative data in order to better examine the risks of transmission in different CDCR environments. Furthermore, CCHCS administrative data does not include whether double and single cells are open/barred or closed-front cells which has the potential to affect the risk of COVID-19 transmission.

Table 6.1 below shows the number of distinct "housing units" as coded in the residential database that fall within each "housing type". The following housing types were developed by our team with a focus on documenting the degree of shared airspace that residents might experience in large, single-building dormitories or cell blocks with open bars and multiple floors, and potential contact between residents, as might happen in day rooms or bunkbed areas. As building units were anonymized in the CCHCS administrative data provided to our team, the areas marked with an asterisk (*) reflect team-derived names and key opportunities for further research. Based on this information, our team identified 1143 distinct housing units across the 35 CDCR institutions from residential housing records. In this report, we utilize the term "housing unit" as it is a CDCR-defined category, and thus, multiple housing units may exist within the same physical building.

Table 6.1. CalPROTECT Housing Unit Types Overview (n=1,143)

Overall Room Type	Housing Unit Type	No. of Institutions with this Housing Unit Type	No. of Housing Units across CDCR	Average No. of Residents per Housing Unit per Week	Total Residents, March 2020-October 2021
Cells	180 Cell (solid door)	8	40	86	43,595
	270 Cell (solid door)	22	62	139	136,489
	Double cells, overall[1]	22	85	163	67,801
	Double cells, solid door (1980+)	14	35	98	24,627
	Double cells, *Door Unknown (1940's-60's)	6	45	181	31,559
	Double cells, open/barred Door (<1920)	2	8	432	11,975
	Single cells, overall[1]	30	69	62	33,892

	Single cells, solid door (1980+)	20	39	47	16,473
	Single cells, door unknown (1940's-60's)	9	30	75	15,328
	Single cells, open/barred Door (<1920)	1	3	200	2,091
	Wingnut cells (double)[5], solid door (1980+)	2	12	140	56,988
Pod Dorms[2]	>1 dorm room per floor	15	26	176	20,812
	270 Dorm	3	35	170	16,922
	Cross-top dorm	5	41	188	30,389
	*D dorm[5]	1	6	134	3,505
Open Dorms[3]	Standalone dorm[4], E-Type or similar (capacity: 150-200)	21	52	82	31,531
	Standalone dorm[4], large (capacity: 100-149)	8	54	60	15,484
	Standalone dorm[4], medium (capacity: 50-99)	10	66	50	15,023
	Standalone dorm[4], small (capacity: <50)	28	66	25	9,869
	Wingnut dorm[5] (open)	2	5	158	16,179
	1 dorm room per floor (multi-floor buildings)	8	13	50	3,053
Other	Other (Room, Closed Ward)	33	12	6	2,699
Unknown	Unidentified	4	1	18	45
Totals:		35	1,143	99	148,583

Note: An asterisk (*) denotes an informal housing type name derived by CalPROTECT.

Cells were assigned as designated "single" or "double" cells based on the maximum room capacity (during the study period) from the CDCR database. Note that "room capacity" refers to the total number of available beds and is unrelated to the institutional design or staffed capacity. Number of residents in a cell at a given point in time may be different from the assigned capacity.

[2] "Pod" dorm structures include multiple smaller dorms on a single shared floor; airspace may be shared across pods if the doors and walls between them are not closed. Otherwise, most pod structures feature a shared day room.

[3] "Open" dorms structures feature a single room per floor, with no barriers between clusters of bunks.

[4] "Standalone" dorms are a subset of open dorms, where the entire housing unit it made up of a single open room, with no other associated floors or buildings (example: E-Type dorms). As with cells, "capacity" in this instance refers to the number of beds and is unrelated to institutional design capacity.

[5] "D dorms" is a name developed by the CalPROTECT team based on the appearance of these buildings, which appear only at SATF. CDCR does not use any identifier for this housing unit because it was never built elsewhere.

When examining COVID-19 risk in certain housing units, it is important to remember that the typical population, if there is one, may differ across standardized housing unit types. To better understand how populations differ across housing units, we assessed the proportion of the residents who were 55 years or older, of female sex, or with a COVID-19 risk score of ≥3 in each housing unit type (Table 6.2). A risk score of 3 is defined by CDCR as high risk and is generated from the age of a patient and their comorbidities (described in detail in Section 4.2.7).

Table 6.2. Demographics of CalPROTECT Housing Unit Types Across CDCR (n=1143)

Room Type	Housing Unit Type	Residents of age 55 years or older (%)	Residents identified as female (%)	Residents who had a COVID risk score of ≥3 (%)
Cells	180 Cell	8%	0%	12%
	270 Cell	13%	5%	15%
	Double cells, overall[1]	19%	5%	19%
	Single cells, overall[1]	25%	4%	29%
	Wingnut cells (double)[5]	7%	0%	8%
Pod Dorms[2]	>1 dorm room per floor	19%	5%	16%
	270 Dorm	23%	0%	15%
	Cross-top dorm	25%	32%	25%
	*D dorm[5]	26%	0%	21%
Open Dorms[3]	Standalone dorm[4], E-Type or similar (capacity: 150-200)	19%	0%	16%
	Standalone dorm[4], large (capacity: 100-149)	10%	2%	8%
	Standalone dorm[4], medium (capacity: 50-99)	19%	2%	16%
	Standalone dorm[4], small (capacity: <50)	19%	1%	17%

	Wingnut dorm[5] (open)	6%	0%	5%
	1 dorm room per floor (multi-floor buildings)	24%	0%	24%
Other	Other (Room, Closed Ward)	13%	1%	18%
Unknown	Unidentified	17%	4%	16%
	Full Cohort	17%	5%	20%

Note: An asterisk (*) denotes an informal housing type name derived by CalPROTECT.

[1] Cells were assigned as designated "single" or "double" cells based on the maximum room capacity (during the study period) from the CDCR database. Note that "room capacity" refers to the total number of available beds and is unrelated to the institutional design or staffed capacity. Number of residents in a cell at a given point in time may be different from the assigned capacity.

[2] "Pod" dorm structures include multiple smaller dorms on a single shared floor; airspace may be shared across pods if the doors and walls between them are not closed. Otherwise, most pod structures feature a shared day room.

[3] "Open" dorms structures feature a single room per floor, with no barriers between clusters of bunks.

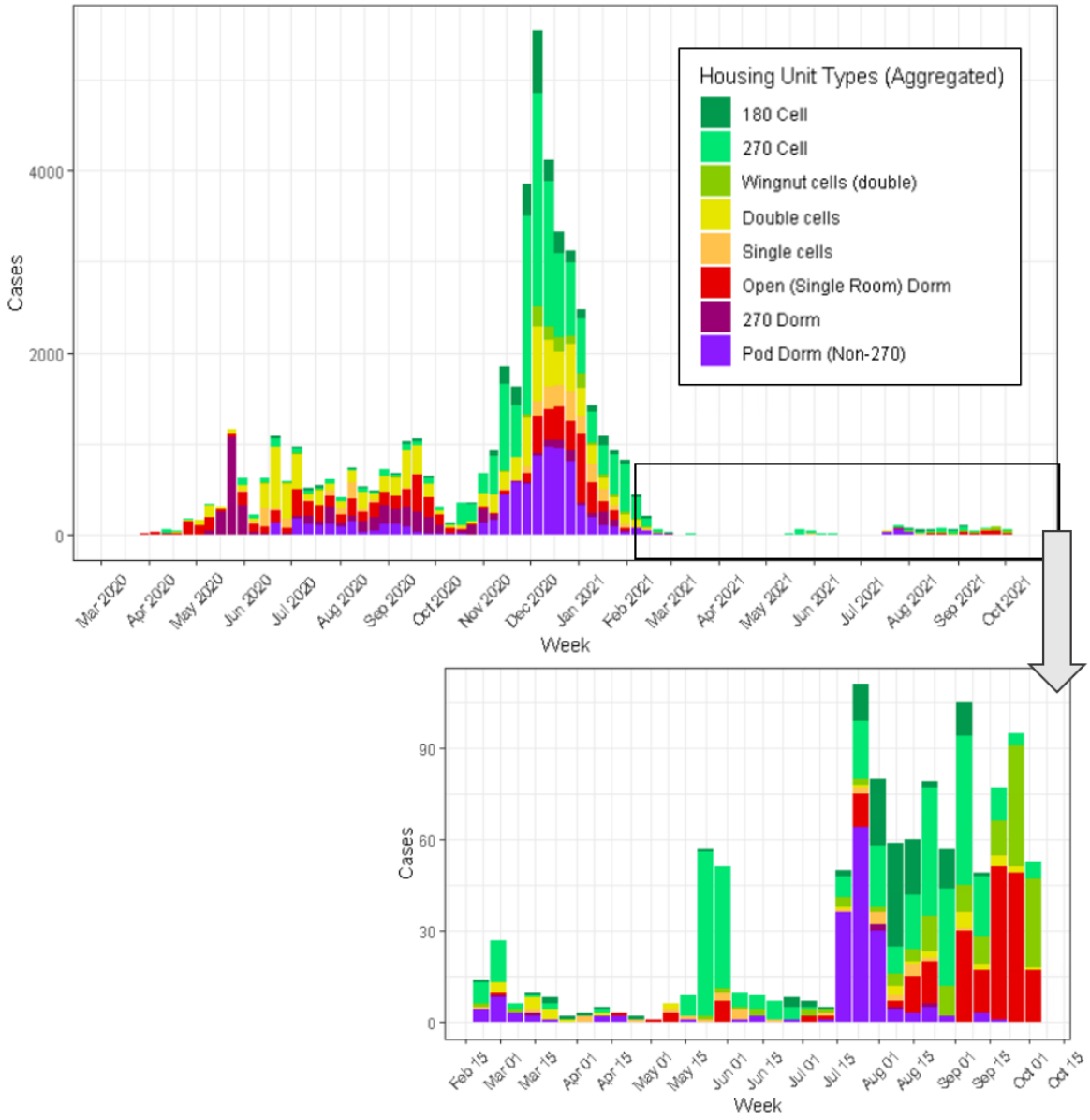
[4] "Standalone" dorms are a subset of open dorms, where the entire housing unit it made up of a single open room, with no other associated floors or buildings (example: E-Type dorms). As with cells, "capacity" in this instance refers to the number of beds and is unrelated to institutional design capacity.

[5] "D dorms" is a name developed by the CalPROTECT Team based on the appearance of these buildings, which appear only at SATF. CDCR does not use any identifier for this housing unit because it was never built elsewhere.

6.3. Risk of COVID-19 According to Housing Type

There are many factors that influence where cases of COVID-19 occur and what factors may facilitate its transmission. To understand how risk of infection varied by housing unit type, we first investigated where cases occurred according to the housing unit types we defined above in **Section 6.2**. As demonstrated in **Figure 6.3**, the first group of COVID-19 outbreaks occurred primarily in 270 dorms and double-celled (non-270, non-180, non-wingnut) housing. When the fall and winter surge occurred in late 2020, cases spiked across a wider variety of housing unit types. In the most recent data (**Figure 6.3** inset), after widespread deployment of vaccines, smaller outbreaks have continued to occur in both cells and dormitories.

Figure 6.3. Confirmed Weekly COVID-19 Cases in the California State Prison System by CalPROTECT-defined Housing Unit Type, March 1, 2020-October 9, 2021.



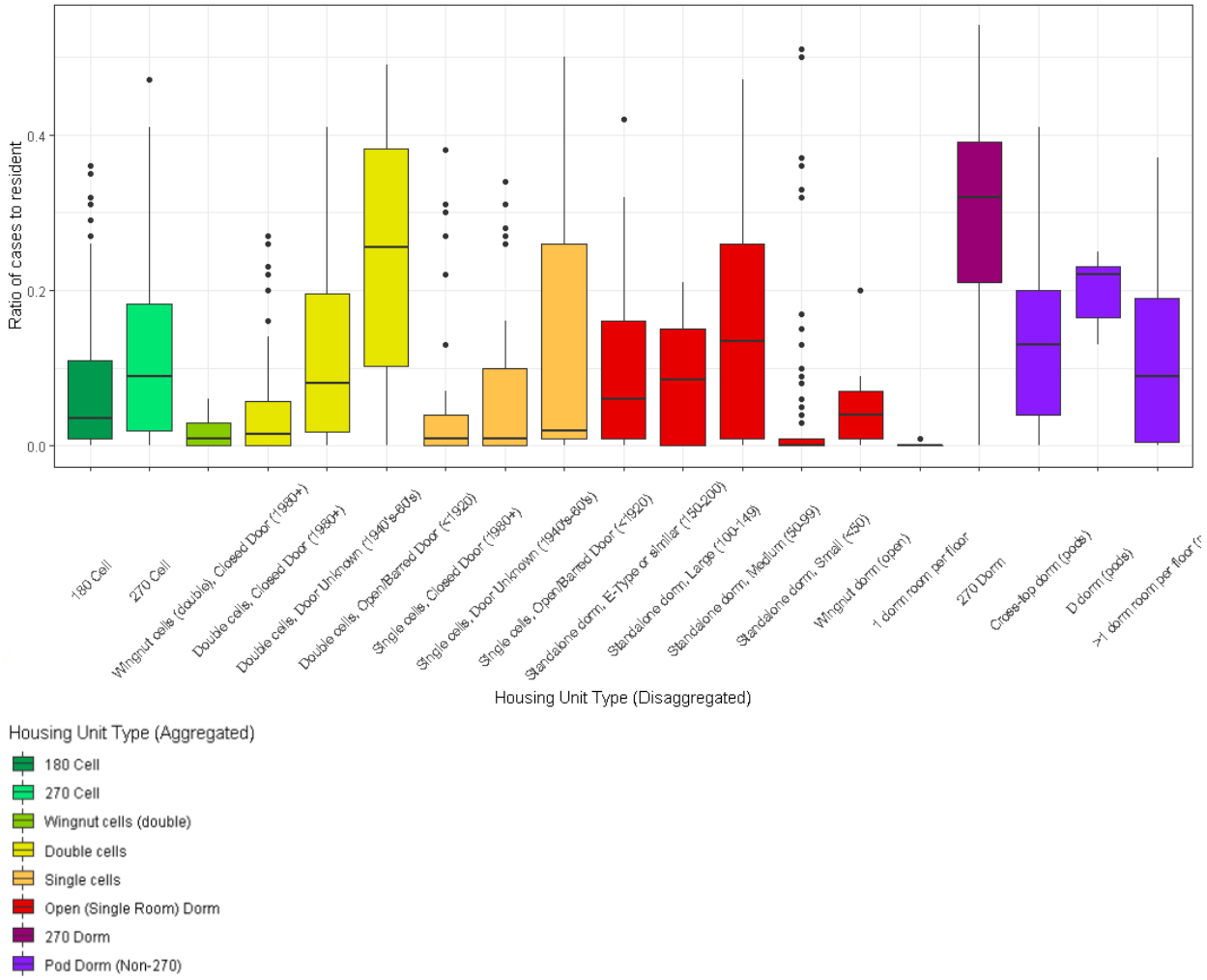
Next, to assess the differential rates of COVID-19 infection across the housing unit types defined above, we calculate case ratios for each type of CDCR housing unit. Cases are assigned to a specific housing unit based on the presumed date of exposure, here calculated as three days prior to testing positive. Case ratio is defined as the total number of cases that occurred in each housing unit over the total number of people that lived in that housing unit for at least 30 days from March 1, 2020 to October 9, 2021. The qualification of "at least 30 days" is intended to facilitate a focus on cases based on place of residence, and to largely

remove short-term moves, such as those for quarantine, transfers, reception, and treatment. The limitations in using this definition of case ratio include that only confirmed cases of COVID-19 are represented, and that we cannot account for differing amounts of time spent in each housing unit. This means that housing units with high turnover of residents will have larger denominators and potentially smaller case ratios than units with fairly stable populations, such as some celled housing units. Additionally, people who lived in more than one type of building will be counted more than once. The case ratios presented are raw case ratios, uncorrected for prior infections among the residents, vaccination rates, community prevalence levels, heating/cooling status, lockdown status, or other factors that may influence probability of infection and transmission within a housing unit.

Figure 6.4 displays the box plot of each housing unit's case ratio, with the box defining the first and third quartile of the distribution of case ratios for each housing unit and the line within the box indicating the median case ratio for each housing unit. This figure suggests that COVID-19 risk may be highest in 270 dorms, double cells with open or barred doors, and D dorm (pod) housing units. Risk may be lowest in housing units with single cells, small standalone dorms, one dorm room per floor, and Wingnut cells and dorms.

Next, we performed a similar analysis of the infection risk across these housing unit types by calculating the number of cases per housing unit type over the total number of person-days spent in each housing unit type (case rate). "Person-days" represent the number of nights a resident was assigned to each housing unit; the total number of person days was calculated for each distinct housing unit; and the rate of cases per person-day (case rate) were averaged across all the distinct housing units in CDCR. These case rates are displayed in red (Table 6.3). We also display the average total person-days spent in each housing unit type across CDCR (in yellow) to indicate how frequently residents are housed in each housing unit type across CDCR. Limitations of this approach include that it does not distinguish between places used for "quarantine-in-place" and those where people would have been moved for quarantine, which can affect the amount of person-time in the denominator. As discussed further in section 7.5, the implementation of quarantine and isolation varies widely across CDCR and across housing unit type, and thus is not included here. As with the case ratios, the case rates presented are raw case rates, uncorrected for prior infections among the residents, vaccination rates, community prevalence levels, heating/cooling status, lockdown status, or other factors that may influence probability of infection and transmission within a housing unit.

Figure 6.4. Boxplots of Case Ratio Per CDCR Housing Unit, Grouped According to CalPROTECT's Defined Housing Unit Types, March 1, 2020 – October 9, 2021



Note: The "case ratio" is defined as the total number of cases that occurred in each housing unit over the total number of people who lived in that housing unit **for at least 30 days** from March 1, 2021 to October 9, 2021. In this figure, we see that as we have seen in our other data, 270 Dorm housing units (far right, burgundy) have the highest average case ratio, followed by double cells with open/barred doors (yellow), most likely the San Quentin outbreak. For most of our housing units, the range of case ratios across the different individual units was quite large, with only a few that had a small range and thus similar case ratio across all buildings of that type.

Similar to the case ratio analysis in **Figure 6.4**, the case rate approach (which describes rates per 100,000 person-days) suggests that 270 dorms (126.6 cases per 100,000 person-days), double cells with open or barred doors (99.6 cases per 100,000 person-days), and D dorm pod (111.3 cases per 100,000 person-days) housing units carry a higher risk of COVID-19 acquisition. In contrast to the case ratio analysis above, the case rate in wingnut dorms also suggests an increase in COVID-19 risk (103.2 cases per 100,000 person-days). Similar to the case ratio analysis above, the lowest case rates were found in housing units with single cells

(38.4 – 49.5 cases per 100,000 person-days), small standalone dorms (44.2 cases per 100,000 person-days), and one dorm room per floor (1.9 cases per 100,000 person-days). The case rate analysis also identified 180 cells (42.1 cases per 100,000 person-days) and double cells with closed doors (39.7 cases per 100,000 person-days) as having lower case rates. Finally, this analysis finds that the infection risk in double cell and single cell housing types is higher in older institutions (with open/barred door cells) than newer institutions (with closed door cells).

Table 6.3. Overview of Cases in Housing Unit Types According to Resident Time in Housing Unit, March 1, 2020 – October 9, 2021.

Housing Unit Type (Aggregated)	Housing Unit Type	Average Total Person-Days Per Housing Unit	Average Case Rate Per Housing Unit per 100,000 Person-Days
180 Cell	180 Cell	55,153	36.5
270 Cell	270 Cell	86,556	62.7
Wingnut cells (double)	Wingnut cells (double)	47,663	46.6
Double cells	Double cells, Closed Door (1980+)	62,425	36.2
	Double cells, Door Unknown (1940's-60's)	104,070	69.4
	Double cells, Open/Barred Door (<1920)	337,851	99.6
Single cells	Single cells, Closed Door (1980+)	24,378	39.4
	Single cells, Door Unknown (1940's-60's)	49,413	55.3
	Single cells, Open/Barred Door (<1920)	119,115	43.3
Open (Single Room) Dorm	1 dorm room per floor	16,502	1.9
	Standalone dorm, E-Type or similar (150-200)	46,320	65.8
	Standalone dorm, Large (100-149)	36,586	71.2
	Standalone dorm, Medium (50-99)	28,163	94.5
	Standalone dorm, Small (<50)	8,130	36.6
	Wingnut dorm (open)	74,140	90.2
270 Dorm	270 Dorm	111,108	126.6
Pod Dorm (Non-270)	>1 dorm room per floor (pods)	116,402	59.4
	Cross-top dorm (pods)	126,247	67.8
	D dorm (pods)	98,087	111.3

Key finding: When we include more detailed features about the housing room types that are not available in the CDCR/CCHCS data, increased risk of COVID-19 infection was found—on two different analyses—in 270 dorms, double cells with open or barred doors, and D dorm pods. Decreased risk of COVID-19 infection was found—on two different analyses—in single cells, small standalone dorms, and one dorm room per floor. This metric differs from the one used in Section 10 analyses, which utilize CDCR/CCHCS room type classifications without these nuanced room features.

Key finding: The risk of COVID-19 acquisition in double cell and single cell housing units appears higher in older institutions with open/barred doors and lower in newer institutions with closed/solid doors.

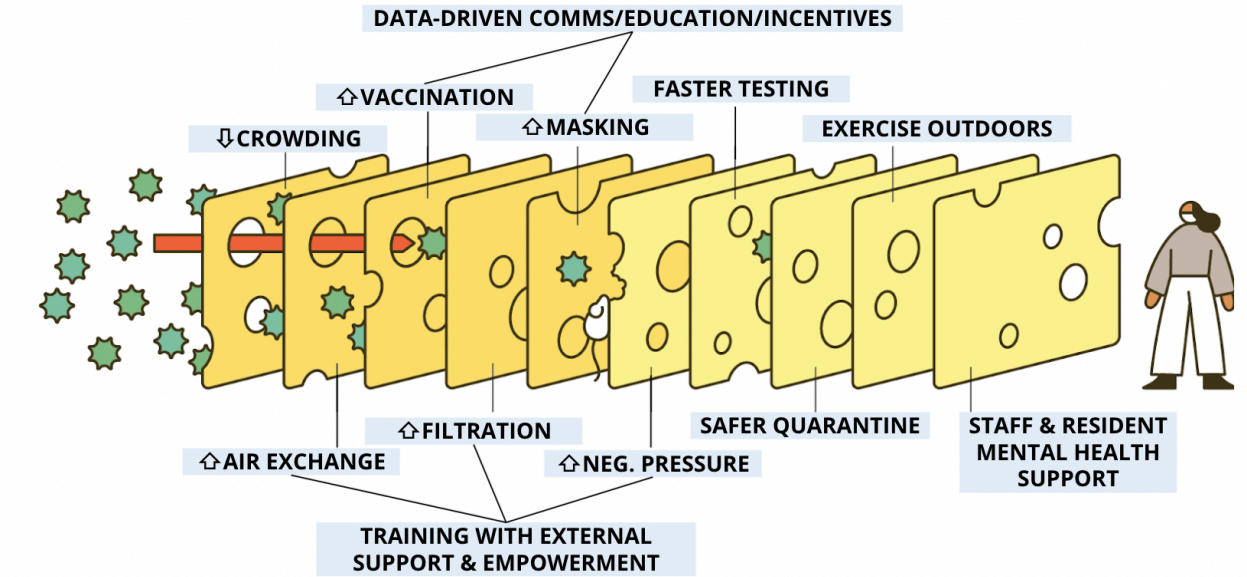
Recommendation 6.1: Initial findings on higher and lower risk building types should be paired with widespread indoor air quality assessments (described in **Section 7.3**) and with multivariable analyses to identify appropriate buildings for quarantine housing and to preferentially house high- and low-risk patients based on COVID-19 risk scores and vaccination status.

7. Outbreak Prevention and Mitigation Efforts

7.1. No single mitigation measure is sufficient

Reducing the risk of COVID-19 requires the application of numerous overlapping strategies as any single strategy alone has proved insufficient in reducing risk to a safe level. **Figure 7.1** shows an adapted "Swiss cheese model" as a framework for considering the needed layers of COVID-19 prevention and mitigation measures. The goal of having multiple measures in place is to reduce both the risk of SARS-CoV-2 introduction into CDCR facilities and the likelihood of onward transmission and rapid spread once it is present. CDCR institutions cannot ever be immune to the dangers of COVID-19, but a pandemic response that includes multiple layers of robust control measures can help protect institutional populations and staff from large outbreaks, morbidity, and death.

Figure 7.1. The Swiss cheese model: For COVID-19, no single mitigation measure is sufficient, and the most effective strategy is a layered approach that combines and optimizes all measures simultaneously.



Note: Adapted from New York Times and Ian M. Mackay (virologydownunder.com) and James T. Reason. Illustration by Rose Wong.

As displayed in **Figure 7.1**, starting at the top left, reducing crowding (through decarceration) can decrease the number of cases, and the speed of spread, that are likely to result when COVID-19 is introduced into a prison. Increasing vaccination reduces the number of people

who are more susceptible to becoming infected, the probability that they will get very ill if infected, and the likelihood that they will transmit the virus. Improving masking and ensuring mask fit can be effective at slowing transmission, recognizing that masking is a measure to prevent onward transmission when somebody is likely infectious. To be effective, vaccination and masking measures require high levels of uptake from the susceptible population and thus can benefit from data-driven communication, education, and incentives directed toward residents and staff.

With regard to faster testing, delays in testing turnaround beyond a day or two dramatically increase the likelihood of onward transmission, as infectious patients who are not yet isolated (such as those who are asymptomatic or pre-symptomatic) will expose the susceptible population during their period of peak infectiousness. Designing systems to employ rapid tests on a much larger scale when an outbreak occurs—with a focus on using rapid tests for exposed patients who are not residing in safe, individual quarantine—is vital. Wastewater surveillance testing at the institution level (or at the building or yard level, if possible) can also help identify outbreaks at an early stage. (Two CDCR institutions participated in wastewater surveillance testing for COVID-19 during the pandemic; however, we did not have the opportunity to work with the data collected and cannot make any more specific recommendations.)

Environmental measures are imperative to combat the airborne spread of COVID-19, including increasing air exchange, filtration, and negative pressure in buildings where people who are likely to be infected are located. Increased air exchange involves diluting indoor air with outdoor air by opening windows and doors and setting Heating, Ventilation, and Air Conditioning (HVAC) systems to maximize air exchange from the outside. For effective filtration, air purifiers can be deployed, and improved filters can be added to HVAC systems. When relying on HVAC systems to filter air, it is critical to ensure the proper functionality of the existing ventilation system by hiring a test and balance engineer. When a system is balanced, the directionality can be known, and appropriate interventions can then be designed. It is important to ensure that systems are not enabling air to bypass the filters and re-channel potentially infectious agents back into a building. Creating negative pressure, if possible, in rooms where people are likely to be infected is important to ensure that infectious aerosols are expelled from rooms to the outdoors and not to common areas or other cells. To complement these environmental measures, Germicidal ultraviolet-C lamps can help disinfect air. For these environmental measures, it is crucial to involve each facility's plant operations and engineering staff in pandemic preparation and response activities and empower them to make necessary in-the-moment decisions by providing training with the availability of external consultation and support. Furthermore, ensuring that all staff have the ability and support to meet the demands of their jobs can prevent burnout, anxiety, and stress.

Creation of safer quarantine spaces requires instituting and maximizing the environmental measures above and designing systems to house as many people as possible in single cell quarantine when needed. Lastly, to improve quality of life and compliance with mitigation measures, it is critical to constantly keep in mind that extended lockdowns and restrictions on activities and programming can have a profound negative impact on the mental health of both staff and residents. Providing mental health support for both staff and residents, acknowledging the burden of their experiences, and implementing risk reduction measures to resume programming is particularly vital as the pandemic enters its third year.

In the following sections, we describe the outbreak prevention, mitigation, and control measure alluded to above in greater detail with a focus on actionable recommendations that CDCR and CCHCS leadership can consider alongside the science informing these recommendations. Specifically, we focus on reducing crowding, increasing ventilation and air filtration, optimizing testing strategies, evaluating safe quarantine and isolation, preventing staff introduction and transmission, early outbreak identification and response, and increasing vaccination.

7.2. Reduce the population to decrease crowding

To understand the role of decarceration, it is useful to think of how safe residents are from infectious diseases given the physical environment and occupancy of a prison under three different scenarios: (i) in the absence of a respiratory pandemic; (ii) in a respiratory pandemic when an active outbreak is not occurring in the institution; and (iii) in a respiratory pandemic with an active outbreak.

First, we recognize, but do not address here, the many physical and mental health harms associated with incarceration in the absence of a pandemic, which have ramifications for the well-being of people currently incarcerated and their families.(1-4) We also recognize that respiratory pandemic planning and response is occurring in the context of historical and contemporary forces that created, maintain, and facilitate the expansion of mass incarceration, as well as inequality in who is targeted for mass incarceration, with implications for population health and health inequity beyond prison walls.(5)

Even in the absence of a respiratory pandemic, it is likely that most public health experts would recommend against 800 people living together in a single, shared airspace. The risk of explosive spread of any respiratory disease in such an environment is too great (such as is the case at San Quentin prison's open celled dormitories). Although occupancy levels are determined by codes that are designed to protect the general safety and welfare of occupants, there is no consistent public health guidance regarding maximum residential room occupancy.

As a society, we accept the possible risk of large congregations of people (theaters, concerts, airplanes, classrooms) but only for limited periods of time, and only if those activities can be suspended in the event of a serious infectious disease threat. For example, during the COVID pandemic, gyms, restaurants and hotels in the community have been ordered to limit their occupancy to 25% to 50% of design capacity, or 200 people, whichever is fewer.(6-7)

When a respiratory epidemic or pandemic occurs, national and local public health authorities limit indoor gathering in large groups (e.g., 6 or 10) to prevent rapid, uncontrolled spread. When the serious threat of a respiratory virus exists, we should ensure that people in prison are not living in large groups where transmission can occur rapidly. Just as plans exist for evacuation in the event of a wildfire, earthquake, or chemical spill, plans should outline steps for the emergency evacuation of high-risk prison housing units that cannot be made significantly safer in the event of an infectious disease outbreak. In some places, it may be possible to achieve this with temporary housing units (e.g., industrial quality trailers, tents). Emergency decarceration runs the risk of being a costly and potentially dangerous activity. For this reason, if an evaluation of whether someone can be safely decarcerated into the community is only done after an outbreak has occurred, then it may take too long to make that assessment and achieve decarceration quickly enough on a large enough scale for a meaningful impact on individual and public health.

In any high-risk setting, there should be prior assessment (e.g., as soon as a pandemic is declared) of who could be decarcerated into the community (e.g., to family), who could be decarcerated into an unsecured setting in the community (e.g., an unsecured hotel), who could be decarcerated into a low-security alternative facility (e.g., a hotel with correctional officers), and who would either need to remain in the facility or be transferred to another correctional facility. The plan should include a process for rapidly making the decision to decarcerate (delayed decarceration is ineffective with a rapidly spreading pathogen). That process should include an assessment of the risk associated with an introduction of a pathogen into that specific facility and the harm associated with the specific pathogen for both incarcerated people and staff.

Further, prior discussion should include what level of expected morbidity and mortality would be high enough to trigger emergency decarceration.

When a respiratory pandemic occurs, we know from experience that carceral settings are at extremely high risk of rapid spread. Leadership should take immediate steps to reduce the probability of introduction of the pathogen into prisons and jails and to reduce the probability of spread within institutions – both within and among housing units. This requires planning and implementing three levels of safety: (1) not exceeding safe occupancy under normal

circumstances in the absence of a pandemic (which also reduces the risk of transmission of endemic infectious diseases); (2) emergency reduction of occupancy of high-risk housing units when faced with an epidemic in the community to further reduce risk of transmission should the pathogen be introduced into the institution; and (3) further emergency reduction of occupancy when an outbreak occurs within an institution (converting affected housing units into safe quarantine and further reducing risk in unaffected housing units). It is difficult to determine in advance what level of structural/housing risk is acceptable, because it depends upon both the transmissibility and lethality of the pathogen. Acceptable risk for SARS-CoV-2 would likely be completely inadequate for Middle East respiratory syndrome–related coronavirus, a different coronavirus with a case fatality rate of 32%.(8)

At a minimum, when faced with an epidemic in the community, CDCR prisons should meet the following standards related to crowding:

- Maintain the resident population below 100% of the architectural design capacity in each housing unit.
- Reduce the population in dorms or in housing units with open cells to a reasonable community standard. There is no clear definition for what such a standard should be, and it will depend on what the system deems to be an acceptable level of risk tolerance. We are not aware of any open dorm housing in the community that exceeds 10 persons per dorm that was permitted to remain open during the pandemic prior to the availability of vaccination. Few households exceed that number, and those that do don't have single shared sleeping quarters. The larger the size of individual dorms, the greater the risk. Thus, dorms of 10 are safer than dorms of 20, and those are safer than dorms of 40, all else being equal.
- Set aside enough vacant housing (temporary or permanent) to house all residents in the two most populated dorms/open-celled housing units plus half the population of the largest 2-person closed-celled housing unit into individual quarantine if any outbreak were to occur. This would enable a rapid response to isolate/quarantine all exposed persons at the start of an outbreak. If the outbreak spreads beyond two dorms and one celled housing unit, other emergency measures will be required to stop transmission.
- The larger the co-housed population, the more important it is to achieve early detection of an outbreak. Thus, increased testing frequency with ability to rapidly isolate/quarantine dorm residents can help to reduce the additional risk of sharing a living space with a large number of people.

In March 2020, CDCR prisons were at 130% architectural design capacity on average, ranging from 91% to 170%. While addressing overcrowding by decarceration during the ongoing

COVID-19 pandemic is a recommendation based on public health guidance, the implementation of this recommendation has been difficult and politically fraught. Between April 2020 and July 2021 CDCR accelerated the release of some incarcerated persons. This was primarily of people close to the end of their sentence, with a small number of medically vulnerable individuals.

Decarceration, a combination of early release with reentry support, furlough (temporary release), and alternative (e.g., home, hotel) confinement, can be considered in an intersectional community effort that is not only effective as a public health intervention, but an integral component of both public safety and community rebuilding.(9) Emergency decarceration measures—alongside appropriate emergency reentry planning—should be part of any prison evacuation plan for future pandemics.(10) There are many approaches to emergency evacuation of high-risk housing units or ones in which an outbreak has occurred, which have been described elsewhere.(5) We have discussed emergency decarceration here, but we recognize that it is difficult to isolate the discussion of emergency decarceration from the discussion of reversing the underlying epidemic of mass incarceration in the U.S. – a moral and public health crisis requiring deep societal reckoning and wholesale policy reform with an importance equivalent, if not surpassing, that of the ongoing COVID-19 pandemic. As part of those reforms, the U.S. must also grapple with the extremely long sentences given to young adults that result in sharp contrast to other nations which do not incarcerate elderly, disabled persons (who are at high risk for COVID-related complications) at anywhere close to the rate we do in the U.S.

Key finding: In a densely crowded prison setting, many of the non-pharmaceutical interventions to reduce COVID-19 transmission are impossible to fully implement (e.g., masks cannot always be worn when around others as people are sharing the same airspace 24 hours a day; cellmates cannot physically distance; even individuals in cells with solid walls and solid doors must come out of their cells for showers, meals, and other activities). The success of all COVID-19 mitigation measures described in this report is highly dependent upon reducing crowding in housing units in CDCR prisons.

Recommendation 7.2.1: In the absence of a pandemic, consistent public health guidance is needed regarding maximum residential room occupancy in buildings, particularly for congregate, high-density living environments that can be dangerous.

Recommendation 7.2.2: When a respiratory pandemic occurs, a pandemic preparedness plan should outline steps for emergency evacuation of high-risk prison housing units that cannot be made significantly safer in the event of an infectious disease outbreak.

Recommendation 7.2.3: Planning for pandemics involves implementing three levels of safety: (1) ensuring housing units do not exceed safe occupancy levels under normal circumstances in the absence of an epidemic; (2) emergency reduction of occupancy of high-risk housing units when faced with an epidemic in the community to further reduce risk of transmission within the institution; and (3) further emergency reduction of occupancy when an outbreak occurs within an institution (converting affected housing units into safe quarantine and further reducing risk in unaffected housing units). Early designation of quarantine and medical isolation space should be a part of pre-pandemic planning, and this must include identifying locations that can appropriately and safely house a sufficient proportion of the needs of the population, including people with disabilities. These planning efforts must also recognize that percent capacity across an entire institution can still mean that certain units are overcrowded.

7.3. Ventilation and Air Filtration

7.3.1 Introduction

As SARS-CoV-2 is transmitted from infectious individuals through droplets and aerosols, appropriate building ventilation and filtration systems are important in controlling the risks of indoor aerosol transmission.(1,2) It has become increasingly clear over the course of the pandemic that airborne transmission of SARS-CoV-2 is the principal mode of transmission.(3) Adding to the risk introduced by the building design itself, we observed high-risk activities, such as yelling between cells and exercising indoors. Such activities are known to increase the rate of viral emission from an infected individual and contribute to higher concentrations of viral particles in the shared air, and a higher risk of transmission within the space.(4,5) Prison "lockdowns" which entail keeping people for long durations indoors may actually increase transmission risk by allowing the accumulation of potentially infectious aerosols in housing units and by moving high-risk activities indoors. Despite the widespread scientific evidence that the virus is primarily transmitted through the airborne route, the lack of broad acknowledgement of this reality early in the pandemic by authoritative sources such as the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO), made it harder to prioritize and justify measures that addressed aerosol transmission. As late as June 2020, the CDC and WHO were still arguing that transmission could largely be prevented by separating prison residents by six or more feet and disinfecting common areas, such as showers and telephones.(6)

The lack of sufficient appreciation of the role of aerosols in SARS-CoV-2 transmission also reduced the perceived urgency of implementing well-known controls for preventing rapid spread of a respiratory pathogen in an indoor congregate space.(7) The lack of existing plans delayed implementation. These controls include minimizing the number of occupants who share the same indoor airspace, increasing air exchange rates (naturally by opening windows and doors and mechanically through HVAC systems), avoiding air recirculation, ensuring adequate filtration, and implementing air disinfection in areas where ventilation is difficult to improve.(8-12) Further controls implemented in congregate settings include improving masking compliance, limiting high-emission activities to the outdoors, maximizing time spent outdoors, ventilating during reduced occupancy times, and utilizing single zone air filters to remove virus from the air in congregate areas.(13-17) However, despite the mitigation recommendations described above, housing high numbers of individuals in high density buildings creates scenarios where slowing the spread of a highly-transmissible respiratory pathogen *enough* to prevent large outbreaks is nearly impossible without other protective measures in place (such as vaccination and early case detection measures).

This part of the report focuses on airflow and ventilation within indoor spaces, factors known to be key to preventing the transmission of aerosols containing SARS-CoV-2. Furthermore, understanding ventilation conditions across the different CDCR facilities will be fundamental to curtailing the transmission of other respiratory pathogens in the future. In this chapter, we describe our findings regarding the environmental conditions in CDCR prisons. Our aim is to document current conditions and suggest interventions to reduce transmission in CDCR and other correctional settings.

7.3.2 Methods

Study Context: For the environmental assessment, our team visited 6 institutions of the 10 total institutions visited by CalPROTECT within CDCR: Central California Women's Facility (CCWF), California Institution for Men (CIM), California Institution for Women (CIW), California Medical Facility (CMF), San Quentin (SQ), and the California Substance Abuse Treatment Facility and State Prison (SATF) The institutions participating in this evaluation were all large institutions at high risk for transmission in housing facilities **(Table 7.3.1**). The measurements taken during site visits are described below.

Table 7.3.1. Population and Architectural Design Capacity of CDCR Institutions Visited for This Study

Institution	Population	% Capacity (March 2020)
CCWF	2,640	131.7%
CIM	3,357	112.8%
CIW	1,553	111.1%
CMF	2,396	101.5%
SQ	3,776	122.5%
SATF	4,844	141.5%

Note: Percent capacity is the population in relation to architectural design capacity and does not refer to the appropriate capacity during a pandemic.

CO2 Concentration Measurements: Baseline CO2 concentrations were measured in the cells of six institutions across CDCR. Baseline measurements were taken in cells, dorms, and common spaces using a TSI9535 Velocicalc (Velocicalc) (TSI, Shoreview, MN).

Estimation of Air Exchange Rate in Cells: In unoccupied cells, we estimated air changes per hour (ACH) using a CO2 tracer gas concentration decay technique.(18) This technique was used in cells that were occupant free. A fire extinguisher containing compressed CO2 was used to release gas into the cell and the Velocicalc monitor was used to measure the concentration decay over a period of 10-30 minutes.

Estimation of Air Exchange Rate in Dorms: In occupied dorms, we estimated ACH using exhaled CO2 concentrations as a natural tracer gas. We measured steady-state CO2 concentrations within dorms by placing four Aranet4 (SAF Tehnika, Riga, Latvia) monitors in different locations of an occupied dorm room for 3.5 hours during a normal day. The Aranet4 monitors recorded the CO2 concentrations at one-minute intervals. To calculate the ventilation rate, we logged CO2 concentration values of all the monitors and used the following equation to derive ACH:

$$ACH = \frac{N \cdot ER}{V(C_{in,ss} - C_{out})}$$

Where ACH is the air changes per hour, N is the number of occupants, ER is the CO2 emission rate in cubic feet per hour, *V* is the volume of the room in cubic feet, $C_{in,ss}$ is the steady state CO_2 Concentration measured using the monitors indoors and C_{out} is the outdoor CO_2 concentration.

Air Leakage from Cells: To measure the leakage of air from cells, individual cells were spiked with CO_2 and the accumulation of the CO_2 in nearby cells was measured. Three Aranet monitors were used to simultaneously measure the release and decay of CO_2 from the cell in which it was being released as well as the accumulation of CO_2 one and two cells away.

Static Pressure from Cells and Closed Dorms: We assessed cells and closed dorms (dorm rooms with a range of four to ten beds) for pressure relative to the hallway or dayroom by measuring the pressure differential inside and outside of the room using a pitot tube attachment with for the Velocicalc. The Static Pressure probe was connected to the + port on the Velocicalc using tubing and the side of the tubing with the probe was placed into the room by sliding it under the gap at the bottom of the door.

Vent Functionality: We conducted qualitative tests for airflow from supply and exhaust vents using a vane anemometer. Because many flows were close to the limit of detection on both ends, we chose to use this test as a qualitative test of flow versus no flow.

Observation of heating, cooling, and recirculation: We were unable to ascertain the dates during which heating and cooling was turned on. However, informal conversations with staff

and residents enabled us to understand approximately when the heating was turned on and the percentage of recirculation that was entailed during the heating period.

Use of hospital air exchange standards: One of the biggest challenges to evaluating air quality in prisons is the lack of guidance, and the lack of standards, specific to prisons in pandemic settings. Current ventilation standards for most indoor spaces are established by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). These standards have been designed with the goal of diluting body odors, rather than infection control. Thus, in this report, we use ventilation standards from hospital settings with the view that a prison during a pandemic is effectively a hospital. We acknowledge that the original design of prison ventilation systems was not specifically for infection control (as hospitals are), but in a pandemic setting we stress the need to implement higher standards to prevent and control transmission. The primary objective of a ventilation system in a hospital or a prison during a respiratory pandemic is to prevent the spread of disease. Both the WHO (World Health Organization) and ASHRAE recommend a **minimum** of 12 ACH and negative pressure for isolation rooms and in rooms where aerosol generating procedures (AGPs) are performed.(19,20) The 12 ACH standard, along with negative pressure (meaning airflow from spaces outside of the isolation zone inward toward spaces within the isolation zone) has also been adopted for COVID-19 isolation spaces in long-term care facilities such as nursing facilities. As such, we use the minimum 12 ACH target (along with negative pressure) for individual quarantine spaces as these are spaces where individuals in a prison are more likely to test positive prior to being moved to buildings that are separate from the rest of the population. For higher-risk housing units and congregate areas such as open dorms and dayrooms, a **minimum** of 15-20 ACH will help prevent transmission and is derived from standards that are applied to highest risk hospital settings.(21) A minimum of 6 ACH for general hospital wards should be met in office and administrative areas of the prison facility during a pandemic. Air exchanges (or equivalent removal of aerosols) may be achieved through natural ventilation, mechanical ventilation, additional air cleaners, and technologies such as germicidal ultraviolet-C (UVC) lamps which can disinfect air and/or provide air changes in a space (see **Supplement S7.3.2 for details on GUV)**. In addition to the air exchange requirements, the ASHRAE and WHO standards both dictate the need to ensure airflow directionality is from clean to less clean areas. Of note, extrapolating from hospitals to prisons using ACH implicitly assumes that the density of occupancy is similar between hospitals and prisons. In some portions of prisons that may be a reasonable assumption – but in others the density is much higher in CDCR prisons (E-type dorms, to cite one example) and ACH levels will need to be adjusted upwards to account for the increased density of occupancy.

7.3.3 Results

Baseline CO2 Measurements

Across the six facilities, CIW exhibited the highest mean and median CO2 concentrations (Table 7.3.2). Higher CO2 concentrations may indicate occupancies of higher density and/or less ventilation.

Table 7.3.2. CO2 Measured in various dorms, cells, and dayrooms across the six facilities

	Mean	Median	Range
CCWF	518+/-46.45	517	448-592
CIM	676+/-235	624	503-1274
CIW	821+/-286	828	325-1258
CMF	533+/-116	548	356-782
SATF	711+/-190	633	503-1120
SQ	512+/-121	502	309-805

Air Exchange Estimated in Housing Units by Institution

The median air exchange rates (Table 7.3.3) measured in air exchanges per hour (ACH) was higher in cells than dorms at CMF and SATF. At CCWF, the median ACH in the dorms was higher than that measured in cells (Table 2). All of the cells sampled at CCWF and half of the cells sampled at SATF were cells of the 270 building type (the other half of SATF cells were the 180 building type). No generalizations can be made about the behavior of ventilation systems in the 270 buildings as variation in air exchange measured in 270 cells was seen within and between institutions.

The median ACH estimated for cells fell below the recommended 12 ACH (the WHO and ASHRAE ventilation rate minimum requirement for areas with a high risk of COVID-19 transmission), including isolation and quarantine areas. The median air exchange rates estimated for dorms at CMF and SATF were exceptionally low, below the minimum 15-20 ACH that we recommend for congregate areas and below the 6 ACH standard used by WHO/ASHRAE for infection control in general hospital wards.

Table 7.3.3. Estimated ACH (Air Changes per Hour) in cells versus dorms

	ACH Cells			ACH Dorms		
	Mean	*Median*	*Range*	*Mean*	*Median*	*Range*
CCWF	6.1+/-2.2	5.1	4.6-9.3	8.4+/-2.2	8.7	5.2-11
CIM	13 +/-8.2	10.7	7.0-32	N/A	N/A	N/A
CIW	6.8+/-1.9	6.8	3.7-10.8	N/A	N/A	N/A
CMF	10+/- 11	8.7	2.2-55.7	3.4+/-1.8	3.8	1.5-5
SATF	7.8+/-5.5	6.2	1.3-16.6	4.1+/-4.3	2.9	1.1-15
SQ	15+/-7.3	10.8	2.3-32.6	N/A	N/A	N/A

Key finding: Air changes per hour (ACH) measurements were below the recommended minimum of 12 ACH for isolation/quarantine areas, below the 15-20 ACH minimum for congregate dorm areas, and three settings had measured ACH below the minimum 6 ACH standard for general hospital wards.

Summer versus winter ventilation in housing units

SATF and San Quentin were visited in both Winter and Summer. In both facilities the mean measured CO2 concentrations were higher in the winter compared to the summer **(Table 7.3.4)**. The estimated ACH was lower in the winter than in the summer, indicating less air exchange during the winter days sampled. The higher CO2 concentrations and lower air exchange rates in the winter are indicative of less ventilation and the accumulation of more CO2 in a given space. For SATF, this is likely due to the use of recirculation systems that only bring in minimal fresh air while recirculating the heated conditioned air through the space to save energy. During normal (non-pandemic) operations in winter and summer, the ventilation system was designed to be energy efficient consistent with statewide priorities. In the summertime, SATF relies on swamp cooling which utilizes 100% outside air, avoiding the issue of recirculating conditioned air.

San Quentin has a number of closed dorm buildings (such as Badger Unit in South Block, North Block, East Block, West Block) that contain individual cells that are separated from each other and a common atrium through metal grate doors and therefore contain a common airspace for the whole building. When these buildings are heated, outdoor air is brought into the buildings through air handling units and heated by hydronic coils located in each ground floor window

and turned on in the winter. A non-ducted and continuously run air circulator distributes the incoming heat throughout the building's tiers. The lower air exchange rates in the wintertime in these buildings are likely due to more doors and windows being closed to retain the heated air (as observed during our visits), as well as higher occupancy in some of the sampled buildings, such as Badger Unit in South Block, that were used for quarantine. San Quentin has no cooling system.

Table 7.3.4. Winter and Summer Ventilation Differences at SATF and SQ

	Winter		**Summer**	
	CO2	*ACH*	*CO2*	*ACH*
SATF	768+/-236	4.3+/-3.3	566+/-56	7.59+/-6.21
SQ	608+/-92	10.5+/-10.3	491+/-18	14+/-6

Key finding: ACH readings at SATF and SQ found low air exchange during winter months compared to summer months, indicating a higher risk of COVID-19 transmission, likely due to closing windows and doors and the use of recirculated air in HVAC systems.

Air leakage from cells with different exhaust functionality and door characteristics

Air leakage was measured at San Quentin in cells from open tier buildings with metal grate doors as well as in cells from buildings with separated floors and solid doors (**Figure 7.3.1**). In the buildings with open tiers, all occupants of the building share the same air space as there is free diffusion of air between the individual cells as well as the common atrium.

Figure 7.3.1. San Quentin's North Block and Adjustment Center which are examples of an open tier building with metal grate doors (versus a building with individually separated floors and solid doors)

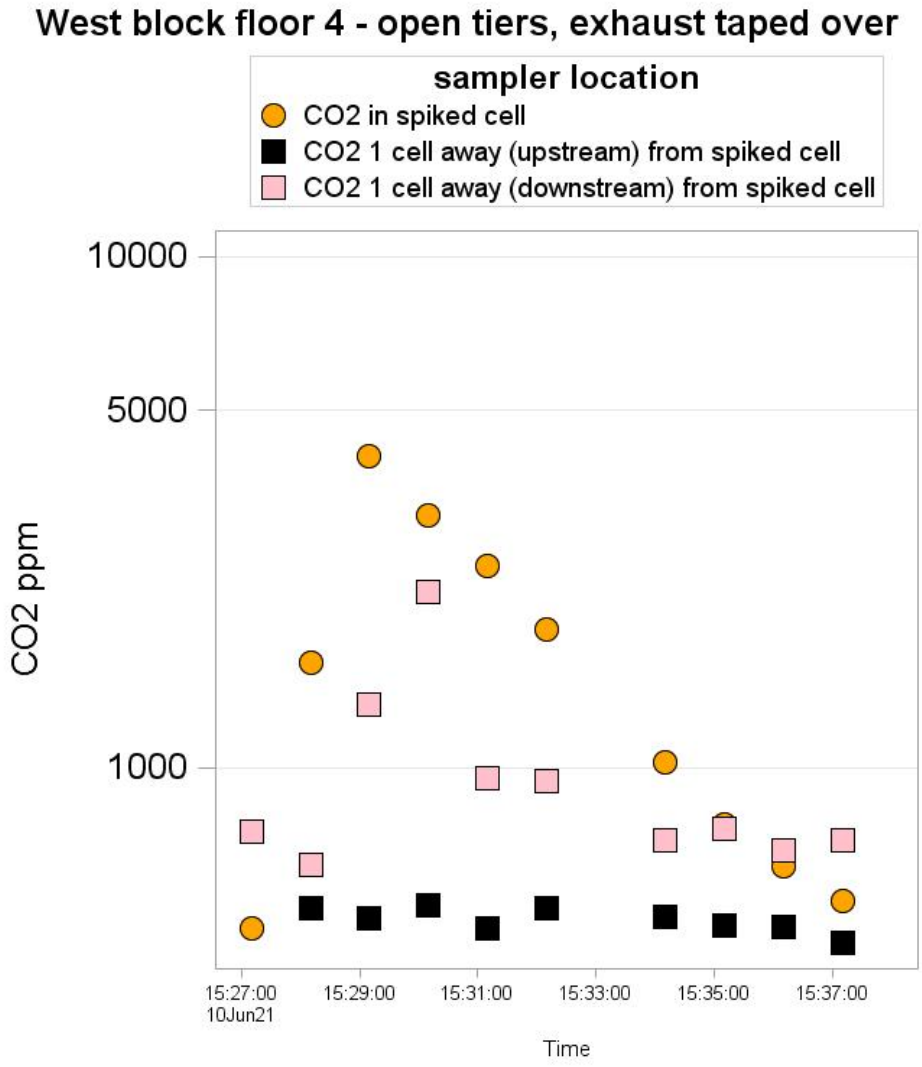
(a) San Quentin's North Block, a building with open tiers and metal grate cell doors

(b) San Quentin's Adjustment Center, a building in which the different floors are separate air spaces and cells have solid doors

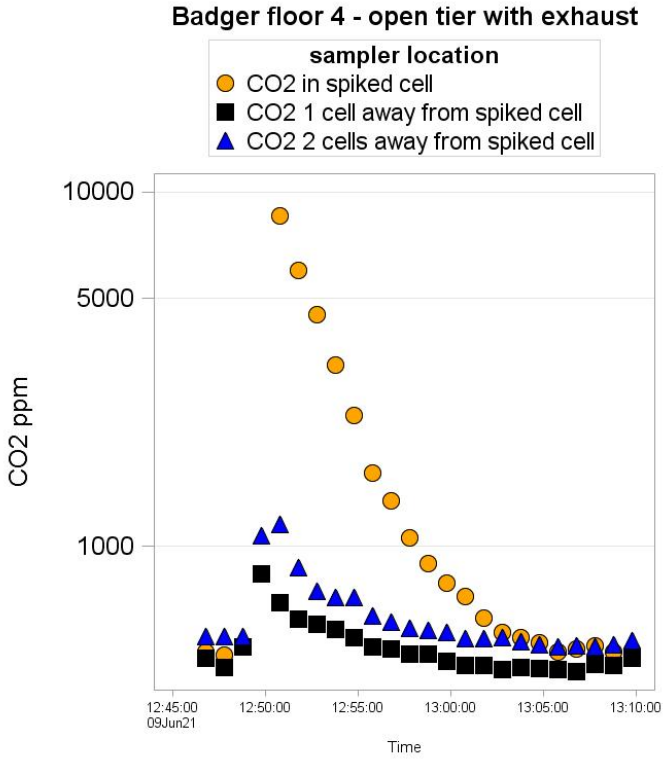
Differences in the leakage of air from cells that were spiked with CO2 were seen in cells that had functioning exhausts versus non-functioning exhausts in the open tier buildings that were measured. In West block, supply vents appear to have been sealed over by facilities. Many residents of West block also blocked their exhaust vents using tape. Following the CO2 release there was an almost immediate spike in the CO2 concentration one cell downstream from the cell in which the plume was released. This is representative of what would happen to aerosols emitted by an infector in the same space—the infectious viral particles would travel from the room and be rapidly dispersed to the airspace outside of the infected person's cell (**Figure 7.3.2a**). In contrast, in the same type of cell with a working exhaust fan in Badger building, the maximum concentration that accumulates one cell downstream from the spiked cell is lower (850 parts per million (PPM), **Figure 7.3.2b**) than the maximum concentration that accumulates in one cell downstream from the cell spiked with a non-functioning exhaust fan (2600 PPM, **Figure 7.3.2a**). While the movement and accumulation of CO2 from the spiked cell to a neighboring cell was significantly higher in the cells adjacent to the spiked cell with no functioning exhaust fan, the relatively high baseline CO2 levels (511 PPM on average) in the cells in both scenarios—working and non-working exhaust fans—suggests the inevitable potential for some air exchange between adjacent cells with open grate doors. When the exhaust fan is functional, this air exchange between two adjacent cells is lessened.

Comparing open tier cells with metal grate doors to cells with solid doors reveals the ability of the solid doors to block the leakage and accumulation of released CO2 in the adjacent cells (**Figure 7.3.2.c**). This finding points to the need to house patients with unknown infection status in cells with solid doors to prevent transmission to neighbors.

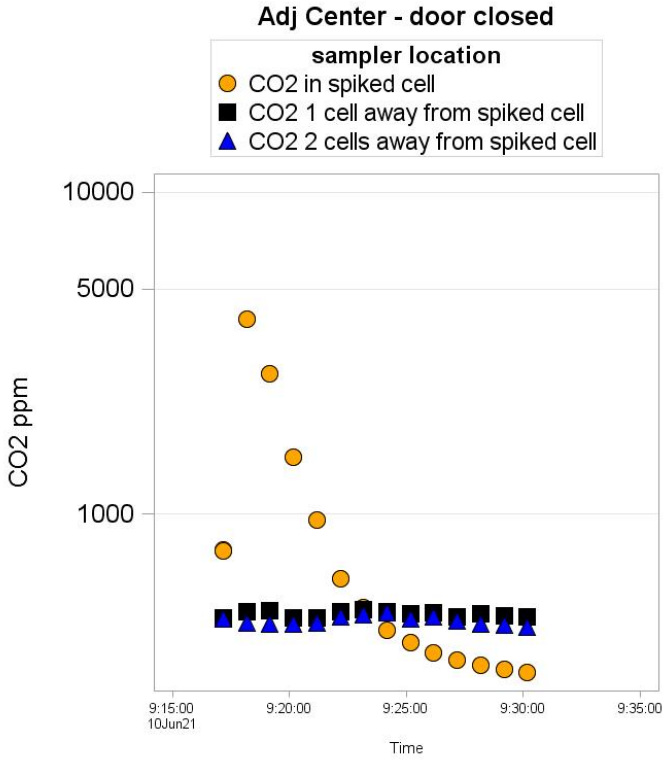
Figure 7.3.2. Air leakage from cells with different exhaust functions and door types.
(a) Cell spiked with a malfunctioning exhaust and metal grate door type



(b) Cell with working exhaust and metal grate door



(c) Cell with solid door



Static Pressure in Cells

The static pressure measured in cells and closed dorms is shown below (Table 7.3.5). The vast majority of pressure readings from all rooms measured was positive, indicating a tendency of air to move from individual cells or dorm rooms to common spaces where it is returned or exhausted from the system from a central air handler in the common area. At CMF, five of the 22 rooms sampled had a negative pressure. As the air systems at CMF were designed for positive pressure from the rooms, the rooms that were measured with negative pressure suggest system malfunction potentially due to blockages in the ducting, malfunctioning exhausts, and other system failures that may create inadvertent pressure flows between spaces.

Table 7.3.5. Static Pressure measured in Cells and Dorms across five institutions

	Mean	SD	Median	Range	Number of Samples	Negative Pressure Samples
CCWF	5.62E-02	6.80E-02	1.45E-02	3.00E-03-1.78E-01	9	0
CIM	5.57E-03	5.35E-04	6.00E-03	5.00E-03-6.00E-03	7	0
CIW	5.67E-03	1.37E-03	6.00E-03	4.00E-03-7.00E-03	6	0
CMF	4.23E-03	8.87E-03	2.00E-03	-1.00E-02- 2.70E-02	22	5
SQ	2.57E-03	3.36E-03	2.00E-03	0.00E+00- 1.0 x 10^{-2}	7	0

Note: SD is standard deviation.

Functionality of supply and exhaust vents in cells and dorms

The presence of inoperable exhaust vents within the living facilities is a common occurrence with 3%-67% of the rooms sampled within each facility exhibiting a nonfunctioning exhaust vent (Table 7.3.6). Malfunctioning supply vents were less common. The combination of variable static pressure reads from individual cells of the same building and malfunctioning supply and exhaust vents suggest imbalance in the airflow and ventilation system in various buildings. Unbalanced airflow can also lead to inadvertent pressure systems that move air from infected areas to uninfected clean areas as demonstrated in Figure 7.3.3.

Table 7.3.6. Performance of supply and exhaust vents in select cells and dorms

Institution	Type of room	Rooms sampled	Rooms with at least one inoperable supply	Rooms with at least one inoperable exhaust
CCWF	dorm	4	0	0
	cell	4	0	1
CIW	cell	10	0	3
CIM	cell	9	0	1
SQ	cell	33	0	1
SATF	dorm	3	0	0
	cell	3	0	2
CMF	cell	24	1	2

Note: Inoperable vents include those that were measured to have zero flow and do not count the vents that were functionally inoperable due to intentional blockages.

Observation of heating, cooling, and recirculation

Most buildings within the facilities we visited, except for an air-conditioned building at CIW and one at CMF, relied on swamp cooling. San Quentin did not have any cooling capacity. Swamp cooling relies on passing outdoor air over water-saturated pads and therefore does not necessitate recirculation of conditioned air within the system.

With the exception of some buildings at San Quentin, most buildings visited relied on a forced air HVAC heating systems that distribute heated air to building areas from a central heat exchanger via ductwork and vents. These heating systems are commonly set to recirculate a percentage of the same air through the area, which controls temperature but does little to improve air quality. This is especially true if the proper filters are not used. Prior to the release of systemwide directives aimed at reducing transmission, facilities such as SATF, CMF, and CIW reported using ~10% outside air, and 90% recirculated air in heated buildings. An example of how recirculation can lead to rapid transmission in dorms is illustrated (Figure 7.3.4). In contrast to the forced air HVAC systems at most CDCR prisons, the housing we visited at San Quentin, apart from the Adjustment Center, lacked a ducted system. Instead, air handling units on the ground floor of both sides of the housing units bring in fresh air to the building and in the wintertime this air is passed through a hydronic coil within each window unit. A circulating fan on the top tier of the units circulates air within the building, but there is no hot or cold coil within these units to temper the air.

Figure 7.3.3. Example of transmission scenarios resulting from malfunctioning supply and exhaust vents in cells.

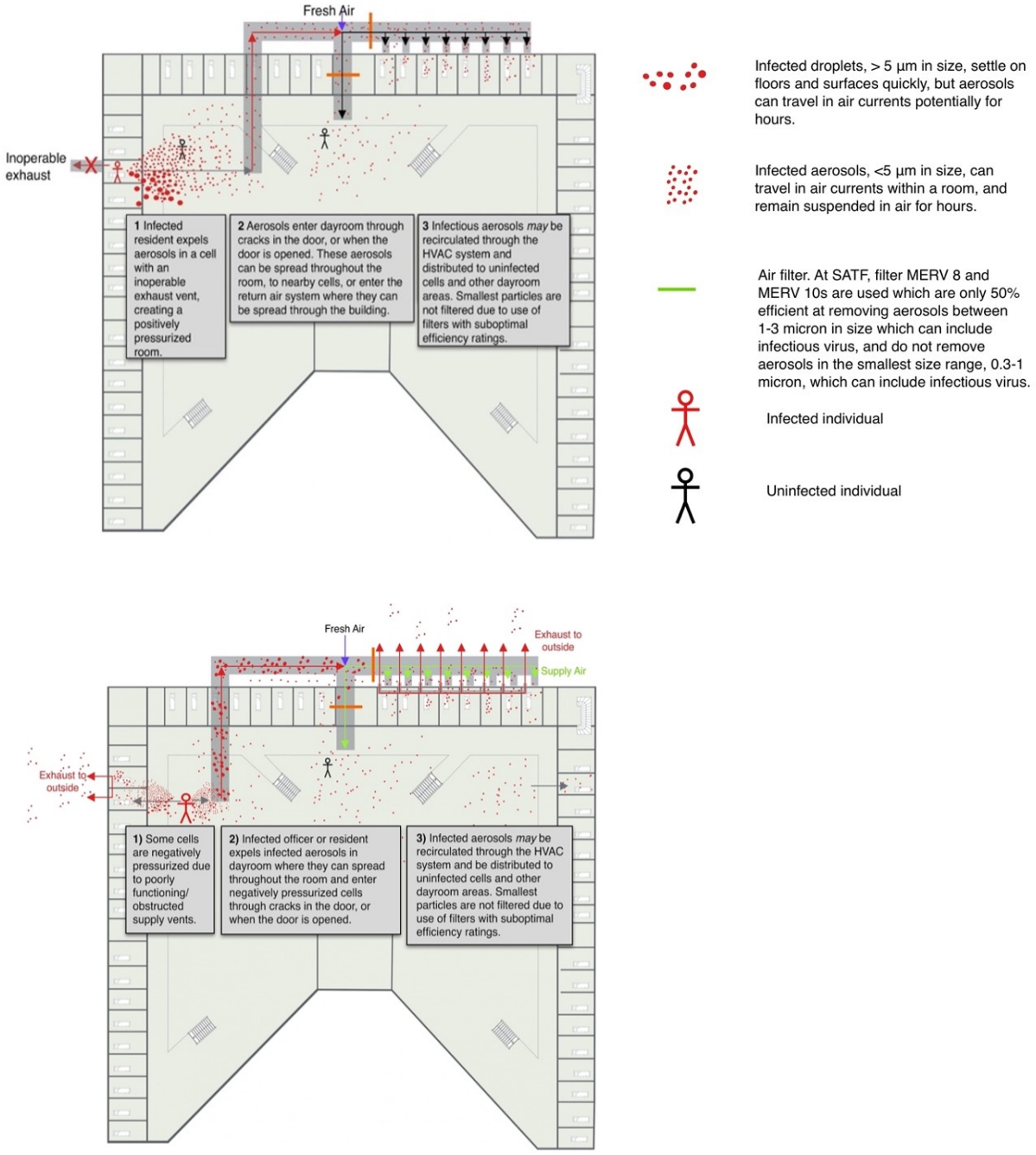
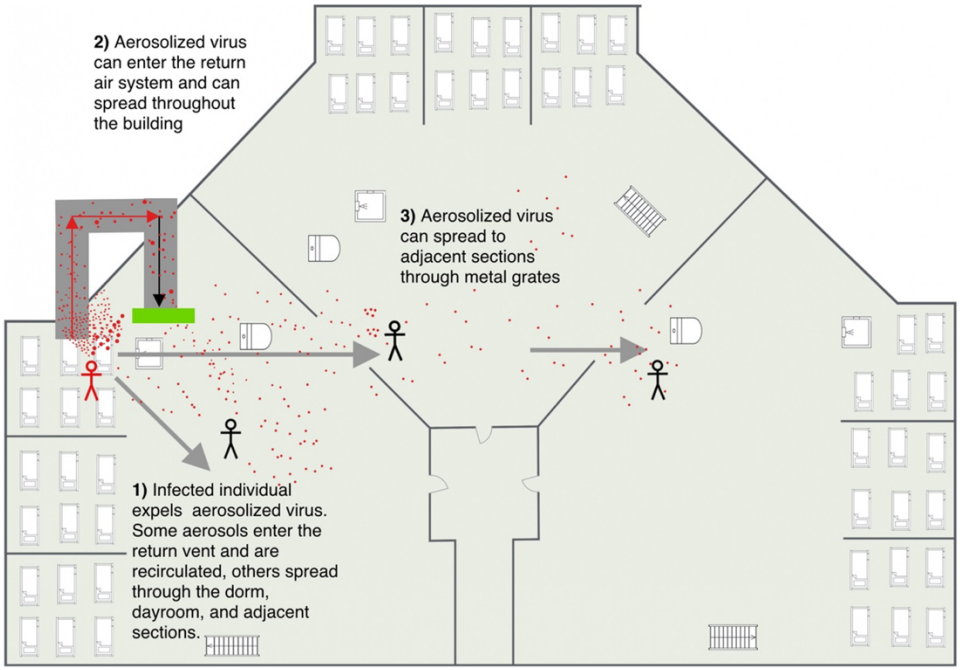


Figure 7.3.4. Example of transmission scenario resulting from recirculation in SATF Yard A dorms



Key finding: When visited, many of the institutions had heating and cooling systems with malfunctioning exhaust and supply vents, filters that were ineffective in removing virus laden aerosols, settings that maximized heating efficiency by greatly increasing the use of recirculated air, and static pressure that, by design, created positive pressure inside cells. All of these findings have the potential to heighten the risk of COVID-19 transmission.

Other Observations

Yard time during lockdown periods: During the site visits, it came to our attention that yard time was decreased for residents in almost every facility visited. At CMF and SATF, exercise indoors in congregate areas was observed which can increase transmission risk for all occupants in the same space. Physical exertion, talking loudly, and shouting or singing increase transmission risk as these activities increase the rate of respiration and/or the production of aerosols.(22,23)

L*ack of engineering/facilities-based decision making*: In our conversations with facilities staff and medical personnel, we learned that most of the decisions about quarantine spaces and movement were made by medical staff with minimal or no training or knowledge of ventilation

or other potential building vulnerabilities. Facilities personnel, those with knowledge on the ventilation and HVAC system performance in various parts of a facility, were typically not involved in making decisions about which spaces should be set aside for isolation and quarantine.

Key finding: Engineering and facilities staff have not frequently been involved in decisions around quarantine space and resident movement that has aimed to mitigate the risk of COVID-19 transmission.

7.3.4 Recommendations

Recommendation 7.3.1: Reduce occupancy, especially in open dorms and other high-density housing units with shared airspaces.

The more people who use or occupy an area, the more people who will be exposed if an infection enters the group and thus the greater the risk of aerosol transmission. The risk increases if an area is poorly ventilated. High-occupancy buildings, especially those with low air exchange, should be prioritized for occupancy reduction (e.g., the dorms at CMF and SATF where we observed very low ACH).

Recommendation 7.3.2: Increase air exchange rates by opening windows to the outdoors, using supplemental air cleaners, and setting HVAC controls to minimize recirculation.

In addition to reducing the occupancy of high occupancy areas, increasing the air exchange rate can help reduce transmission in housing units. Increasing air exchange rates can be accomplished in a number of different ways outlined below.

- If windows exist to the outdoors, opening them can increase the air exchange in room or building. We strongly suggest reopening the windows at San Quentin.
- Use of supplemental air cleaners can add substantial air changes to a space and is especially useful in congregate areas. Specific options for supplemental air cleaners are listed in the appendix. If ventilation is not enough, portable HEPA filters and high-volume filtration units can add additional air changes to a space. The CADR (clean air delivery rate)

specification on portable filtration units is valuable because it can be used to estimate the ACH being delivered to the room. The estimated ACHe is calculated as [CADR in ft^3/min × 60 min] divided by the room volume in ft^3. A device with a CADR of 300 in a 500-square-foot room with 8-foot ceilings will therefore deliver 4.5 ACH.(24) A general rule of thumb is to look for a CADR of at least 300 for every 500 square feet of floor area. Of all ventilation interventions possible, supplemental air cleaners can be most readily implemented and should be considered for immediate implementation, even if further ventilation system improvements are planned further in the future. A portable air cleaner purification calculator is available to simplify decision making around portable air cleaners in offices, schools, or residential buildings (**Supplemental Text S7.3.1**).

- HVAC controls set for energy conservation must be revisited in a pandemic. Recirculation during winter should be avoided when possible. If recirculation is necessary, MERV 13 filters should be installed to filter return air prior to its reentry into a given space. It is important not only to ensure that the correct filters are used but also that the filter racks are properly adjusted and sealed to prevent air from bypassing the filters. This is important because the MERV 13 filters create more airflow resistance than MERV 8 or 10 filters, increasing bypass airflow which will decrease filtration efficiency.

Recommendation 7.3.3: Ensure the proper functionality of the existing ventilation system by hiring a test and balance engineer.

As described in the results section, there are several indications of imbalance in the ventilation system including variable static pressure reads from individual rooms of the same building and malfunctioning supply and exhaust vents in individual housing units. Imbalance can lead to inadvertent pressure and temperature differences between spaces and inadvertently move virus laden air to spaces containing uninfected individuals. When systems are imbalanced, it is difficult to know the directionality of flow in most spaces and thus the impact of an intervention. When a system is balanced, the directionality is known and appropriate interventions can be designed.

As contractors are brought in, it is our recommendation to highlight the maximization of clean air exchange as a general principal that applies throughout, especially for housing units used as quarantine and units at high-risk for rapid transmission (high occupancy units and/or those environments with low existing clean air exchange/high CO2 levels).

The following should be prioritized (starting with quarantine buildings):

a. Eliminate recirculation within common spaces at a building level even if it requires bringing in supplemental heating units.
b. Increase air exchange for day room/common spaces if possible (open windows, open doors, place fans in windows, etc.)
c. Ensure functioning exhaust fans from cells to the outdoors (or decommission those cells without).
d. Clean all vents
e. Assess whether it is possible to switch the current airflow configuration to render negative pressure rooms in buildings used for quarantine and/or whether additional rooms (that are not currently being used as quarantine) could be made to have more optimal negative air pressure and could therefore be designated for this purpose instead of those that are currently in use. This assessment should result in institution-specific plans for how to convert any potential quarantine units into a negative-pressure units (or at least less positive) in the event of an outbreak.
f. Add supplemental air cleaners or GUV (Germicidal Ultraviolet) lamps to common areas (We have included a detailed discussion on GUV in **Supplemental Text S7.3.2**).

Recommendation 7.3.4: Monitor ventilation with CO_2 monitors.

CO_2 monitors should be used to identify areas that need ventilation improvements. Since people exhale CO_2, if there is a build-up of CO_2 in an area it can indicate that ventilation needs improving. It is important to recognize where there might be other sources of CO2, with the most common being the presence of combustion (e.g., in a kitchen, bakery or laundry with gas-fired appliances). However, CO_2 monitors not useful in all situations, for example in very large spaces or rooms with few occupants. Accurate and reliable portable CO_2 monitors utilize the non-dispersive infrared (NDIR) sensor technology. Aranet4 is an example of a low-cost NDIR-based monitor and was used by the CALPROTECT team during site visits.

To get more accurate measures in large spaces, multiple monitors in multiple sampling locations is required. For example, in the CMF dorm, we utilized 4 monitors placed in the breathing zone of different corners of the room. Several measurements should also be taken throughout the day to represent changes in the use of the room. For example, if people are exercising or shouting in the room, the CO_2 concentrations can rise, reflecting higher rates of exhalation as well as higher risk for viral transmission.

The CO_2 in a room is measured in parts per million (PPM). To interpret the measured concentration values logged from a room, the volume and occupancy of a room is necessary to consider. A spreadsheet tool (see Appendix), which was developed for schools, can be helpful as one can set the desired ACH rates (a minimum of 6 ACH for administrative areas; 12 ACH for isolation rooms in quarantine buildings, and 15-20 ACH for open dorms and common areas) and estimate target CO_2 levels based on the room dimensions and the occupancy. If measured CO_2 is higher than the target (based on calculation output), the recommendations above can be used to increase air exchange rates.

Recommendation 7.3.5: Increase yard time to allow high respiration activities to stay outdoors.

Yard time was either decreased or completely eliminated for residents in all of the facilities we visited with the rationale that complete physical distancing would curb transmission. However, restricting yard time is counterproductive to curbing transmission and reducing the concentration of viral particles indoors. This is true for two reasons. For one, the more time residents spend indoors, the more virus accumulates in the indoor space without a chance to be cleared by the ventilation system. One of the primary strategies being used by congregate facilities across the country is to continue ventilating buildings while occupants are away from them.(25) Secondly, if residents are restricted from going outside, high respiration activities such as shouting and exercising will inevitably happen more frequently indoors. Performing high respiration activities indoors can further the accumulation of viral aerosols and lead to higher transmission risk.

Recommendation 7.3.6: Educate and empower facilities staff and involve them in decision making about use of facilities for quarantine and isolation.

Given that the facilities staff have knowledge of the ventilation systems within the different institutions, it is imperative to give them a seat at the pandemic response decision making table. Many decisions were made to house residents and transfers of unknown infection status in buildings with faulty ventilation systems (e.g., SATF quarantine units had cells with malfunctioning exhausts) or in buildings with no effective separation of airspace (San Quentin's Badger block). Such decisions may have been avoided by engaging with members of facilities/engineering teams that had knowledge of the state of the ventilation system in those

buildings. Furthermore, facilities staff should be empowered to learn about the importance of ventilation, filtration, and other building elements for resident health. Continual learning programs can ensure that facilities staff have up-to-date knowledge and expertise that they can bring to their institutions. Continuing education programs are available through multiple vendors. The Labor and Occupational Health Program at UC Berkeley can help direct interested institutions to appropriate vendors.

7.4. Testing: Rapid Antigen vs PCR Testing

This section focuses on how to draw on evidence to design a testing system to control an incipient outbreak in a prison setting.

7.4.1 Introduction and Background

Symptom-based isolation is an insufficient measure to control transmission of the SARS-CoV-2 virus. One study found that 59% of COVID-19 transmissions may come from individuals who are asymptomatic at the time and recent CDCR evidence suggests symptomatic case detection may miss as many as 80% of cases, owing to the number of individuals with no or mild symptoms as well as those who may conceal symptoms (1). Additionally, even among symptomatic individuals, the virus tends to reach peak viral load (the highest level of infectiousness) at the time of symptom onset, meaning even if it does lead to the detection of a case, intervening based on symptoms will occur only after an individual has become infectious. (2-5)

Previous modeling efforts in nursing homes and dormitories have shown that in congregate settings, where quarantining all potentially exposed residents is often impractical in the face of substantial space constraints, a robust response testing system is vital in effectively containing outbreaks.(4,6) A response testing protocol is undertaken in a housing unit when an infection is detected in the housing unit or when suspected exposure has occurred. Three key parameters exist in evaluating the quality of a response testing program: (i) time-varying test accuracy (sensitivity and specificity of the test over the course of an infection), (ii) testing frequency, and (iii) testing turnaround time (the time between sample collection and the receipt of results).

While polymerase chain reaction (PCR) tests (which constitute over 85% of tests administered in the California Department of Corrections and Rehabilitation (CDCR) system) provide the highest level of accuracy over time and the shortest delay from initial exposure until infection is reliably detected, they typically face substantially longer turnaround times compared to rapid antigen testing due to the need to process tests offsite and the inability of commercial laboratories to consistently return results quickly. Recent work suggests that the slight advantage in accuracy over time held by PCR tests is more than offset by the same-day turnaround offered by antigen testing for the timely detection and isolation of infectious individuals.(6,7) Antigen tests are generally less expensive per unit than PCR tests (including both kit costs and staff costs), but tests run at point of care are more demanding of prison staff time at the same time as those staff are facing other demands related to responding to a new

outbreak. The increased initial staff burden of immediate point of care testing, however, should be more than offset by the staff burden avoided by averting additional infections.

The importance of testing turnaround time becomes clear when one examines the experience with COVID-19 testing during the outbreak at San Quentin State Prison (see **Figure 7.4.1**). At the peak of the outbreak, the average turnaround time for PCR tests reached 7.5 days, as shown in **Figure 7.4.2**. This means that even with daily testing, residents given a PCR test on their first day of detectable infection may still transmit the virus for 7.5 days on average before receiving their test results. If, instead, the facility could have relied on widespread antigen testing, test administration and receipt of results could occur on the same day. Ultimately, this would have provided the staff with immediately actionable information to allow for preemptive isolation of infectious patients and quarantine of exposed individuals. Such an approach—particularly if combined with frequent testing and re-testing—might have decreased the severity of the outbreak if sufficient and appropriate space were available (which was not the case in June at San Quentin once the outbreak had grown beyond the original housing unit).

Figure 7.4.1. San Quentin daily cases by room type show how quickly COVID-19 spread in 2-person cells configured in open dormitory style cell blocks.

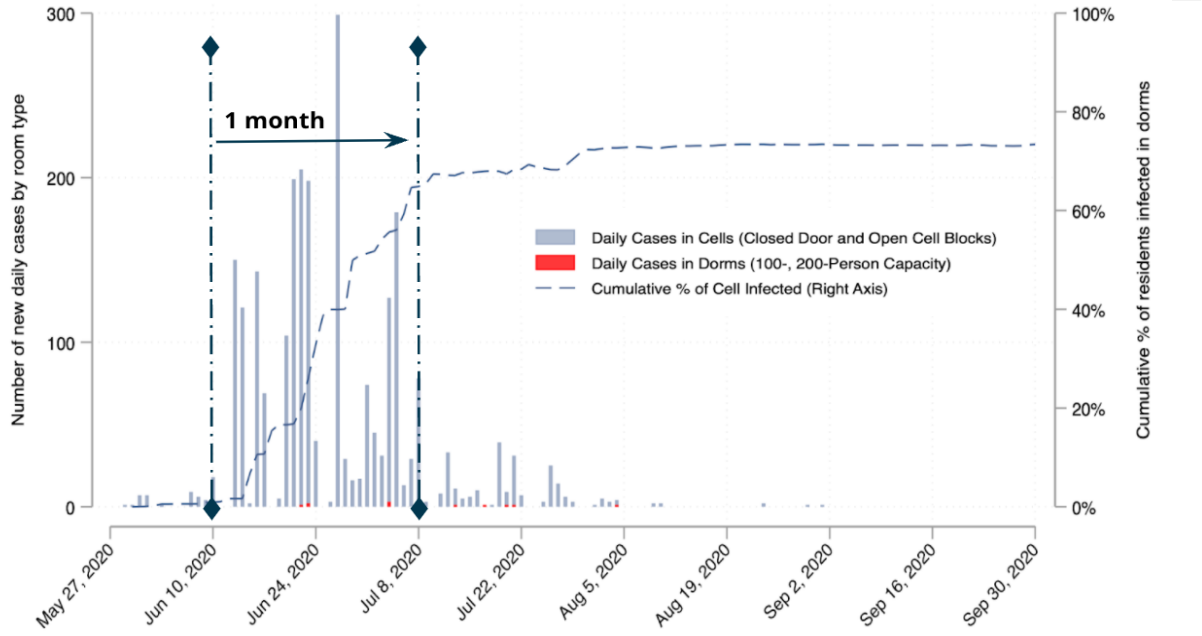
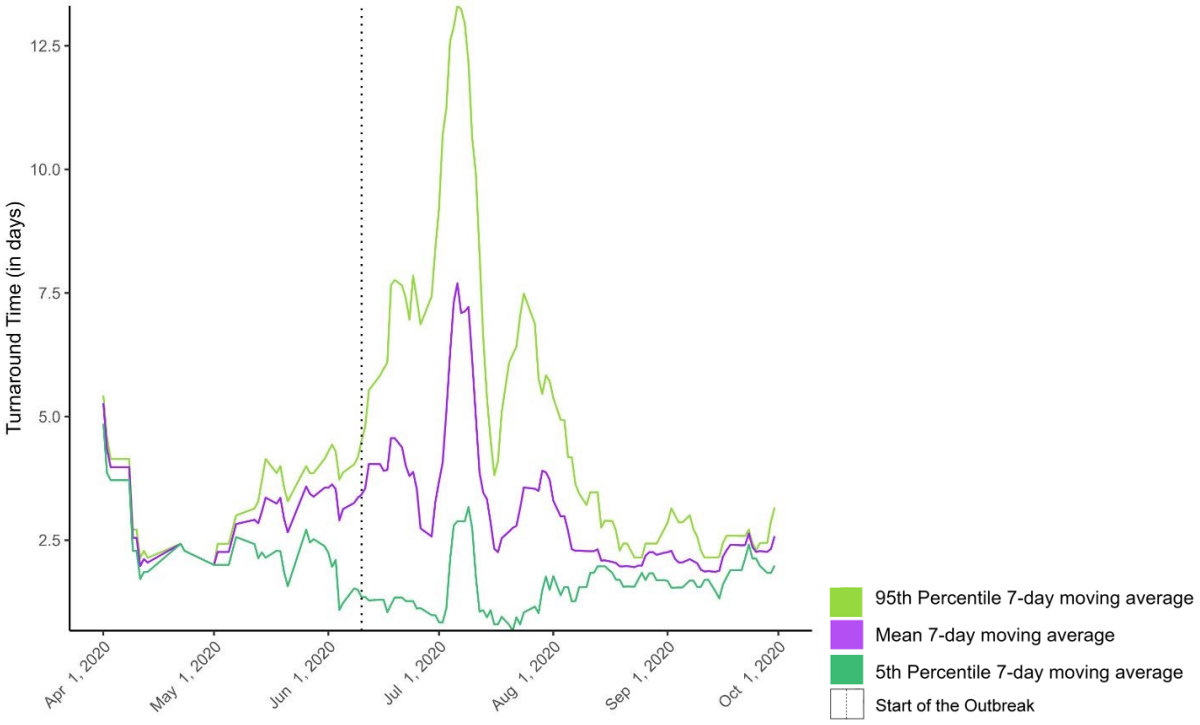


Figure 7.4.2. PCR testing turnaround at San Quentin was the slowest (approximately range of 3-13 days) during its outbreak acceleration phase.



Note: 7-day moving average refers to the rolling average across seven days for: tests in the 95th or higher percentile of turnaround time, the mean turnaround time for all tests, and the 5th percentile or lower of turnaround time across San Quentin. Dashed line represents the start of the outbreak.

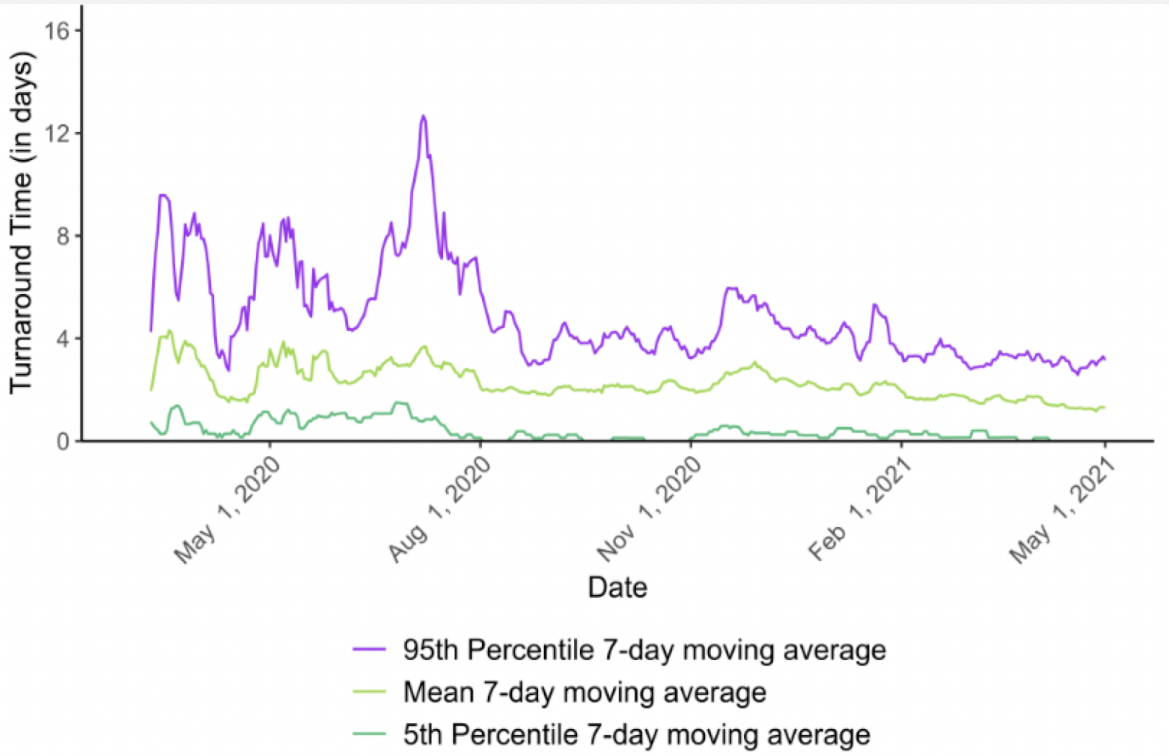
Table 7.4.1 and **Figure 7.4.3** illustrate the improving trend in PCR testing turnaround time across CDCR. While the early days of the pandemic were marked by an average turnaround time in excess of 3 days and a large degree of variability, the mean and system-wide variation have fallen over time, which is vital to preventing and lessening the impact of future outbreaks. However, these reductions in turnaround time have not been experienced equally across different institutions.

Table 7.4.1: Trends in Average PCR Test Turnaround Time across CDCR

	March 2020	July 2020	December 2020	May 2021
Mean	3.67	2.88	2.45	1.17
(SD)	(3.44)	(2.44)	(1.20)	(0.80)

Note: SD is standard deviation.

Figure 7.4.3. 7-Day PCR testing turnaround across CDCR has declined over time.



To evaluate the effect of the three key testing parameters (time-varying accuracy, testing frequency, and testing turnaround time) on viral transmission among residents, we present findings from an individual-based simulation model in a dormitory setting, in which shared airspace presents a particularly high risk of virus transmission among individuals. We then use this analysis to inform the development of a generalized set of testing recommendations. We also discuss the tradeoff between testing frequency and expected cases to ground the analysis in the realities of an institution's financial and human resources.

7.4.2. Methods

Using the approach of Hoover et al., we have modeled infectiousness with a triangular distribution, wherein the lower limit is the latency time (time until first infectious), the peak is the time until highest infectiousness, and the upper limit is the total time spent infected. These values are drawn stochastically for each infected individual from the distributions present in the literature to allow for the realistic modeling of individual variation in viral dynamics characteristic of SARS-CoV-2's delta variant, as presented in **Table 7.4.2**.

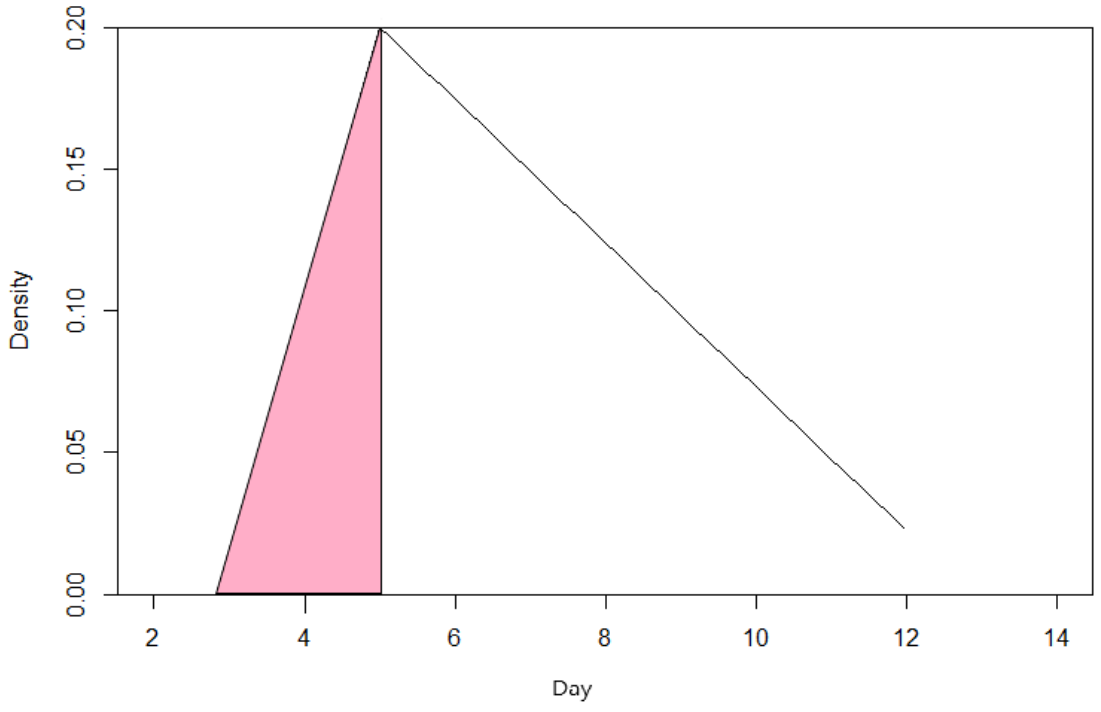
Table 7.4.2. Summary of Infectiousness Parameters for SARS-CoV-2 Delta Variant

Parameter	Distribution	Source
Time to Peak Infectiousness	*Lognormal*(1.39, 0.18)	(3)(7)(9-10)
Latent Period	$T_{incubation} - Uniform(0, 2)$	(8)
Infectious Period	*Uniform*(7, 10)	(8)

Note: Table was produced courtesy of Hoover et al. (2021).

In order to translate from this distribution of infection to infectiousness, it is important to understand how these drawn distributions relate to the "effective reproduction number", or the expected cases generated by an infected individual. The proportion of infectiousness on any given day is the effective reproduction number multiplied by the density of the distribution over that day. Figure 7.4.4 represents an example infectiousness distribution and corresponding proportion of expected cases potentially averted by same day turnaround compared to a two day delay. In this figure, we have assumed that the effective reproduction number over the course of each simulation is 2, a realistic estimate considering both the setting, as well as masking and other precautions taken against the virus.

Figure 7.4.4. Demonstration of Cases Averted by Same Day Turnaround Compared to Two-Day Turnaround



The above figure assumes an individual was tested on the first day they became infectious. The highlighted area under the curve between day three and day five represents 30.1% of the distribution. If the effective reproduction number is 2.0, this means that this individual would cause 0.62 additional expected cases over this time period if they were isolated based on the results of testing on day five instead of immediately on day three.

Timely testing is vital because it allows healthcare staff to isolate infected individuals early in their infectiousness period and, therefore, prevents future expected cases from being actualized. The "infectiousness removed" is the proportion of the distribution that remains when an infected individual is isolated multiplied by the total expected cases over the duration of their infectious period in the absence of intervention. Below we simulate different testing scenarios in a dormitory setting to determine the tradeoffs between the key testing parameters. We then generate actionable information regarding optimal response testing strategies.

In each simulation scenario below, we utilize the existing literature to account for the time-varying sensitivity of PCR and antigen testing. A recent study found that PCR testing is 80% sensitive prior to symptom onset (i.e., before the incubation period ends) and reaches a nearly perfect sensitivity of 99.9% thereafter.(11) Antigen testing faces a similar divide, with a sensitivity of only 58% to detect asymptomatic cases compared to 78% for symptomatic (a conservative assumption given that we make no distinction in terms of level of infectivity and the presence of symptoms). However, because many existing studies on antigen test performance do not record time since exposure (and instead focus on time since symptoms presented), a straightforward estimate of the pre-symptomatic performance of antigen testing remains unclear.(12) Instead, we assume that this 58% sensitivity applies for individuals who have not yet had symptoms. Test specificity for both antigen and PCR tests is nearly perfect and consistent over time and so is simply treated as a constant of 100%.

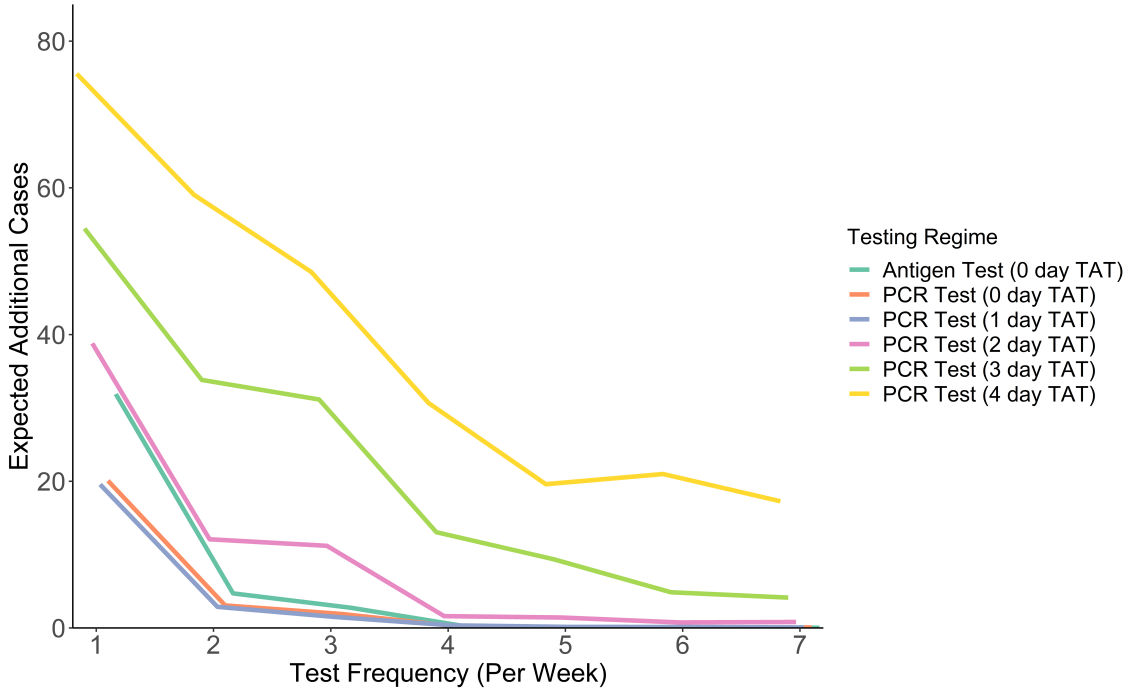
While PCR testing has a sensitivity advantage over antigen testing, we vary the turnaround time for PCR tests from 0 to 4 days as compared to same day turnaround for antigen testing (consistent with values in **Table 7.4.1**). We assume 30% of resident cases would have been detected with symptom screening and that symptom-based isolation occurs the day symptoms present. We recognize that the probability of detecting an infection with symptom screening will vary by age and across housing units, but we do not model that heterogeneity. Each simulation occurs over a 175-day period. The process is modeled as an individual-based compartmental model that allows residents to enter and exit six different states: susceptible, infected but not yet infectious (latent), infectious, recovered, tested (tested and awaiting results), and isolated (after receiving positive test result or demonstrating symptoms). Each modeling simulation begins with 200 susceptible residents and 1 infected resident all in the

same dormitory and is repeated 100 times to produce stable estimates. The CDC recommends response testing at least every three days in congregate settings and so we vary testing frequency from daily to weekly to explore the impact of more and less frequent testing (13).

7.4.3. Results

In the case where no testing, quarantine, or isolation takes place, nearly all 200 susceptible individuals in the dormitory will eventually become infected. As **Figure 7.4.5** illustrates, daily testing is extremely effective even with a turnaround time of up to two days, as almost all cases can be averted, providing that the infectious residents can be moved to isolation. We do not model it here, but once repeated testing no longer identifies positive individuals, then the testing frequency can be reduced with little reduction in total effectiveness. While the PCR test is equal or superior to the antigen test in terms of cases averted with same day or one-day turnaround, it averts significantly fewer cases at and beyond a two-day turnaround, which is more typical of PCR testing realities in CDCR facilities.

Figure 7.4.5. Expected Cases Under Different Testing Regimes in Dormitory with 201 People



Note: The dormitory begins with 1 infected and 200 susceptible residents and the simulation lasts 175 days. This model assumes perfect ability to isolate residents who are suspected because they report symptoms or who test positive, R=2, time-varying test sensitivity (perfect specificity), 30% of cases detected because they are symptomatic (in absence of testing) and utilizing the most recent data on the delta parameter viral load function.

7.4.4. Interpretation

Figure 7.4.5 clarifies two key points. First, barring the ability to process PCR tests in one day or less (such as with on-site rapid PCR testing), antigen testing is a superior choice compared to PCR for response testing. In other words, turnaround time is at a premium when trying to curb an outbreak in a dormitory setting even at the expense of test sensitivity. Second, the usefulness of any testing regime is reduced when testing frequency is only once a week and has cumulating advantages when testing more frequently. When an outbreak occurs and it is not possible to individually quarantine exposed individuals, then the housing unit should ideally be tested with point-of-care tests daily (if testing with point of care antigen tests) or every other day (with point of care PCR tests or PCR with one-day turn-around) until transmission has been arrested.

There are several important considerations for the present analysis. Firstly, the infectiousness profile is retrospective. As with any individual-based simulation model, we have also made several important simplifying assumptions, including here the exclusion of vaccination, which should not change the relative performance of different testing protocols but will cause an overall reduction in cases. Similarly, the social and behavioral determinants of the reproductive number, which acknowledges that individual behaviors likely change over the course of the pandemic, is not explicitly modeled.(14-16) This again should have minimal impact on the relative performance of testing strategies but could also change the ideal frequency. In particular, testing performance would be predicated on capturing the people likely to cause superspreading, which is extremely challenging to determine *a priori*. The simulations focus on a dormitory setting in which some residents have already been exposed. However, cases generally begin as a result of staff introduction, for whom vaccination and regular testing is particularly vital for prevention of the introduction of infection into the prison. We have also not discussed the potential role of pooling and sewage testing to reduce the testing burden. When prevalence rates are low (i.e., routine screening of asymptomatic staff, testing of a housing unit that has not had positive tests for several days) then use of pooling should be strongly considered as it can decrease the number of tests that need to be done by tenfold. Similarly, sewage testing can be used to detect introduction of infection into an institution especially in a context where residents are reluctant to disclose symptoms for fear of provoking isolation.

Lastly, we acknowledge that focusing on widespread antigen testing of exposed individuals when a new case is detected (as described above) represents a significant departure from the current testing protocols and, therefore, could constitute a significant increase in the in-house labor costs of the testing program. However, rapid testing becomes most crucial in institutions that are running out of space to safely quarantine exposed residents. In these cases, limited testing resources should prioritize large areas of shared airspace where individual quarantine is

not possible (including dormitories and rooms without solid doors) and emphasize the use of regular antigen testing to attempt to contain an incipient outbreak whenever possible. These resources were deployed less efficiently in many outbreaks across the CDCR system, where mass testing occurred after an outbreak had already occurred, PCR testing turnaround time was delayed, and facilities lacked the necessary space to effectively separate infected residents.

7.4.5 Conclusions & Recommendations

From these simulations and evidence developed in the existing literature from other congregate settings (i.e., nursing homes), antigen testing appears superior to PCR testing at preventing SARS-CoV-2 spread if the PCR test faces a turnaround time of 2 or more days. While the PCR test can detect infection earlier, a delay in results of two days or longer completely erases this advantage. Furthermore, our simulation suggests that antigen testing may also be superior to PCR testing when the PCR turnaround time is 1 day (note: rapid, on-site PCR testing – if available – would be the ideal choice with the greatest sensitivity and a turnaround time similar to antigen tests). Operationally, the advantage of antigen testing is especially important in settings where residents are forced to quarantine as a group (e.g., dormitories), as residents who test positive must be rapidly removed to prevent a widespread outbreak. An additional benefit of antigen testing is that it may more rapidly identify individuals who would be candidates for monoclonal antibody therapy or oral antiviral therapies, treatments that are more effective the earlier they are started following infection.

In some scenarios—such as when a resident exposed to COVID-19 is in safe individual quarantine—the short turnaround time of an antigen test is not as important and PCR testing with a turnaround time of 2 or more days would be appropriate, provided the institution is not running out of quarantine space. In Table 7.4.3 we use CCHCS testing strategies described in "*COVID-19 and Seasonal Influenza: Interim Guidance for Health Care and Public Health Providers*" (17) to describe scenarios when rapid antigen tests may be superior to a PCR test with a turnaround time of 2 days or more:

Table 7.4.3. Optimal Test (PCR with ≥2 Day Turnaround Time vs Rapid Antigen) Based on CDCR-Defined Testing Strategies

Strategy	**Comments on Preferred Testing Type (if PCR test has turnaround time of ≥2 days)**
Diagnostic Testing (patients with symptoms)	Co-testing with PCR and rapid antigen tests: antigen would not be needed if both isolation of the patient and quarantine of exposed contacts will occur prior to receipt of results
Outbreak Response	Rapid PCR (e.g., Cepheid) or rapid antigen testing

Quarantine Testing	PCR testing provided patients are in safe, individual quarantine and rapid receipt of results is not needed to free up additional quarantine space
Risk-Based Routine Testing	PCR or rapid antigen testing
Inmate Worker Testing	Rapid antigen testing
Testing for Movement	Between institutions (or from jail to reception center): Rapid antigen testing preferred just prior to movement; PCR testing can be used by receiving institution provided patient is in safe, individual quarantine
	Within institution: rapid antigen testing preferred just prior to movement, particularly if there have been any active cases in the institution in the last 14 days
	Outside of CDCR institution (e.g., fire camp, routine medical, court, etc.): rapid antigen testing preferred just prior to movement
Public Health Surveillance Testing	PCR or rapid antigen testing
Staff Surveillance Testing	Rapid antigen testing (particularly at the start of a shift)

Overall, these modeling data suggest a benefit to the increased use of rapid antigen tests in many scenarios if the PCR turnaround time is ≥2 days. Due to the increased demands that point-of-care testing places on institutional staff, CDCR might consider cross-training additional staff on the administration of antigen tests so that each institution can rapidly and effectively test, particularly in response to an outbreak (with a focus on training staff who may not be taking on additional responsibilities in response to a new outbreak).

The implications of this analysis lead to three important recommendations:

Recommendation 7.4.1: Use rapid antigen testing in place of PCR testing in most scenarios when the PCR testing turnaround time is ≥2 days. If a patient is in safe, individual isolation or quarantine while awaiting test results then PCR testing (with turnaround time ≥2 days) is appropriate.

Recommendation 7.4.2: When capacity to perform widespread antigen testing is diminished, prioritize antigen testing in settings with the potential for rapid transmission (e.g., dorms and

during large uncontained outbreaks) and/or where medically vulnerable residents are housed.

Recommendation 7.4.3: Cross-train additional staff on the administration of antigen tests so that each institution can rapidly and effectively test, particularly in response to an outbreak. Current self-administered test technology is such that it would not be difficult for existing staff in a housing unit to administer such tests to a housing unit daily.

7.5. Quarantine & Medical Isolation

In a review of the quarantine and isolation statuses of CDCR residents during the pandemic, several patterns emerge. Here, we summarize these patterns that extend beyond the simple assignment of individuals to either quarantine or isolation status:

1. **Individual isolation:** This typically has been used for symptomatic individuals whose COVID-19 test is pending or for individuals who have tested positive with an antigen test but who are awaiting PCR test confirmation or during small outbreaks where individual isolation space has not reached capacity constraints.
2. **Group isolation:** This typically has been used in larger outbreaks for PCR-confirmed COVID-19-positive patients.
3. **Individual quarantine:** This has been the standard of care for housing individuals with a high-risk exposure. It is generally used by moving people to a designated quarantine housing unit.
4. **Quarantine in 2-person cells:** In the absence of sufficient space for individual quarantine and with the recognition that there are potential transmission risks of moving large numbers of residents to different housing units, quarantining "in-place" in 2-person celled housing has been commonplace.
5. **"Quarantine" status for dormitory residents in response to a low-risk or uncertain exposure:** There are instances of entire dormitories being designated as "in quarantine" in response to a possible exposure to an infected staff member, in response to the extraction of a symptomatic resident without confirmed COVID-19, or due to other low-risk exposures. Often this quarantine designation has lasted just a couple of days (e.g., until a suspected infection is ruled out). However, without institution-specific investigation, it is difficult to determine the reasoning for each instance of dormitory quarantine.
6. **Emergency quarantine in place in dorms or barred cells because of lack of available safer quarantine:** There have been repeated examples in which an institution's safer quarantine capacity has been exhausted and exposed residents are instead locked down in "quarantine" in environments that cannot prevent person-to-person transmission. This includes dorms and cellblocks with barred cells.
7. **Unexplainable patterns of quarantine and isolation:** There have been numerous examples in the data of partial quarantine of a dormitory or housing unit, or of residents being "isolated" in a dormitory with other non-infected persons. We suspect that most of these reflect errors in the data (e.g., quarantine or isolation orders entered at a different time) but monitoring such patterns could be a useful way of both identifying

issues in management of quarantine and isolation and as a way of improving data quality.

8. **Partial areas of isolation and/or quarantine in the same housing unit:** Given that CDCR housing units were not designed for housing infected residents, subdividing any housing unit into areas with different levels of biosecurity is inherently risky in the absence of a rigorous evaluation of both volume and directionality of air flow. For example, the safety of designating one wing of a cross-top housing unit as an isolation unit depends upon the ability to isolate that wing (and its airspace) from the rest of the building. We have not been able to attempt to assess whether there is evidence of transmission in these situations as we do not have within-building location data available to us. In absence of evidence of safety, such mixed-use buildings should be avoided when possible; when not possible, they should receive an emergency and rigorous HVAC assessment designed to optimize safety.

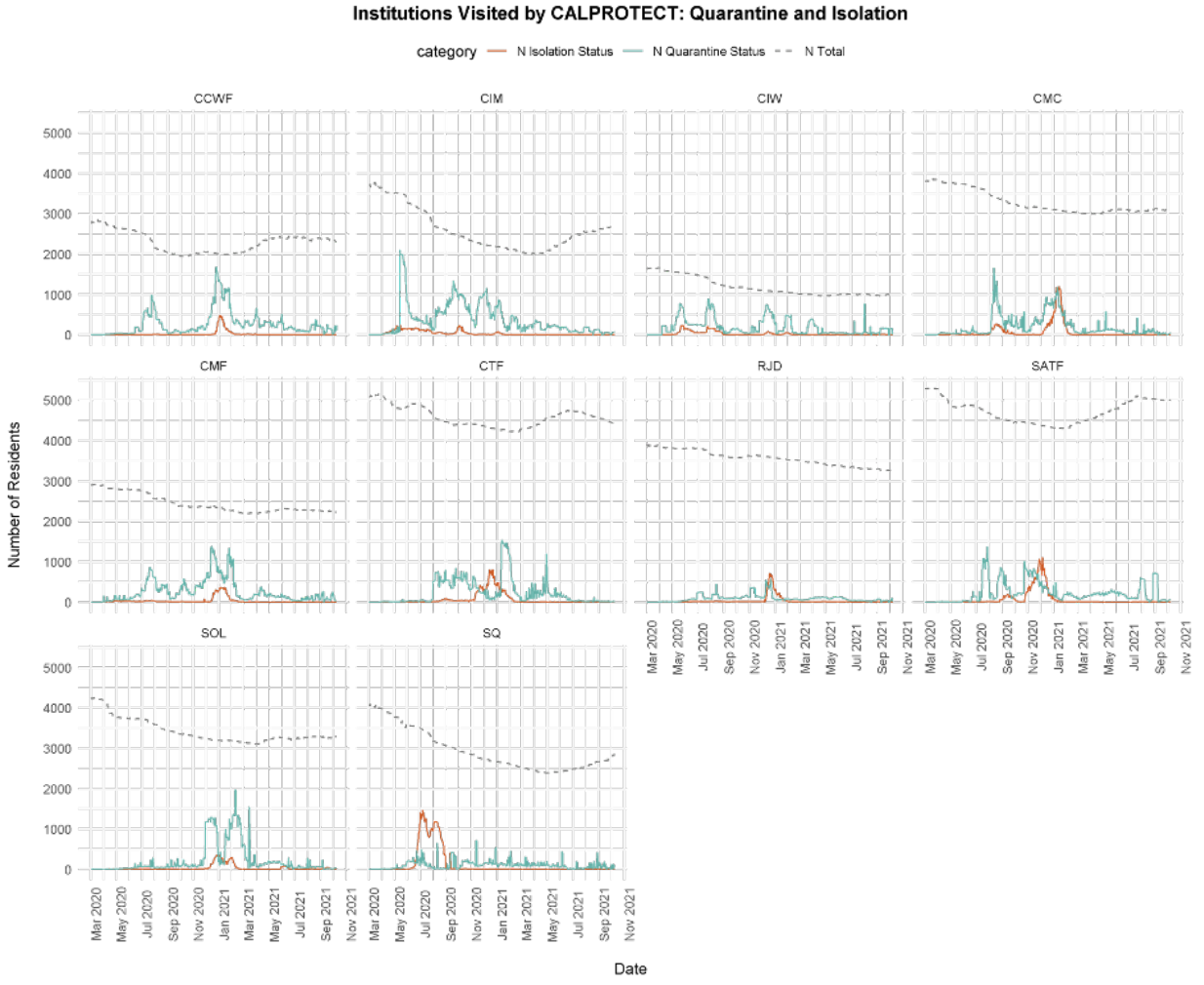
Analytic Considerations: People with Special Housing Needs:

It is worth noting that in this report, we do not separately consider the designation of isolation and/or quarantine spaces for incarcerated people with special housing needs, such as individuals who have disabilities. These areas should be designated according to the needs of the population to avoid creating housing issues for those who were displaced. All necessary accommodations should be made for these people, including paths of travel, assistive devices (e.g., trapeze bars and ADA-accessible showers and restrooms), acclimation support in the new spaces (e.g., for people with visual impairments), equal accessibility and ability to communicate over the phone, access to ADA-accessible yards, and so on. CDCR is already assessing different housing units with respect to being able to "quarantine in place." Such planning should prioritize housing a high proportion of persons with disabilities because of the additional difficulties associated with moving people with disabilities to new quarters, especially when that must be done urgently. Unfortunately, such "quarantine in place" is not possible when large numbers of persons with disabilities are housed in open dormitories (such as is the case at CMF). In absence of a feasible solution for adequately quarantining such people, preemptive release into safer community housing is the only feasible alternative.

Data Limitation: Nightly housing data was used to assess the quarantine and isolation status of residents for each night that they were present at a CDCR institution. However, quarantine and isolation status in this data set may indicate either the actual quarantine or isolation of a resident or the need to quarantine or isolate that resident. Additionally, quarantine and isolation status may be incorrect for some residents. Lack of data on the specific section of a housing unit that each resident is housed in limits our ability to determine when housing units may have been subdivided in some way for quarantine and isolation.

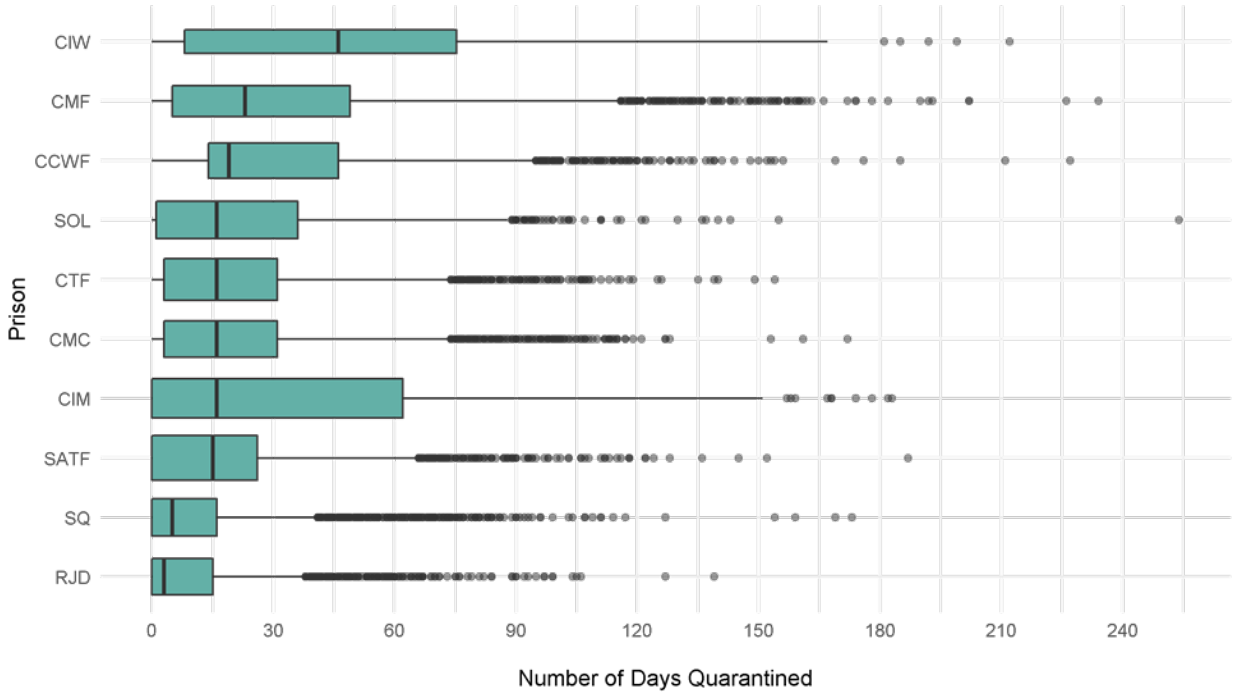
Institutions across the CDCR experienced different patterns in the quarantine and isolation statuses of their residents over time. Some institutions had periods in which greater than 50% of residents were classified as being in quarantine, such as the spikes in quarantine seen for CCWF, CIM, and CMF (**Figure 7.5.1**). Some institutions saw large outbreaks that necessitated having a high percentage of the population on isolation status at a given time, such as at SQ and CMC (**Figure 7.5.1**). Adequate quarantine and isolation space is hard to come by within many institutions, and safe quarantine space can be particularly difficult to establish for a large number of residents at once. Moreover, according to the California Correctional Health Care Services (CCHCS) *COVID-19 and Seasonal Influenza: Interim Guidance for Health Care and Public Health Providers* "Patients who develop symptoms while in quarantine should be immediately isolated in a single cell with solid walls and a solid door" but patients testing positive for COVID-19 can be isolated together.(1) Sufficient safer quarantine space, especially in prisons that are already operating above design capacity or that have small numbers of closed cells, has been impossible to achieve at the height of outbreaks. **Supplemental Table S7.5.1** shows the total person-days of isolation and quarantine for each institution. Plots of the quarantine and isolation numbers over time for all institutions can be found in **Supplemental Figure S7.5.3** (**A.1 through A.35** with institutions presented in alphabetical order).

Figure 7.5.1. Number of residents with quarantine status and isolation status for some CDCR institutions, compared to total institution population.



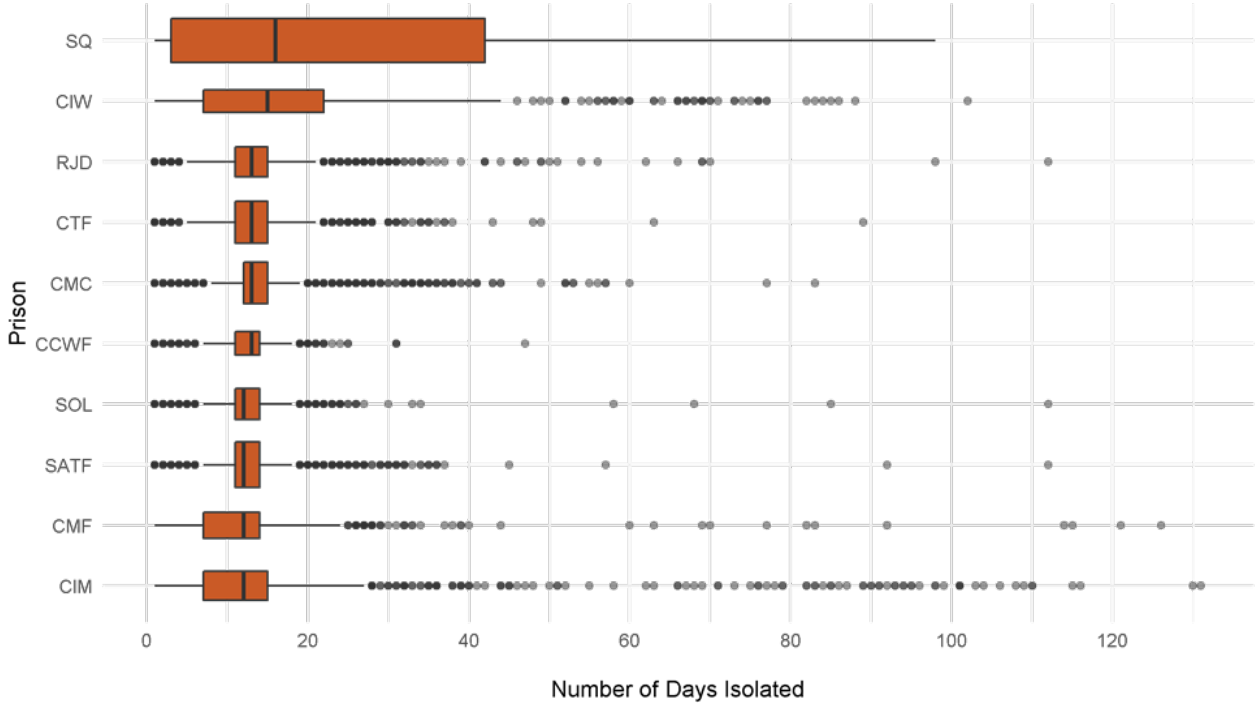
Residents experienced different levels of quarantine and isolation burden across institutions – a majority spent time in quarantine and many were medically isolated (also discussed in **Section 4.2**). Of all residents incarcerated at some point between March 1, 2020 and October 9, 2021, 125,677 (84.6%) spent at least one day in quarantine with a median of 32 total days spent in quarantine (IQR: 16 – 57). There were 58,323 residents (39.3%) who spent time in isolation, with a median of 13 total days spent in isolation (IQR: 11 – 16). **Figure 7.5.2** shows the median (center line of the box) and spread of the number of days in quarantine for all residents at the institutions that CalPROTECT visited. **Figure 7.5.3** shows the median and spread for the number of days in isolation for all residents who were ever isolated in each prison that CalPROTECT visited between the summer of 2020 and December 2021 (see **Supplemental Figures S7.5.1** and **S7.5.2** for quarantine and isolation boxplots for all institutions).

Figure 7.5.2. Median and distribution for the number of days each resident spent in quarantine from March 1, 2020 and October 9, 2021 by institution.



Note: Each boxplot contains a teal box, which indicates the interquartile range (IQR)—50% of residents fall within this range—and the vertical line in the center of the box shows the median value for number of days spent in quarantine. The height of the box is relative to the number of observations. The horizontal lines extending from the box on either side show 1.5 times the IQR (added or subtracted from the end of the teal box; ending at zero if the value goes below that) , and the dots are outliers that are outside of this range.

Figure 7.5.3. For all residents who were ever isolated, the median and distribution for the number of days each resident spent in isolation from March 1, 2020 to October 9, 2021, by institution.



Note: Each boxplot contains an orange box, which indicates the interquartile range (IQR)—50% of residents fall within this range—and the vertical line in the center of the box shows the median value for number of days spent in isolation. *The height of the box is relative to the number of observations.* The horizontal lines extending from the box on either side show 1.5 times the IQR (added or subtracted from the end of the brown box; ending at zero if the value goes below that), and the dots are outliers that are outside of this range.

Table 7.5.1 shows the percent of total quarantine and medical isolation days by housing unit type (using CalPROTECT housing unit classifications described in Section 6.1 of this report). Across all institutions, 270 cells were used most frequently for quarantine and isolation and accounted for 28.1% of total quarantine days and 23.2% of total isolation days. When all pod and dormitory style housing units are combined, they account for 19.2% of total quarantine days, with 3.7% of total quarantine days occurring in large E-type or similar dorms (**Table 7.5.1**). Within dorms, there were also some discrepancies in who was considered being on quarantine status, with some large dormitory buildings showing only part of the population on quarantine status. For example, some E-type dorms at CMF and CIM show extended periods where only part of the population in the dormitory was classified as being on quarantine status (**Figure**

7.5.4). We presume that institutions de facto had two types of quarantine (as described above) with one being lower-risk (no known exposure) versus higher risk (known exposure), but we are unable to differentiate them from the data. Thus, we cannot differentiate a dorm that is in "low risk" quarantine – which might be an appropriate precautionary measure as a suspected case is ruled out – from a dorm that is in high-risk quarantine because of an inability to transfer the exposed residents to safer quarantine.

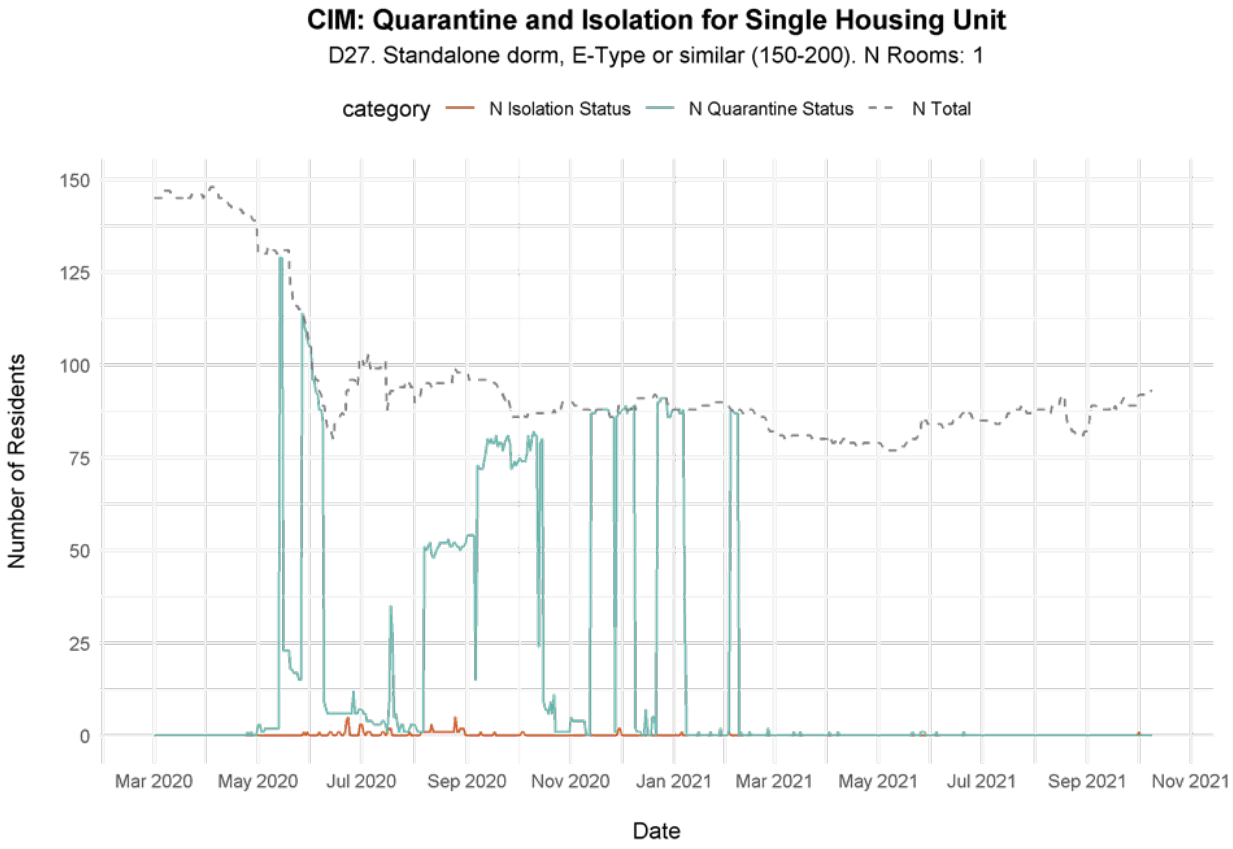
Table 7.5.1. Quarantine and isolation distribution for CalPROTECT-classified housing unit types.

Quarantine and Isolation Distribution by CalPROTECT Classified Housing Unit Type		
Housing Unit Category	**Percent of total quarantine days**	**Percent of total isolation days**
>1 dorm room per floor (pods)[1]	4.4%	6.4%
1 dorm room per floor	0.2%	1.7%
180 Cell	9.4%	7.4%
270 Cell	28.1%	23.2%
270 Dorm	2.8%	9.9%
Cross-top dorm (pods)[1]	5.6%	5.8%
Cross-top dorm (pods) & Other[1]	0.6%	0.2%
D dorm (pods)[1,2]	0.4%	0.7%
Double cells, Closed Door (1980+)	6.2%	2.8%
Double cells, Door Unknown (1940's-60's)	8.4%	5.7%
Double cells, Door Unknown (1940's-60's) & >1 dorm room per floor (pods)[1]	0.3%	0.1%
Double cells, Door Unknown (1940's-60's) & 1 dorm room per floor	0.1%	0.6%
Double cells, Open/Barred Door (<1920)	1.9%	5.9%
Other	0.0%	0.0%
Single cells, Closed Door (1980+)	7.6%	2.5%
Single cells, Closed Door (1980+) & >1 dorm room per floor (pods)[1]	3.0%	1.7%
Single cells, Closed Door (1980+) & Standalone dorm, Small (<50)	0.1%	0.0%
Single cells, Door Unknown (1940's-60's)	3.0%	3.4%
Single cells, Door Unknown (1940's-60's) & >1 dorm room per floor (pods)[1]	0.5%	0.2%
Single cells, Door Unknown (1940's-60's) & Standalone dorm, Small (<50)	0.1%	0.1%
Single cells, Door Unknown (1940's-60's) & Standalone dorm, Small (<50) & Other	0.4%	0.4%
Single cells, Open/Barred Door (<1920)	0.4%	1.8%
Standalone dorm, E-Type or similar (150-200)	3.7%	6.3%
Standalone dorm, Large (100-149)	2.1%	2.2%
Standalone dorm, Medium (50-99)	1.7%	4.5%
Standalone dorm, Small (<50)	0.5%	2.2%
Standalone dorm, Small (<50) & Other	0.0%	0.0%
Wingnut cells (double), Closed Door (1980+)	7.9%	4.2%
Wingnut dorm (open)	0.5%	0.2%

Note: Cells were assigned as designated "single" or "double" cells based on the maximum room capacity (during the study period) from the CDCR database. "Room capacity" refers to the total number of available beds and is unrelated to the institutional design or staffed capacity. Number of residents in a cell at a given point in time may be different from the assigned capacity. "Open" dorms structures feature a single room per floor, with no barriers between clusters of bunks. "Standalone" dorms are a subset of open dorms, where the entire housing unit it made up of a single open room, with no other associated floors or buildings (example: E-Type dorms). As with cells, "capacity" in this instance refers to the number of beds and is unrelated to institutional design capacity.
1. "Pod" dorm structures include multiple smaller dorms on a single shared floor; airspace may be shared across pods if the doors and walls between them are not closed. Otherwise, most pod structures feature a shared day room.
2. "D dorms" is a name developed by the CalPROTECT team based on the appearance of these buildings, which appear only at SATF. CDCR does not use any identifier for this housing unit because it was never built elsewhere.

Data limitation: Since we do not know the door type for many of the cells, especially for the prisons built between the 1920s and 1980, it is difficult to assess the availability of different types of quarantine and isolation spaces (with different risk levels) per institution.

Figure 7.5.4. Two large dorm buildings (likely E-type) at CMF and CIM that show periods of prolonged partial quarantine of a dorm population, indicating potential issues with data or unclear quarantine practices or periods of full quarantine in a large dorm indicating limited capacity for safer quarantine during outbreaks, which is worth further investigation.



CDCR institutions can consider the following hierarchy of quarantine responses (from lowest risk to highest risk):

Quarantine with no known exposure:

1. **Precautionary quarantine** without any known exposure. This is typically done following a move to prevent the possibility of introduction of infection into a new population.

Quarantine with possible or low-risk exposure:

2. **Enhanced safety precautions** in response to a possible or low-risk exposure. This might trigger a "**limited quarantine**" status for the housing unit with actions, such as elimination of work outside of the unit, strict adherence to masking, yard time not shared with other housing units, and enhanced testing frequency.

Quarantine with known exposure:

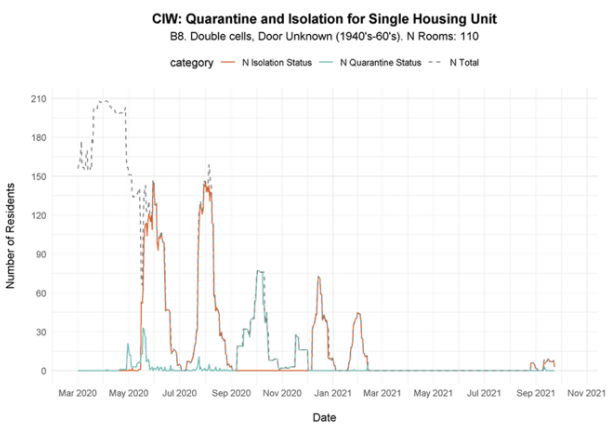
3. **Individual quarantine**, which is the community standard for a known exposure.
4. **Quarantine in 2-person cells** is less safe than individual quarantine, but the additional risk may be offset by the risk associated with moving large numbers of people out of 2-person cells to be able to achieve individual quarantine. Two-person quarantine should not be used for people with very high-risk exposure (such as for the cellmate of an infected person) or with very high COVID risk scores. As soon as a building is designated as being a quarantine building, quarantine procedures must go into place, and a full HVAC assessment should be immediately conducted to minimize transmission risk.
5. **Quarantine in larger groups** following known exposure is unacceptably risky, but it may occur when there is insufficient safer quarantine space available. If this occurs, then *all* possible precautions should be taken simultaneously to minimize spread within the group (e.g., masking, **daily rapid testing**, no indoor exercise, maximum air exchange, supplemental filtration)
6. **Quarantine in larger groups without ability to minimize spread within the group**. With a massive outbreak in an institution, a situation may arise where there is no capacity to identify and isolate asymptomatic infected individuals or to minimize onward transmission. This may occur, for example, if a large proportion of the staff are infected and are unable to work or if sufficient numbers of rapid tests are not available. In such a situation an institution may be reduced to monitoring for significant symptoms that may herald clinical deterioration so as to reduce mortality among those who are infected. Several institutions have already experienced this

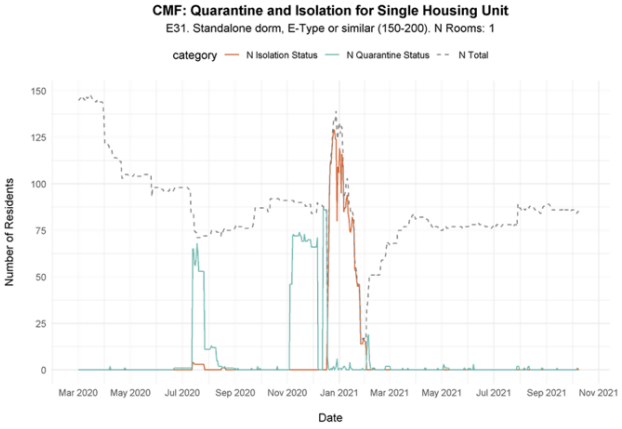
situation during this pandemic, and the Omicron variant (or a new one) could lead to new explosive outbreaks in the future that can overwhelm institutional capacity.

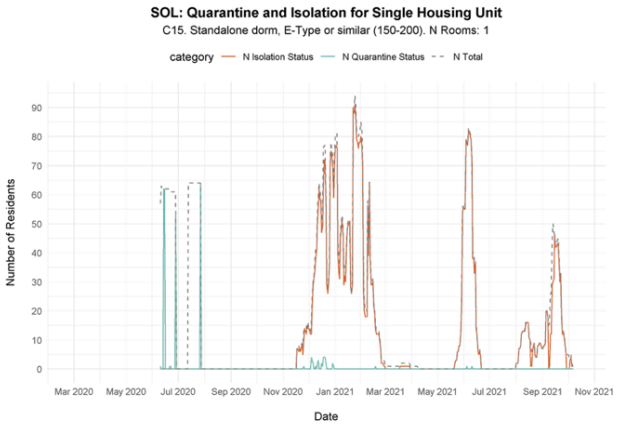
In all quarantine settings, testing can be used to identify infected persons and move them to safe isolation to reduce the probability of transmission within the building. The larger the number of persons quarantining in the same room, the more important it is to test frequently. The difficulty of having a single "quarantine" designation for all of the above situations is that it is difficult to distinguish whether appropriate protocols are being followed or not. For example, in precautionary quarantine of a group transfer it is minimally important to reduce person-to-person transmission because of the low likelihood of any infected persons in the group. With group quarantine following known exposure (e.g., in a dorm where a number of residents tested positive and were transferred to isolation), then maximal attention must be paid to reducing person-to-person transmission including minimizing the time that a newly infectious person remains in group quarantine.

Some institutions were able to use entire housing units as isolation spaces, however others lacked the infrastructure to do this. Figure 7.5.5 shows a housing unit with double cells at CIW that was used for isolation, and three standalone dorms (likely E-type) at CMF and SOL that were used for isolation. Other institutions, such as SQ, lacked the space and structures to be able to create effective isolation spaces. Figure 7.5.6 shows two of the large housing units at SQ where residents on isolation status had to be housed with residents on quarantine status or with the general population in housing units with open/barred door cells because of a lack of availability of other more appropriate spaces to house people in isolation and quarantine.

Figure 7.5.5. Some institutions were able to create isolation housing units at various times during the pandemic, such as the housing units shown below at CIW, CMF, and SOL. These are easily identifiable in the data and not all institutions had the structural capacity to do this.







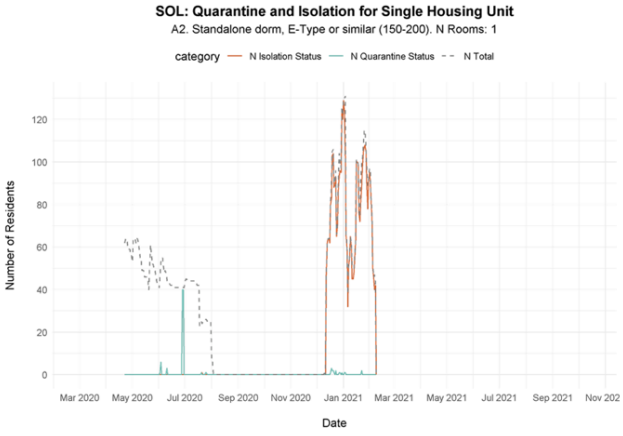
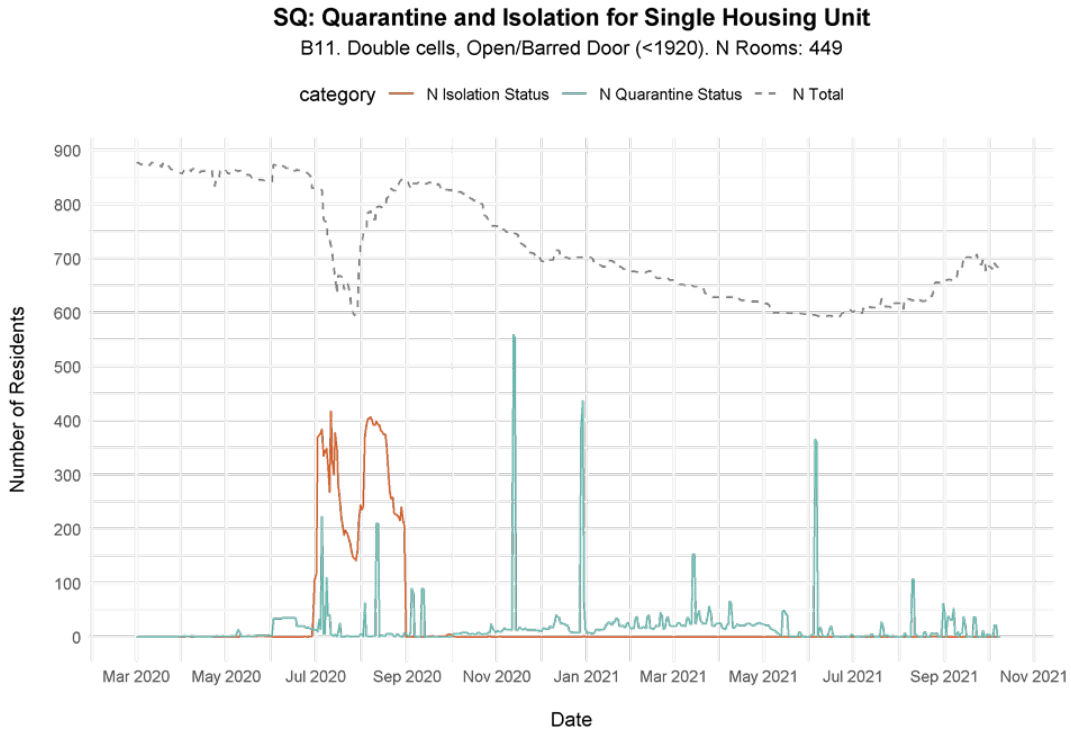
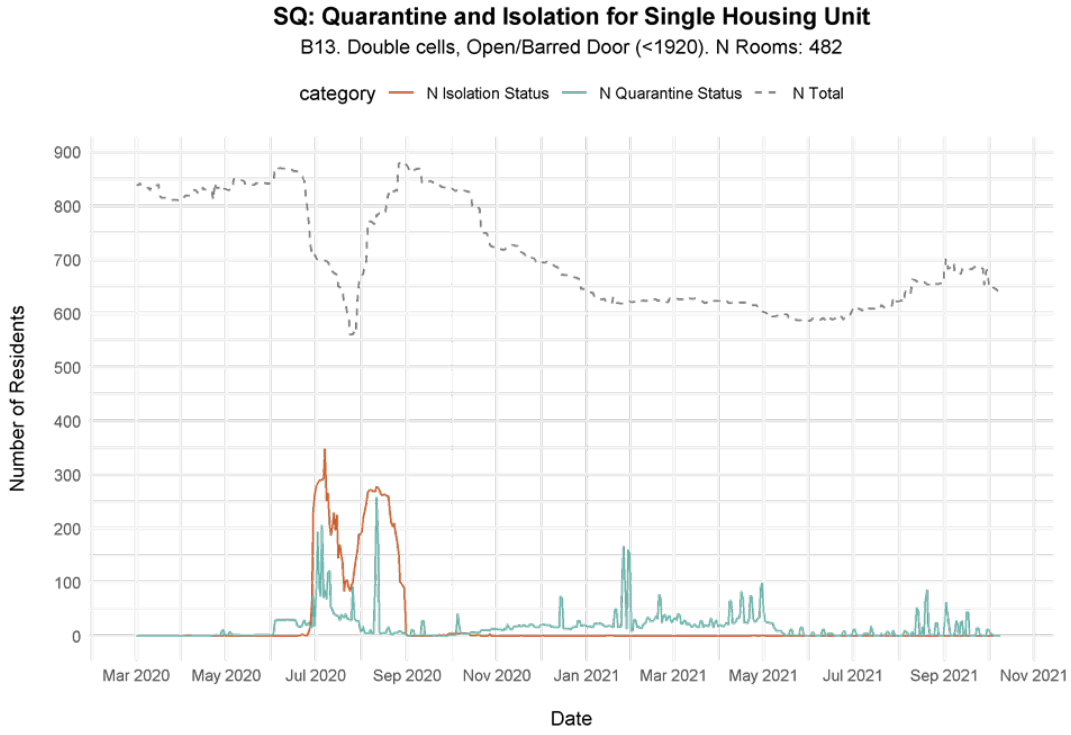


Figure 7.5.6. Number of residents with quarantine status and isolation status in two housing units at SQ with open/barred door cells.





While isolation and quarantine procedures and policies in CDCR are sound, discrepancies in the data highlight the need to further investigate how quarantine and isolation has been used across different institutions. Some discrepancies that we observe in the data may be attributable to data lags or errors—such as prolonged partial quarantine of large dormitories—and some may point to issues that institutions faced in creating adequate quarantine and isolation spaces. It is also difficult to distinguish from the data cases in which residents were recorded as being on isolation or quarantine status, but not yet moved to the intended new housing location. For example, small, short spikes in quarantine for only a few residents in a housing unit may represent cases in which residents had not yet been moved. The CCHCS *COVID-19 and Seasonal Influenza: Interim Guidance for Health Care and Public Health Providers* recommends that "each institution should develop a plan for various contingencies including the possibility of setting up temporary exam rooms, tents, and other areas that keep quarantined persons separated from all other populations," (1) using the data to identify important areas for further investigation of quarantine and isolation practices during the pandemic could be helpful for honing and revising each institution's quarantine and isolation plans.

Key finding: Almost 20% of quarantine days for residents occurred in dormitory style housing units, with 3.7% of quarantine days occurring in large standalone dorms (such as E-type).

Key finding: Housing units without solid doors to separate residents (dorms and cells with open/barred doors) were used for quarantine and isolation at the same time. Some institutions such as San Quentin had to primarily isolate and quarantine residents in these types of housing units.

Key Finding: There are inconsistencies in quarantine and isolation data that warrant further investigation.

Recommendation 7.5.1: Investigate discrepancies in quarantine and isolation data to better understand quarantine and isolation practices and constraints, particularly during large outbreaks.

Recommendation 7.5.2: Due to incredible difficulty of following recommended quarantine and isolation procedures in the prison environment, consider revising each institutions quarantine and isolation plans based on the infrastructure limitations of that institution. Assess past quarantine and isolation successes and failures to further improve plans for future quarantine and isolation.

Recommendation 7.5.3: Reducing the prison population is an important component of the COVID-19 response particularly in prisons that lack sufficient safe quarantine and isolation space.

Recommendation 7.5.4: Consider creating sub-categories of quarantine to reflect different types of quarantine, including those that safely match the needs of the population (e.g., ADA-accessible spaces), with different associated quarantine protocols.

7.6. Preventing COVID-19 Transmission from Staff

Early in the pandemic, the introduction of cases from staff was a major vulnerability due to a patchwork of policies and practices concerning the occupational health of prison staff.(1) This vulnerability emerged as a consistent theme in interviews with residents and staff during our site visits early in the pandemic. Specifically, at CDCR, there was no integrated occupational health program, policies were not in place for staff screening upon entry to the institution, many staff who did not work in healthcare were not educated in the appropriate use of PPE, testing for COVID-19 was done off-site and difficult to access, and most staff were not cohorted to work with a small and consistent cross-section of residents and other staff during outbreaks (in fact, some worked in multiple institutions, including moving between institutions with and without outbreaks). These vulnerabilities put residents at risk of staff-based introduction and COVID-19 transmission but also placed staff at enormous risk themselves, leading to elevated rates of COVID-19 compared to the general population as described in **Section 5** and in other prison systems.(2,3)

The creation of a statewide employee health program beginning in August of 2020 was an important achievement and a critical step in addressing the risks posed to and by staff. This action demonstrated how CDCR shifted their approach rapidly to an area identified as a key deficiency. Since the beginning of the pandemic, the following key measures have likely substantially reduced the risk of COVD-19 infection and transmission from staff:(4)

- Creation of an Employee Health Registered Nurse position at each institution with support staff to help identify potentially infected employees and take measures to reduce transmission
- On-site staff testing for COVID-19
- On-site staff COVID-19 vaccination
- Widespread training in appropriate PPE use (including distribution of KN95 and N95 respirators to staff depending on the state of an outbreak in the institution)
- Enhanced measures of risk mitigation for unvaccinated staff (e.g., mandated use of N95 respirators by unvaccinated staff inside institutions as of December 3, 2021 and increased testing mandates)
- Symptom screening upon entry
- Modified programming during outbreaks to limit staff movement
- Dedicated personnel to perform contact tracing and approve returning to work in relation to staff cases
- Partnership with outside experts in employee/occupational health

Despite these advances, staff remain the primary source of COVID-19 introduction. Much of this risk is purely a matter of numbers: based on data from October 2021, there are 56,585 staff moving multiple times a week between the community and CDCR prisons, while the 97,740 residents are rarely transferred outside of their institutions. In addition, CDCR implemented protocols beginning in 2020 pertaining to the movement of residents into, out of, and within CDCR prisons.(5) CCHCS's preliminary evaluation of these protocols has found that very few residents tested positive at the time of transfer, and there were only a few cases of transmission related to resident movement which were rapidly contained.

Given that the risk of COVID-19 introduction from staff remains a primary threat to CDCR prisons, a re-evaluation of staff policies could help determine how the occupational health program can be further bolstered. Based on our key informant and stakeholder interviews, our recommendations for the next iteration of policies to optimize employee health are below. Of primary importance is the mandate to require all CDCR employees to be fully vaccinated (a mandate that is currently in legal limbo). We strongly support this vaccine mandate as a cornerstone to protecting everyone who lives and works in or around a CDCR prison as well as family and friends who visit the institution. We also advocate for the mandate to be broadened to define full vaccination as the additional receipt of a booster dose and we support policies that would extend this mandate to all adults who enter a CDCR prison. Short of a staff vaccine mandate, the characteristics of staff who are less likely to be vaccinated (described in **Section 5.3**) may inform vaccine messaging and uptake strategies tailored to specific staff.

Furthermore, based on our work on optimal testing type (PCR vs rapid antigen) and frequency in **Section 7.4**, **we support the use of rapid antigen tests at the start of a staff member's shift**. If rapid testing is not performed, there appears to still be benefit to testing staff at the beginning of their work week based on a modeling study.(6) We recommend that CDCR explore the possibility of pooled staff testing with on-site PCR to reduce the cost and complexity of staff testing and enable more frequent testing. Testing frequency should be adjusted based on risk level in staff communities of origin and on testing yield.

Recommendation 7.6.1: Full vaccination should be required for any eligible employee, contractor, volunteer, government official, visitor, or other non-resident adult entering a CDCR prison. The definition of full vaccination should be changed to require CDC-recommended booster dosing, with sufficient time for individuals to meet this new requirement.

Recommendation 7.6.2: Continue to address staff disincentives to report symptoms and take sick leave; problems that are still prevalent based on interviews with staff.

Recommendation 7.6.3: Mandate at least twice weekly testing among staff who are not fully vaccinated. Testing should be conducted as close as possible to the start of a shift and would ideally be done with rapid antigen tests. Pooled staff testing with on-site PCR could also be explored.

Recommendation 7.6.4: Continue to work with custody leaders to improve cohorting of staff so as to minimize the risk of transmission between housing units, yards, facilities, and institutions. Employ same-day rapid testing when staff begin a work assignment with a different cohort in institutions with any active cases. Staff assigned to housing units used for isolation or quarantine should not work in other parts of the institution and should test daily if the institution has any active cases.

7.7. Outbreak Identification and Early Response

7.7.1. Background

The exponential spread of COVID-19 across susceptible populations in CDCR prisons has highlighted the importance of early case detection and a robust outbreak response to control case introductions before they lead to institution-wide outbreaks. In one of CalPROTECT's first site visits—examining an outbreak which was isolated and contained after 11 resident and 3 staff infections at CMC, CMC leadership stressed that the most important factor in controlling this outbreak was the early identification of index cases and the immediate testing of exposed individuals. CDCR's *COVID-19 and Seasonal Influenza: Interim Guidance for Health Care and Public Health Providers* also stresses the importance of broad testing "as soon as possible, after one or more COVID-19 positive individuals (patients or staff) are identified in a facility or housing unit". Early case detection can be challenging, however, owing to the rates of asymptomatic and minimally symptomatic infections and the disincentives that residents and staff may perceive for seeking testing. In this section, we examine CDCR's experience managing case introductions and make recommendations to guide the response to an outbreak in the crucial first few days after an index case has been identified.

7.7.2. Responding to a New Outbreak

Scientific consensus, and CDCR's internal policies, recommend the following when a new case is detected among residents or staff in a congregate living environment such as a prison: (i) immediate isolation of an individual from the susceptible population, (ii) identification of all exposed individuals through contact tracing and quarantining them from the rest of the population (ideally individually), and (iii) immediate serial testing of exposed individuals. If the first case detected on a housing unit is truly one of the first cases present, then the above measures should result in small numbers of residents testing positive (particularly on the first round of testing the exposed population) as the virus will not have had enough time to undergo multiple cycles of transmission (the exception being a superspreader event where the index case transmits to high numbers of people simultaneously). Examining epidemic curves in the prisons where CalPROTECT conducted site visits, however, presents a different picture, particularly in the first year of the pandemic. Institution-level epidemic curves frequently demonstrated two patterns which illustrated the challenge of early outbreak control: (i) there was often a delay in the time between the identification of the first resident case and the rollout of mass testing in response, and (ii) when mass testing was implemented (particularly if

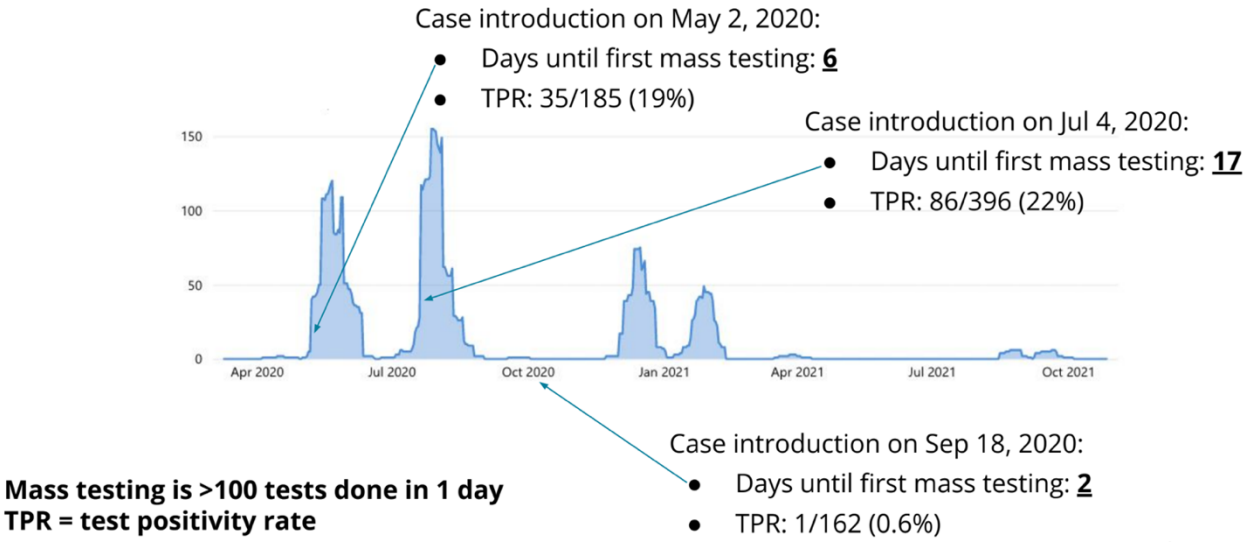
delayed following the first case introduction), high numbers of residents were found to be positive.

Testing in response to case introduction at CIW is illustrative of the two points above **(Figure 7.7.1a** and **7.7.1b).** There were three distinct periods through September of 2020 when CIW went from having no known resident cases to detecting a first case. The first resident case was tested on May 2, 2020 and there was a 6-day delay until CIW conducted mass testing (defined as testing more than 100 residents on a single day). This testing then revealed 35 new cases (for a test positivity rate, or TPR, of 19%). A similar scenario played out after a resident tested positive on July 4, 2020 and 17 days elapsed until mass testing, which then revealed 86 new cases for a TPR of 22%. Needless to say, controlling an outbreak in a densely populated prison – where quarantine and isolation space are limited – becomes enormously challenging when a large proportion of the population tests positive on a single day.

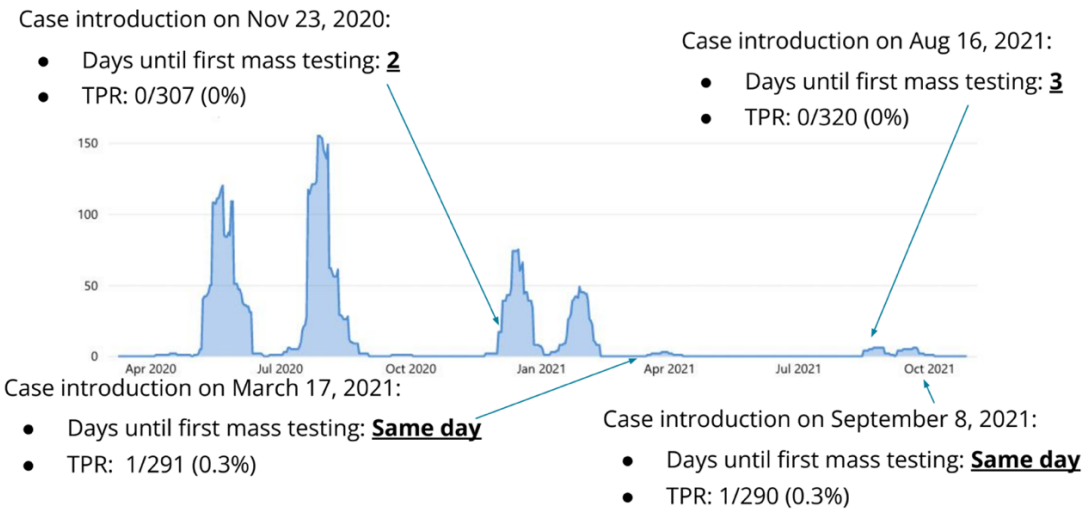
Encouragingly, subsequent case introductions on September 18, 2020 and in **Figure 7.7.1b**, demonstrate a shorter timeframe between first case detection and mass testing (0-3 days), lower numbers of patient testing positive on mass testing and lower TPRs (0-1 and 0-0.6%, respectively), and ultimately smaller outbreaks (which could be due to a multitude of factors beyond the mass testing response).

Figure 7.7.1. Mass testing in response to resident case introduction at CIW

(a) Initial case detections

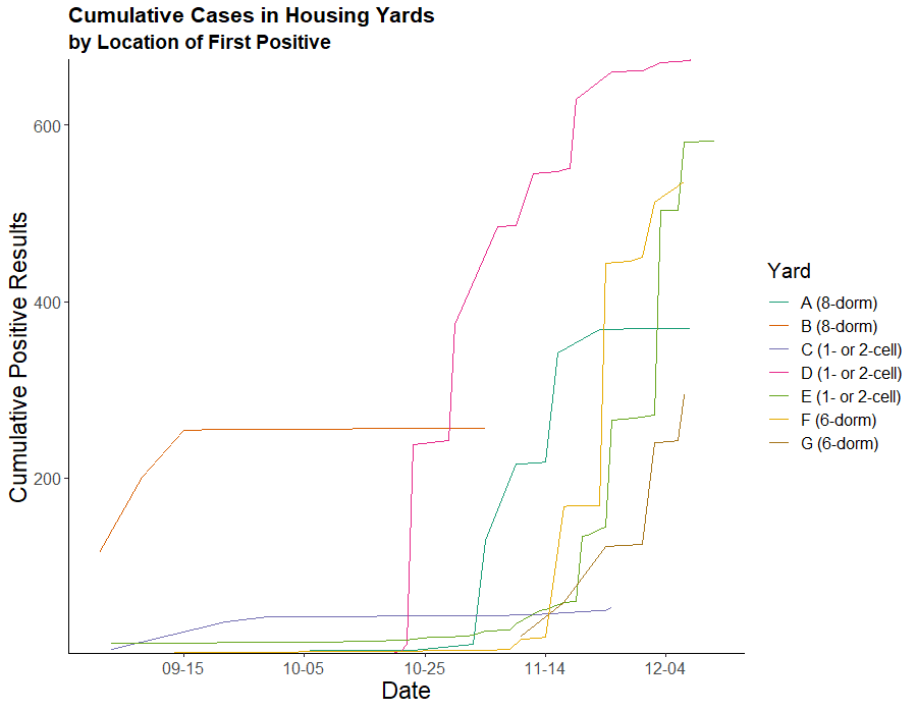


(b) More recent case detections



The SATF outbreak in the winter of 2020-2021 also demonstrated a similar pattern of large numbers of cases being detected during mass testing events when epi curves were displayed at the level of the yard (**Figure 7.7.2**). This figure demonstrates 1-day and 2-day case spikes of 100-200 new cases in multiple yards, indicating that the virus had likely completed multiple cycles of transmission amongst the population before mass testing was implemented on each yard.

Figure 7.7.2. SATF epidemic curves by yard from October 2020 – December 2020



There are some limitations to our interpretation of these epidemic curves in relation to mass testing that could bias findings regarding the duration between case detection and mass testing in either direction. For one, we are only examining the time from the first resident case to mass testing, yet residents could have been exposed by staff or other individuals which would have necessitated mass testing even sooner than the resident data indicate. On the other hand, new case detection could occasionally come in the form of an individual who entered the prison (from a reception center, jail, or hospital, for example) and was immediately placed into quarantine and thus was unlikely to have exposed others, thus obviating the need for mass testing. Irrespective of these limitations, the high TPRs following the rollout of mass testing in many institutions (described in other site visit reports, **Supplemental Section 12**) indicates that in many institutions testing following case detection was not happening quickly enough to prevent widespread transmission.

Key finding: There was frequently a delay between the first case detection in an institution and mass testing of exposed residents in response.

Key finding: Large numbers of cases were often detected when mass testing was deployed, indicating that multiple cycles of transmission likely occurred prior to mass testing

7.7.3. Reasons for Delays in Mass Testing Following New Case Detection

The reasons for the delays in mass testing and the high initial test positivity rates are manifold. Based on discussions with staff and residents at multiple institutions, they include the following:

- Delays between testing the index case and receipt of results
- Concealment of symptoms by residents, which could be due to the following: fear of removal from housing and separation from personal belongings if diagnosed with COVID-19, fear of getting sicker as a result of being housed with other symptomatic COVID-19 patients, lack of understanding of possible COVID-19 symptoms and/or risk of transmission to others
- Concealment of symptoms by staff, which could be due to the following: lack of sufficient sick leave, inconvenience of testing, lack of understanding of possible COVID-19 symptoms and/or risk of transmission to others
- Narrow definitions of who may have been exposed to the initial case due to guidelines—from CDCR and the CDC—regarding close contacts and the earlier focus on large droplets as the primary mode of transmission

Recommendation 7.7.1: Given the importance of rapid testing turnaround time, policymakers should consider negotiating contracts with testing companies where payment for tests is contingent upon results returning within 48 hours. If tests are not returning within 48 hours, institutions should work with their county Department of Public Health to explore options for expedited testing.

Recommendation 7.7.2: Remove barriers to the reporting of symptoms by residents (e.g., avoiding isolation or quarantine cells that are otherwise used for solitary confinement, allowing residents to bring their belongings with them when isolated, maximizing return of residents to their original housing location, facilitating communication with loved ones, education from trusted sources on the importance of symptom self-report).

Recommendation 7.7.3: Remove barriers to the reporting of symptoms by staff (e.g., guaranteeing fully paid sick leave, offering on site testing, education from trusted sources on the importance of symptom self-report).

7.7.4. Additional Responses to a New Outbreak

Beyond medically isolating the first new case(s) in an institution and immediately implementing mass testing, there are a number of measures that institutions should take in those crucial first few days. These are summarized below:

- Any new case should trigger the immediate deployment of the Incident Command Post (ICP) at the institution. This was reported as vital to a coordinated early response in a number of institutions, such as CIM and CCWF. Features of an effective ICP—as described to our team—include strong cooperation between custody and healthcare staff, prominent roles for high-ranking staff, frequent communication among ICP members, and decisive and clearly communicated decision-making.
- A pre-existing memorandum of understanding (MOU) between an institution and the local or state Department of Public Health (DPH) should establish what role DPH is going to play in outbreak response and what the triggers are for that involvement.
- A hierarchy of dedicated quarantine space should be established well in advance of any outbreak with the safest quarantine space filled with exposed individuals first. Quarantine in place should be considered when the housing among exposed individuals is safer than any remaining quarantine space. Quarantine should take place

in areas that maximize the environmental mitigation measures described throughout the report.

- Contact investigation of exposed residents should cast a wide net. All residents housed in the same air space as the index case should be considered a contact, irrespective of their distance from the index case. The same should apply to other indoor contacts, particularly those who share work assignments or participate in the same indoor programming.
- As described in **Section 7.4**, rapid antigen testing may be prioritized over PCR testing in response to outbreaks where exposed individuals are not in safe quarantine, particularly if the PCR testing turnaround time is 2 days or longer. High-frequency testing is also advantageous at stopping an early outbreak, with daily testing the ideal strategy—if feasible—before being spaced out to every 2-3 days when all individuals have tested negative in the prior cycle.

Key finding: Features of an effective incident command post (ICP) include strong cooperation between custody and healthcare staff, prominent roles for high-ranking staff, frequent communication among ICP members, and decisive and clearly communicated decision-making

Recommendation 7.7.4: Each institution should have a memorandum of understanding (MOU) with their local Department of Public Health (DPH) regarding the role DPH will play in outbreak response and what conditions will trigger the involvement of DPH.

Recommendation 7.7.5: Exposed residents should be housed in areas that maximize environmental mitigation measures described throughout the report. This includes (but is not limited to): 1) maximizing outside air exchange (opening windows and doors to the outside, setting HVAC systems to maximize the intake of air from the outside), 2) housing residents in areas where negative pressure can be achieved within cells, expelling potentially infectious aerosols to the outside, and 3) increasing air filtration (e.g., deploying MERV13 or higher air filters in the HVAC system and adding supplemental filters such as Corsi-Rosenthal boxes)

Recommendation 7.7.6: Respond to a new staff case with immediate, broad, testing of all potentially exposed residents and staff (rapid antigen testing preferred if PCR testing turnaround is ≥2 days or more). This includes all residents who are in any housing units

where the staff member may have worked while infectious and any others who may be housed in the same shared airspace where the staff member worked while infectious (irrespective of distance). Other staff and resident close contacts should be identified and immediately tested.

Recommendation 7.7.7: Respond to a new resident case with immediate, broad, testing of all potentially exposed residents and staff (rapid antigen testing preferred if PCR testing turnaround is ≥2 days or more). This includes all residents who are in the same housing unit and any others who may be housed in the same shared airspace as the index case (irrespective of distance). Other staff and resident close contacts should be identified and immediately tested.

Recommendation 7.7.8: The ideal testing strategy for a housing unit with an outbreak is to test daily until no new cases are identified. Once no new cases are identified testing can be spaced out to every 2-3 days until no new cases have been identified for 14 days (if new cases are identified then testing frequency should revert back to daily). Rapid antigen testing is preferred if the PCR testing turnaround time is ≥2 days.

7.8. Vaccination

The benefits of vaccination are well-documented and the impact of CDCR's staff and resident vaccination program is described above (**Sections 4.4 and 5.3**). As has been seen in the community, vaccination has dramatically lowered the risk of infection (and thus onward transmission), hospitalization, and death. How the imminent threat of Omicron is likely to change the efficacy of vaccines is discussed in **Section 13**; in short—while little is currently known as of December 22, 2021—we expect a substantial drop in vaccine efficacy (particularly against acquisition of infection, with less known about the impact on severe disease) and a heightened importance of booster shots (particularly with mRNA vaccines).

CDCR and CCHCS have made a huge and laudable push for resident and staff vaccination. This has been particularly successful on the resident side where the current rate of full vaccination (80%) exceeds the rate among all adults in California (77%) as of December 15, 2021.(1,2) Furthermore, nearly all residents eligible for boosters have been offered them and 80% (among the 80% who are fully vaccinated) have received a booster dose.

Examining vaccinations in the recent cohort (CDCR residents on October 9, 2021) where more detailed information is available, 65,436 (67%) unique residents were fully vaccinated without a booster, 3,877 (4%) were fully vaccinated with a booster, and 1,880 (1.9%) were partially vaccinated (**Table 7.8.1**). Regarding vaccine types, 11,726 (12%) had received 2 or more doses of the BNT162b2 (Pfizer) vaccine, 51,587 (53%) had received 2 or more doses of the mRNA-1273 (Moderna) vaccine, and 6,008 (6%) had received 1 or more doses of the Ad26.COV2.S (Janssen/J&J) vaccine.

Despite successes in resident vaccination, the vaccination push is not over. In the months ahead, vaccination uptake will continue to be vital and the focus is likely to be on increasing uptake of booster doses, continuing to address vaccine hesitancy (particularly among staff), and preparing for a rollout of next generation mRNA vaccines better targeted to emerging variants of concern, such as Omicron. In the following sub-sections, we describe the characteristics of residents who have declined vaccination, briefly summarize the importance of booster doses, describe the asymmetry of vaccine uptake in housing units, and then focus on a number of targeted suggestions to increase vaccine uptake.

Table 7.8.1. Descriptive statistics of vaccination among continuous and recent cohorts.

	Continuous Cohort N = 73,318		Recent Cohort N = 97,740	
	Freq	Mean or %	Freq	Mean or %
Total Residents				
Not vaccinated	12,725	17.4%	26,547	27.2%
Partially vaccinated	1,218	1.7%	1,880	1.9%
Fully vaccinated without booster	**55,960**	**76.3%**	**65,436**	**66.9%**
Fully vaccinated with booster	**3,415**	**4.7%**	**3,877**	**4.0%**
Number of vaccines of type				
BNT162b2 (Pfizer) vaccine				
2 or more	**10,891**	**14.9%**	**11,726**	**12.0%**
0	62,241	84.9%	85,771	87.8%
1	186	0.3%	243	0.3%
2	9,379	12.8%	10,017	10.3%
3	1,512	2.1%	1,709	1.8%
mRNA-1273 (Moderna)				
2 or more	**45,065**	**61.5%**	**51,587**	**52.8%**
0	27,129	37.0%	44,405	45.4%
1	1,124	1.5%	1,748	1.8%
2	43,164	58.9%	49,426	50.6%
3	1,900	2.6%	2,158	2.2%
4	1	<0.0%	2	<0.0%
5	0	<0.0%	1	<0.0%
Ad26.COV2.S (Janssen/J&J) vaccine				
1 or more	**3,424**	**4.7%**	**6,008**	**6.2%**
0	69,894	95.3%	91,732	93.9%
1	3,422	4.7%	6,001	6.1%
2	2	<0.0%	7	<0.0%

7.8.1 Characteristics of Residents Declining Vaccination

CDCR residents and staff rightfully received priority access to COVID-19 vaccination as early as December of 2020 and vaccination coverage in institutions outpaced vaccination rates in the general California adult population, particularly early in the pandemic (Figure 7.8.1). A number of residents have continued to refuse vaccination but—encouragingly—CDCR has continued to develop meaningful approaches to offering vaccination to these individuals. While many have declined vaccination on multiple occasions, there have been a number of successes, as the proportion of vaccinated residents has increased from 71% on October 9th, 2021 to 80% on December 15, 2021. Among the 34,089 individuals in the recent cohort who have refused a vaccination at least once, 41% accepted at least one dose when vaccination was "offered" again. We were informed that CDCR offered the first round of vaccinations as standing orders for all patients, and subsequent rounds among those who initially declined were orders placed after speaking with the patient. Table 7.8.2 further demonstrates the importance of offering

vaccination to unvaccinated residents on multiple occasions: even some individuals who refused vaccination as many as 7 times eventually accepted and are at least fully vaccinated, and many more accepted to be fully vaccinated after far fewer refusals.

Figure 7.8.1. Vaccine doses and refusals over time.

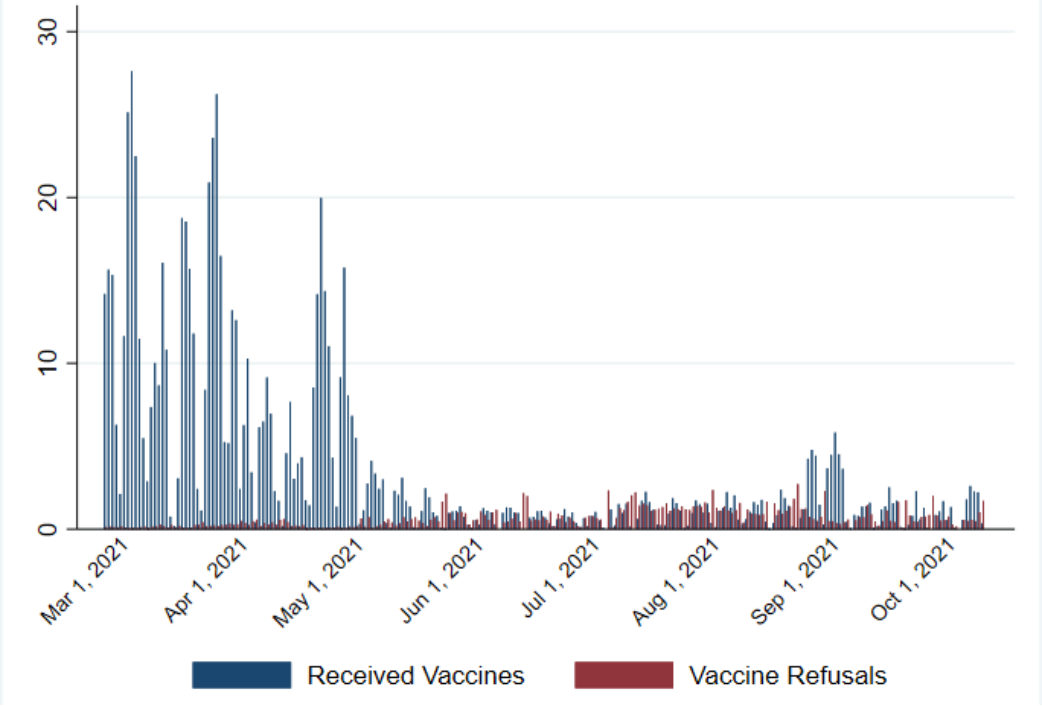


Table 7.8.2. Descriptive statistics of refusals across vaccination status among recent cohort.

No. Refusals	Not Vaccinated	Partially Vaccinated	Fully Vaccinated w/o Booster	Fully Vaccinated w/ Booster	Total
0	6,538	188	53,333	3,592	63,651
1	9,188	554	9,209	174	19,125
2	8,349	642	1,878	47	10,916
3	2,018	342	819	51	3,230
4	366	122	147	9	644
5	60	23	36	3	122
6	21	8	11	0	40
7	7	1	3	1	12
Total	26,547	1,880	65,436	3,877	97,740
% Recent Cohort	27.2%	1.9%	66.9%	4.0%	

Select variables associated with resident vaccine acceptance as of March 4, 2021 (when 67% of the resident population had received at least one dose of vaccine) have been reported

previously using CDCR data.(3) Examining full vaccination rates in the recent cohort (Table 7.8.3) demonstrates that acceptance was highest among the Latino(a)/Hispanic (Mexican) group (84%), unknown or other races (78%), and White (73.4%) residents and lowest among Black/African American residents (65%). Acceptance was also higher among residents 55 years or older (87% vs. 67% of those younger than 55 years) and those with higher COVID-19 risk score categories (93% of individuals with COVID-19 risk score 7 and higher, 87% of those with COVID-19 risk scores 4-6, 69% of those with scores 0-3). Those who had prior COVID-19 also had higher rates of full vaccination than those who were never infected (82% vs. 63%, p-value < 0.001). Vaccine messaging campaigns at the population level could target these demographic groups with lower rates of vaccine uptake.

Table 7.8.3. Descriptive statistics of those who are fully vaccinated and not fully vaccinated in the recent cohort.

	Recent Cohort (N = 97,740)				
		Not fully vaccinated		Fully vaccinated	
	Total	*N*	*Row %*	*N*	*Row %*
Gender					
Female	3,541	1,126	31.8%	2,415	68.2%
Male	94,199	27,301	29.0%	66,898	71.0%
Age Group					
Younger than 30	18,447	8,501	46.1%	9,946	53.9%
30 to 39	29,637	10,453	35.3%	19,184	64.7%
40 to 49	22,390	5,534	24.7%	16,856	75.3%
50 to 64	21,517	3,406	15.8%	18,111	84.2%
65 or older	5,749	533	9.3%	5,216	90.7%
Race					
Asian or Pacific Islander	1,385	416	30.0%	969	70.0%
Black	27,884	9,879	35.4%	18,005	64.6%
Latino(a) / Hispanic (non-Mexican)	31,405	9,742	31.0%	21,663	69.0%
Latino(a) / Hispanic (Mexican)	12,614	2,048	16.2%	10,566	83.8%
American Indian/Alaskan Native	1,193	326	27.3%	867	72.7%
White	19,333	5,142	26.6%	14,191	73.4%
Other or Unknown	3,926	874	22.3%	3,052	77.7%
COVID-19 Risk Scores					
Low Risk: 0-3	86,560	27,165	31.4%	59,395	68.6%
Intermediate Risk: 4-6	6,890	875	12.7%	6,015	87.3%
High Risk: 7 and higher	4,194	292	7.0%	3,902	93.0%
Unknown	96	95	99.0%	1	1.0%
Prior infection					
No	57,734	21,425	37.1%	36,309	62.9%
Yes	40,006	7,002	17.5%	33,004	82.5%
Vaccine					
mRNA-1273 (Moderna): 2 or more	97,740	N/A	N/A	49,426	50.6%
BNT162b2 (Pfizer): 2 or more	97,740	N/A	N/A	10,017	10.2%
Ad26.COV2.S (Janssen/J&J): 1 or more	97,740	N/A	N/A	6,001	6.1%

Recommendation 7.8.1: Offer vaccination to every resident who is unvaccinated or not boosted at every encounter with the healthcare system.

Recommendation 7.8.2: Target vaccine messaging campaigns to the demographic groups most likely to be unvaccinated; this includes residents who are Black/African American, of younger age, have a lower COVID-19 risk score, and who have not been previously infected

7.8.2 Waning Vaccine Efficacy and Boosting

Gradual waning vaccine efficacy in the months following immunization is now well documented.(4-6) Boosting a primary immunization series is recommended by the CDC for all adults.(7) Current guidance recommends boosting at least 6 months after completing a primary 2-dose mRNA vaccine series or at least 2 months after receiving the 1-dose Ad26.COV2.S (Janssen/J&J) vaccine. CDC has stated a preference for boosting with an mRNA vaccine over Ad26.COV2.S (Janssen/J&J).(8) The evidence for boosting is growing and is now supported by multiple studies across all three approved vaccines.(9-11) As described in section 11, boosting with an mRNA vaccine may provide substantially more protection against the Omicron variant than a primary series alone.(12,13)

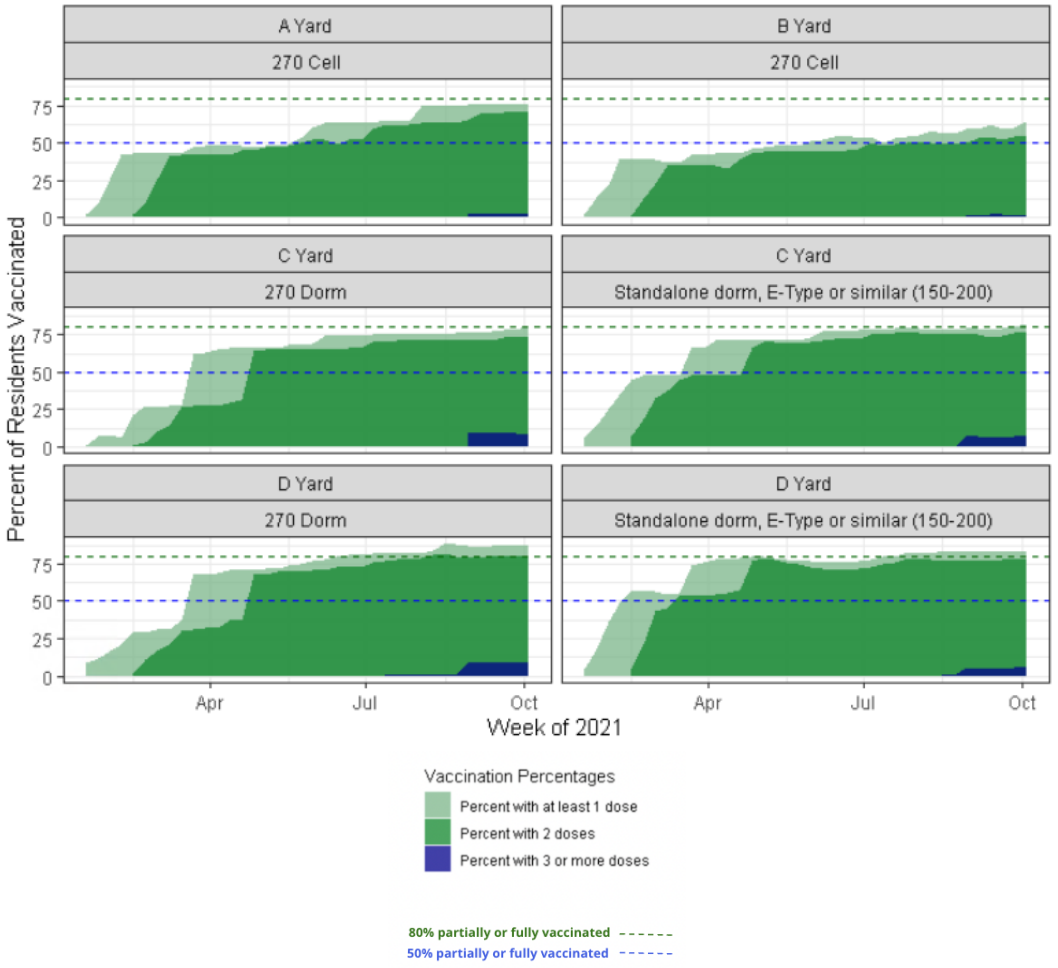
Given the decline in vaccine efficacy, the emergence of the Omicron variant, and evidence on the effectiveness of boosting, CDCR staff and residents should not be considered fully vaccinated unless they have received a primary COVID-19 immunization series and a booster dose. Consideration could be given to allowing individuals to be classified as fully vaccinated if they have had a prior documented infection and a full primary vaccination series with an mRNA vaccine (irrespective of boosting) but the evidence that these individuals have a degree of immune protection that is comparable to boosted individuals is not strong at the moment. This new definition of "fully vaccinated" can be adopted for operational planning purposes when fully vaccinated residents and staff are allowed to take part in activities and work responsibilities that involve mixing with more individuals within the institution or visitors. This approach—with a sound scientific evidence base—may also have the secondary effect of increasing booster uptake as the opportunity to partake in activities with greater mixing (e.g., programming, work programs, and visitation) is highly valued by many residents.

Recommendation 7.8.3: To be considered fully vaccinated, individuals must have received a complete primary vaccination series (two mRNA vaccines or a single shot of the Ad26.COV2.S vaccine, also known as the Janssen/Johnson & Johnson vaccine) followed by a booster dose with an mRNA vaccine if they are eligible for a booster.

7.8.3 Assessing Differential Vaccine Risk in Resident Housing

Studies have demonstrated a social component to vaccine acceptance; individuals are more likely to be vaccinated if peers, friends, and family members are also vaccinated. This social component—combined with CDCR housing policies that group residents in different housing units based on security concerns, medical needs, mobility, and health issues—has likely led to asymmetrical vaccine uptake across CDCR housing units. The heterogeneous rates of vaccination inside a prison merit tracking at each institution as they present a differential risk of outbreaks at the yard, building, and housing unit level. **Figure 7.8.2** provides one such as example (from California State Prison Solano, SOL); rates of completing a primary vaccination series at the level of the yard (through September of 2021) range from approximately 50% to 75%. This information could be used to identify buildings that are higher priority for prevention and mitigation measures (e.g., increased testing, ventilation, and air filtration).

Figure 7.8.2. Example of variation of vaccination rates across yards at Solano between January and September 2021.



Recommendation 7.8.4: Vaccination rates should be tracked at the level of individual buildings and housing units; areas with low vaccination rates may be higher priority for measures to reduce the risk of COVID-19 introduction and spread.

7.8.4 Staff Vaccination

A discussion on staff vaccination is included in **Section 5.3**.

7.8.5 Strategies to Increase Resident and Staff Vaccine Update

At the initiation of CCHCS, CalPROTECT participated in a highly effective vaccination drive at Salinas Valley State Prison that also involved prison staff, a meditation teacher, and a representative from the Prison Law Office. Details of the event and lessons learned regarding increasing vaccine uptake among residents are described in **Sections 9.2 and 9.3**.

A review of the evidence base for addressing vaccine hesitancy is beyond the scope of this report but we strongly recommend CDCR engage with external partners to build institutional capacity to promote vaccination and tailor an ongoing vaccination campaign to the unique needs of their residents and staff. One such program, offered free by the California Virtual Training Academy (a group with representative from CDPH, UCSF, and UCLA) addresses vaccine communications and is designed for "Local Health Jurisdiction (LHJ) and state employees who will be working in the area of COVID-19 vaccine outreach and communication."(14)

Recommendation 7.8.5: Engage with external partners to build institutional capacity to promote vaccination and tailor an ongoing vaccination campaign to the unique needs of their residents and staff.

Case Study: The Alpha Variant Outbreak Investigation at California State Prison, Solano (SOL)

This box summarizes our investigation of the Alpha variant outbreak at California State Prison, Solano (Solano; SOL) and how transmission was influenced by vaccination.

The Solano Alpha variant outbreak began on May 21, 2021, when two patients were found to be positive for SARS-CoV-2, with a few additional cases detected in the following days. The outbreak occurred on the institution's A Yard, which is comprised of six 270 building structures. Cases were contained to 4 buildings out of 6 on the yard (A-02, A-04, A-05, A-06), with the majority of cases in Building A-05, where it was first detected. Because there was resistance to testing, Solano leadership requested authorization from headquarters for mandatory testing, which was approved on May 26. More than 20 cases were detected on both May 27 and 28. The outbreak was contained in June after a total of 92 identified cases.

During the outbreak, records show that all but 4 residents of these buildings were tested (reasons for why these residents remained untested are unknown), demonstrating almost complete testing coverage. Once mass testing was implemented, medical leadership was able to respond with appropriate use of quarantine and isolation, and the outbreak was contained.

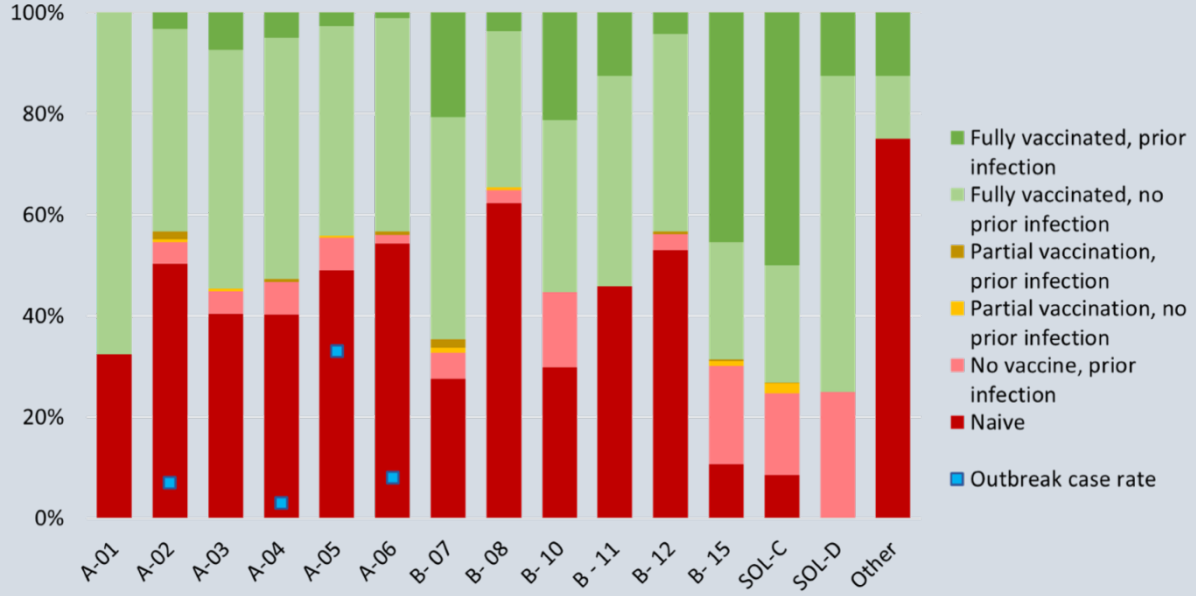
In investigating this outbreak, our key questions were the following:

1. How effective was vaccination in this outbreak?
2. How effective was it against symptomatic and severe infection?
3. How did the vaccination status of an individual's cellmate affect how likely that individual was to get infected?

Figure 7.8.3 shows the vaccination status of residents at Solano the day before the first case was detected. It demonstrates that that the vaccination rates in yards A and B were significantly lower than those in C and D on the far left (these are aggregated across the yard). In our conversations with staff and leadership we learned that this was, in part, because C and D yard residents were older than Yard A and B residents and that many experienced infections early in the pandemic. Older residents are more likely than younger adults to be vaccinated in CDCR. In addition, a more negative personal experience with COVID-19 may have contributed to higher vaccine acceptance rates. Overall, it seems likely that low vaccination rates in A and B, contributed to the outbreak.

It is also worth noting that Building A-01—which did not have any known cases—only housed fully vaccinated and never positive (or "naïve") cases. As such, it is an interesting model for preventing transmission. Building A-01, the Delancey Street program, also has a different housing configuration regarding the number of individuals in cells and their spacing within cells. At the time of the Alpha variant outbreak, there were approximately 70 people in A01, compared to 180 in A-02.

Figure 7.8.3. Vaccination Status and Outbreak Cases by Building on May 20, 2021 at California State Prison, Solano



Note: May 20, 2021 is the date before the first case was detected in the May outbreak (May 21, 2021). "Fully vaccinated" in this context refers to vaccination status at the time of the outbreak, representing either one dose of an Ad26 vaccine or two doses of an mRNA vaccine.

Preliminary Study Results (Among Residents of Outbreak Buildings):

Using epidemiological models (not shown), we assessed vaccination and infection rates among the 720 residents housed in the four outbreak buildings (A-02, A-04, A-05, A-06). We found:

- Among the four outbreak buildings, 330 people were fully vaccinated, 9 were partially vaccinated, and 381 people had no vaccination.
    - 78/92 cases **(85%) were among unvaccinated people**; there were no cases in partially vaccinated people.

- In this outbreak, **20% of unvaccinated people became infected, and 4% of vaccinated people became infected.**
    - After accounting for age and COVID risk, **vaccines were approximately 81% effective against infection.**
    - **For symptomatic infections, effectiveness was about 90%.**

There were no hospitalizations and only one person required oxygen. As a result, we cannot make estimates about vaccine efficacy in preventing severe disease.

We also found that vaccination status has a distinct effect on transmission among cellmates:

For **unvaccinated** residents (n=381, 53% of total), the rate of infection was:

- **11%,** when they **lived alone** (4 cases)
- **17%,** when their cellmate was **vaccinated** (19 cases)
- **23%,** when their cellmate was **also unvaccinated** (55 cases)

For **vaccinated** residents (n=330, 46% of total), the rate of infection was:

- **2.2%,** when they **lived alone** (1 case)
- **4.5%**, when their cellmate was **unvaccinated** (5 cases)
- **4.4%,** when their cellmate was **also vaccinated** (8 cases)

We found that unvaccinated people living with an unvaccinated person had a higher risk of infection than those who lived alone or who lived with vaccinated cellmates. This suggests that unvaccinated people may receive some protection from their vaccinated cellmates, and that a cellmate's vaccination status may influence overall risk. However, a cellmate's vaccination status did not appear to change how likely vaccinated residents were to become infected.

In summary, our findings suggest: (1) earlier mass testing may have reduced the size of the outbreak at Solano prison, but surge testing after residents were mandated to be tested may have helped interrupt transmission, (2) vaccination was highly effective, especially against symptomatic disease, and (3) cellmate vaccination may have provided additional protection to the unvaccinated.

This analysis should be interpreted with the following limitations in mind: (1) this investigation does not provide specific data on newer COVID-19 variants (Delta and Omicron), and (2) we cannot make conclusions on the waning effectiveness of vaccines, as the majority of people who experienced the outbreak were vaccinated fewer than 3 months before it began (waning immunity is more likely to occur around 6 months post-vaccination).

This text complements the case report for Solano, which can be found in ***Supplemental Presentation S12.SOL.*** All case reports are described in **Section 12**.

7.9. Summary of Outbreak Prevention and Mitigation Measures

COVID-19 outbreak prevention and mitigation measures fall into three broad phases: (1) reducing the probability of introduction of the virus into each institution, (2) reducing the probability of transmission from an introduced case prior to identification of the case, and (3) reducing ongoing transmission from an identified case/cluster. Here we present a summary framework for how to approach these three phases of COVID-19 prevention and mitigation. Many of the strategies for each phase have been discussed in the proceeding section of this report.

7.9.1. Reduce the probability of introduction of the virus into each institution

1. Reduce the probability of infection among staff, visitors and residents transferring into the system by:
    a. Obligating staff, visitors, volunteers, and residents seeing visitors to become vaccinated and boosted
    b. Encouraging staff families to become vaccinated
    c. Requiring use of masks by visitors and residents when visiting indoors
    d. Encouraging visitation outside whenever possible
    e. Optimizing a combination of frequent testing of people coming daily into the prison with stringent masking while in the prison, taking into consideration community prevalence rates in their communities of origin. Staff infections may be less likely than resident infections to appear in clusters, so detecting individual infections as soon as possible is key. To do this,
        i. Consider frequent pooled testing of staff – ideally daily, ideally with on-site PCR to enable testing of large pools with a high sensitivity. This has been implemented at SFO for much larger volumes of people who are in transit and could be implemented with minimal disruption at California's state prisons.
        ii. Consider frequent self-testing by providing self-test kits to staff that they are expected to report via app or through another reporting mechanism

7.9.2. Reduce the probability of transmission from an introduced case prior to identification of the case

1. Reduce the population to decrease crowding
2. Increase ventilation
3. Improve/increase filtration
4. Encourage exercise outside instead of inside

5. Require masks in group settings where possible (this is difficult at nighttime or when eating)
6. Target testing of any housing or work units exposed to an infected staff member or visitor
7. Incentivize early detection of infections via volunteering for testing for any symptoms (such canaries should be rewarded!)
8. Implement institution-wide screening in proportion to risk (staff infections, community infections, etc.). Such screening should be as continuous as possible (10% of a housing unit every day is significantly better than 100% of a housing unit every 10 days) and should prioritize unvaccinated individuals. The goal here is early identification of a new outbreak to enable early response measures.

7.9.3. Reduce ongoing transmission from an identified case/cluster

1. Immediate quarantine status for any affected unit even prior to movement/isolation
2. Immediate activation of quarantine ventilation procedures
    a. Maximize ventilation, open doors/windows, window/door fans, supplemental air scrubbing filters
3. Immediate distribution (equipment already in units) of n95 masks for all residents in cells with other people or in day rooms
4. Immediate mass testing with rapid tests and removal to isolation of anyone positive
5. Movement to quarantine of anyone living in the same cell/dorm with an infected person
6. Consider moving to quarantine anyone in the same housing unit living with more than one other person, especially those sharing the same day room.
7. Daily mass testing with rapid tests or one-day-turnaround PCR until no positive cases are detected for two days then every other day, then every third day. This is highest priority for anyone in quarantine with more than one other person and is not necessary for those in single-cell quarantine.
8. Restrict time outside of cells to the minimum possible while in the building but maximize time spent outdoors.

8. Experiences of the COVID-19 pandemic among those working and living in CDCR institutions

8.1. Introduction

The primary goal of this portion of the CalPROTECT project was to understand and document the experiences of those living and working in CDCR institutions during the COVID-19 pandemic. Each section of this report addresses a set of major themes that emerged from our conversations with residents and staff, as well as from analyses of relevant survey responses. We offer key findings and recommendations drawn from our interviews and survey data.

8.1.1 Data and Empirical Approach

Between January of 2021 and August of 2021, we engaged in a wide range of semi-structured conversations with staff and residents across California's state prisons. In January and February 2021, we conducted twelve in-depth conversations via Zoom with Chief Medical Executives (CMEs), Chief Nursing Executives (CNEs), and California Correctional Peace Officers Association (CCPOA) chapter presidents at eight CDCR prisons. We used these initial conversations to develop core questions relating to the wide-ranging themes that emerged, including experiences during the pandemic regarding quarantine, vaccination, and COVID-related policies.

Between February and August 2021, we participated in visits to eight of the 10 CalPROTECT institutions visited, including one (SOL) which we returned to for a second visit. During these visits, we engaged in conversations with over 250 individuals. We used the information collected in these discussions to describe common experiences among California Department of Corrections (CDCR) and California Correctional Health Care Services (CCHCS) stakeholders during the pandemic.

- California Substance Abuse Treatment Facility, Corcoran (SATF) - June 29-30, 2021
- California Medical Facility (CMF) - June 22, 2021
- Correctional Training Facility (CTF) - March 2, 2021
- Central California Women's Facility (CCWF) - May 4-5, 2021
- Richard J. Donovan Correctional Facility (RJD) - June 7-8, 2021
- California Institution for Men (CIM) - June 14-15, 2021
- California Institution for Women (CIW) - June 16-17, 2021
- California State Prison, Solano (SOL) - July 15-16, August 24, 2021

These site visits included both one-on-one and group conversations with institutional leadership, supervisors, and frontline staff from medical, nursing, and custody teams, and with members of the Inmate Advisory Council (IAC) at each institution. While we used semi-structured interview guides for these discussions, we also allowed our conversations to focus on the topics most pressing for those with whom we spoke. For the purpose of confidentiality, we have excluded from this report any details that would potentially reveal the identity of individuals or institutions.

We did not conduct interviews with individuals from CDCR headquarters nor from CCHCS leadership. As a result, the perspectives and ideas we document do not necessarily fully reflect the experiences of these leaders and their staff or their recommendations.

Qualitative Interviews

We transcribed notes during our conversations, and later coded these notes using an inductive process by topic, as well as by institution, speaker, and tone. This allowed us to systematically elucidate the major themes arising across institutions and categories of people. Our four-person coding team met on a weekly basis over the course of several months to discuss progress and resolve questions about how to code specific statements. This allowed us to clarify as a team how we were approaching the coding process, helping to ensure that the process was consistent across coders.

In this report, we summarize the findings from our visits and conversations. Our results represent a broad cross-section of the experiences of institutional leadership, staff, and incarcerated people. Again, this report is focused on the facility level and does not include perspectives of people from CDCR or CCHCS headquarters.

Survey Data

This report also includes findings from surveys we conducted with correctional staff in 2017 and 2020. The 2017 survey was designed to understand the well-being, attitudes, and needs of CDCR correctional officers. The survey was fielded both online and through postal mail and included more than 60 questions to assess officers' exposure to violence, mental health, perceived level of organizational support, and attitudes towards rehabilitation and the purpose of prison. In total, 8,334 officers completed the survey, a response rate of 42%. Respondents were broadly representative of the officer population by race and gender and were drawn from all CDCR institutions.

In 2020, we fielded a second survey via email to understand the impact of COVID-19 on CDCR officers, including their experiences with mitigation efforts at work and the effects of the pandemic on their mental health and well-being. The respondents (n=1,761) were broadly

representative of the overall CDCR correctional officer population regarding general demographics. In this survey, we repeated a subset of questions from 2017 and included new questions to assess officers' experiences with COVID-19, the extent to which COVID-19 had made their job more difficult, and what resources they needed during the pandemic. The results of these surveys largely reinforced the findings from our interviews and provide additional context for our results.

8.2. The Impact of Pre-Existing Challenges

A variety of pre-existing challenges, including a complex communication structure, staffing shortages, and low morale, made it difficult for institutional leadership, staff and residents to prepare for and curb the effects of the COVID-19 pandemic. These challenges were exacerbated by other pre-existing constraints including the physical layout of the facilities and overcrowding. A consistent finding across the system was summarized aptly by one staff member: "we felt doomed from the start."

8.2.1 Physical Layout and Population Size

Leaders and residents throughout the system shared their belief that the combined effect of the physical layout and population size at each CDCR institution made it extraordinarily difficult to prepare effectively for and respond to the pandemic. In the months leading up to the pandemic, eleven institutions and reception centers were over 100% capacity, with most institutions being at or above 90% capacity.[1] As COVID-19 began to spread throughout the United States, the population size dropped in each institution, though the amount and types of space available for quarantine in each facility remained limited. Consistently, participants described the belief that "space and layout constraints made everything worse."

"We felt doomed from the start."

The looming prospect of the rapid spread of COVID-19 in the close congregate settings of CDCR institutions weighed heavily on the minds of everyone we spoke with in the institutions. Many staff and leaders described their profound concern that it would be impossible to identify and make available enough appropriate space within the institution to implement swift and safe quarantine or isolation during large outbreaks.

Key finding: Many residents and staff believed that the correctional system was unprepared to respond to an emergency at the scale of the COVID-19 pandemic. As one staff member noted, "The system needs to already be in place when you really need it."

Recommendation 8.1: Emergency contracts, equipment, policies, and relationships with community partners need to be established *before* times of crisis. For example, the department might consider establishing longer-term contracts now with the companies that supplied needed resources during this pandemic, so that these contracts can be called on quickly in the future if needed.

Recommendation 8.2: Draw on lessons learned during this pandemic to develop clear plans for how to maintain critical operations during prolonged emergency situations at every institution. These plans should outline several contingency strategies for how an institution might respond to different scenarios, so that local leadership can adapt to the specifics of their own situation.

Recommendation 8.3: If not already in existence, establish a community liaison unit at every institution that builds on or shores up community partnerships so that institutions can turn to them for support during future emergencies.

8.2.2 Complex Communication and Operations Infrastructure

Running the California state prison system involves managing a complex communication and operational infrastructure at the best of times. The system employs over 50,000 people across 34 institutions working across 3 shifts with up to 120,000 incarcerated individuals. It is serves many different functions (e.g., housing, healthcare, rehabilitation) and operates within the constraints of many different policies and legal requirements. This complexity meant that when the threat of COVID-19 emerged, there were a multitude of programs and services that became even more complicated to coordinate. From converting meal times from chow halls to cells, to arranging one-to-one escorts for patients to attend pill lines and health appointments, to trying to identify ways to enable residents to access yard time and programming despite lockdowns during outbreaks, the day-to-day operations of each institution during the pandemic became increasingly stressful and chaotic for people who lived and worked in them.

8.2.3 Staffing Shortages

Even prior to COVID-19, CDCR institutions were facing staffing shortages. According to COMPSTAT reports, vacancy rates among uniformed custody staff averaged 5% in the early months of the pandemic, with other types of prison staff experiencing vacancy rates as large as 13-17%. In response to a question in the 2017 survey, 70% of officers reported believing there

were not enough staff where they work to provide for the safety and security of staff. Notably, in 2017, 67% of officers stated that they would immediately take another job if they were able to find one that offered similar salary and benefits. These findings, alongside findings from our interviews (described below), suggest that at the outset, staff already had profound concerns about the impact the pandemic would have on these pre-existing shortages, creating additional work related to the implementation of mitigation measures and lockdowns, and adding additional vacancies due to illness and resignations.

8.2.4 Morale and Distrust

An overwhelming theme that emerged in our conversations, with incarcerated people, medical staff and correctional staff alike, was the significant distrust that exists across the CDCR system even prior to COVID-19. In the 2017 survey, for example, 82% of officers perceived their supervisors as competent, but about half did not think their supervisors cared at all about their feelings. This lack of trust likely contributed to concern and perhaps anger about how staff would be taken care of during the pandemic. For example, in response to an open-text question on the 2020 survey, an officer stated: "Nobody cares about you. We are not appreciated in any way at all;" and "Rank and file are mostly just numbers. If you get sick or die, it's just another day."

"Rank and file are mostly just numbers.
If you get sick or die,
it's just another day."

8.2.5 Emergency Response Infrastructure

Across the system, participants reported frequently that the pre-existing emergency response infrastructure within CDCR was inadequate or inadequately understood by those at the institution level. In a survey conducted with CDCR staff in 2006, roughly 15% of respondents indicated that they were not aware of plans at their institution for how to respond in the event of an emergency situation, or they were unsure of whether or not such plans exist. Of those staff that had been made aware of emergency plans, almost a quarter (23%) reported that those plans were either very or somewhat unclear.[2]

More recently, in 2017 roughly a quarter of officers (23%) reported having never received training in how to work with incarcerated people who were sick or dying. Of those who had received at least some training, 67% rated the quality of that training as either fair or poor (as opposed to good or excellent). These deficits appeared to leave institutional leadership and staff feeling ill-equipped to leverage training or emergency infrastructure appropriately and effectively in their pandemic response.

8.2.6 Mental Health and Support Services

Participants reported that prior to COVID-19, the mental health and social support services available to residents within CDCR institutions were limited. Both staff and residents reported that even prior to outbreaks, staffing shortages and competing institutional priorities limited resident access to mental health services and other programming. Likewise, staff also reported a lack of access to confidential, quality services and programs related to health and well-being (before the pandemic). High levels of stress and limited access to supportive services before the pandemic likely set the stage for many residents and staff to feel even worse with the added pressures of the pandemic.

8.3. Difficulties in Communication During the Pandemic

Throughout the pandemic, communication was reported to be an issue at many institutions, both between staff and residents and between leadership and staff. All institutions that we visited utilized and relied heavily upon Incident Command Posts (ICPs) for decision-making, information-sharing, and other emergency response activities. Especially during outbreaks, ICPs met and sent out information daily. During the pandemic when there were no outbreaks, the ICPs met one to several times per week to update one another and communicate new policies or changes to existing policies.

At the same time, the decision of who shared what communication, when, and through what medium varied across institutions. During the early period of the pandemic, staff in particular described facing myriad questions about how to keep themselves safe, as well as their families, their peers, their colleagues, and those under their care. In early 2020, almost three-quarters (73.3%) of CDCR officers reported feeling that COVID-19 had made it more difficult for them to protect their health. About 45.6% also reported the belief that COVID-19 had made it more difficult to manage tensions between staff, and 55.5% said the same about managing tensions between staff and prison residents. Yet many staff reported a lack of input from headquarters about how to address these concerns, and difficulties communicating about these and other issues with residents.

8.3.1 Staff-Resident Communication

"No one cared how bad it was."

Political and social pressures around the ethics of managing COVID-19 in a carceral setting loomed in many staff member's minds (especially healthcare staff) and were reinforced by the protests taking place at many prison gates. People incarcerated in CDCR institutions shared with us the helplessness and anxiety they felt at being unable to take steps to keep themselves and their loved ones safe. Residents reported a "helpless feeling that no one cared how bad it was."

There was substantial heterogeneity in who had access to what information across resident populations and different facilities within the eight institutions we visited. At best, residents heard regularly from staff about policies, including education around vaccination. In a striking counterexample, some respondents reported that the PA system was broken and never fixed, so "officers would just stand and yell down hallways". Moreover, many Inmate Advisory Council (IAC) members reported to us significant difficulty in getting reliable and clear information from staff or leadership.

Even when there was good communication from executive management to line staff, many people reported that information often did not trickle down to residents. One IAC member stated that it was "like pulling teeth" just to get a copy of the Operational Daily Report, which he believed the IAC was supposed to receive every day. Often, residents reported that medical teams also did not provide sufficient (if any) information. They described wanting information and interactions but finding that healthcare staff were frequently unavailable.

Additionally, residents described that it was often quite difficult for IACs to fulfill their obligation to communicate with one another and with other residents even at institutions where residents had access to electronic tablets. For example, at one institution, tablets only worked in the day rooms because the wireless connection that was available in the hallways was not compatible. When the residents lost access to the dayroom due to lockdowns, they lost access to the tablets. In some institutions, the lack of information shared with IACs undermined the prison population's trust in IACs.

Several staff with whom we spoke acknowledged the need for improved communication with residents and information-sharing to keep them informed and up-to-date, especially when decisions were made that might not make sense or that could be frustrating to residents. One

example that was offered was that the movement of a new person into a unit that was COVID-free engendered a great deal of fear about whether the new person would introduce COVID. According to staff and residents, some staff did a great job being proactive, sharing why this move was happening and what precautions they took to ensure it was a safe decision. In other contexts, however, residents experienced COVID-19 protocols, including the mass movement of residents, as chaotic and reported that they were not provided with clear explanations of where, when, and why protocols were being implemented. A feeling of "terror" among residents was a consistent theme during this period and was exacerbated by the powerlessness felt by many residents.

In the facilities we visited, residents described watching the early days of the pandemic unfold on the news. Because they could not rely on information coming from staff or institutional leaders, many reported that their *primary* source of information during this stage was the television news. They reported feeling frustrated to see recommendations from the Center for Disease Control (CDC) that seemed out of line with the protocols being implemented in their institution.

Residents also reported witnessing decision-making that appeared to be chaotic. Since the reasons behind a policy or policy changes were not well-known or communicated, residents frequently described coming up with their own reasons and understanding for why policies were written the way they were or why they had changed. As a result, residents often filled in the gaps with limited information or based on prior experiences, which frequently meant they inferred that changes in policies were motivated by malice or neglect. As one IAC stated, "it felt like they were trying to kill us." Meanwhile, correctional staff described feeling frustrated that they were rarely given the opportunity to understand the reasons behind policies, or *why* the policies were written the way they were. This hindered their ability to articulate the reasoning to residents or to each other. In the absence of context on <u>why</u> policies were being implemented, some policies felt ill-suited to even the staff's needs, or even antithetical to maintaining the safety of residents and fellow staff.

For example, residents described not understanding why people from entire hallways would be moved when only one individual tested positive on the unit. Residents described feeling that rules were altered or disregarded only when it benefited the institution or its staff, such as being lax about mask-wearing and social distancing, mixing housing units, and increasing the number housed in units beyond their stated capacity. We heard another example of this concern when residents reported that they were originally told that quarantine was for 14 days, and then it changed to 8 days, and then changed back to 14 again. Residents were not told why the policy changed and, therefore, were left to surmise the motivation behind these

changes, but when we asked correctional staff about these changing policies, few had any knowledge about the reasons that they were changing with such frequency.

Residents often took the initiative to share information with others in the prison population on their own, including making and printing their own posters and newsletters. The Life Support Alliance (LSA) lifer's newsletter and the newsletter started by a member of the IAC at CIM were both highlighted by residents as invaluable resources for staying up to date on COVID-19 developments. One resident noted that they would use newsletters to share updates with their community, including program status reports (PSRs) since they were not accessible to residents who were quarantined. Clear information from trusted sources was largely unavailable, but incredibly valued when it was present and contributed to building trust in and compliance with policies.

Residents also described that communication with their families was challenging during this period. Family members of residents were deeply concerned for the well-being of their loved ones and called frequently to check on the status of their incarcerated family members. At one point, amidst the chaos of responding to the pandemic and inadequate resources to appropriately staff the phones, we heard reports that phone calls in at least some institutions stopped being answered altogether. When families would call in, they were met only with a recording which stated that the system was experiencing "technical difficulties," leaving families with no information about the well-being of their incarcerated loved ones.

We heard from one IAC that video visits had been a crucial way for residents to connect with family during the pandemic when in-person visits were suspended. However, the availability of video visits was reportedly hampered by the security requirement that individuals undergo the same level of administrative background check as an in-person visit, despite the visit being virtual. This IAC member suggested that the approval process for video visitation be made simpler, to reduce the burden on family members and staff. Despite these challenges, members of every IAC we spoke with also acknowledged that COVID-19 posed exceptional challenges for staff and expressed gratitude to those who had continued to show up and do their jobs to the best of their ability during this difficult time. Residents were especially thankful to medical staff who made an effort to speak directly with them and described their presence as being appreciated and truly necessary during this period of uncertainty. Some residents described dedicated correctional staff who went above and beyond their job description to share information and connect with residents. For example, at one institution, we were told that there was a custody officer who regularly visited each of the IAC executive members to share up-to-date information.

Key finding: Inmate Advisory Councils (IACs) were often left out-of-the-loop around policies (e.g., why residents were being moved, or how the institution was responding to the pandemic). As a result, prisons missed an important opportunity to share information and get feedback on potential barriers to optimizing policies at the local level.

Recommendation 8.4: Develop (or enhance if one already exists) a feedback process for IACs during emergencies that allows residents to bring hidden concerns and ideas to leadership.

8.3.2 Leadership-Staff Communication

A perception that there was a lack of accurate and clear information and education was one of the most difficult issues for staff, alongside substantial heterogeneity in the frequency and quality of communication. In some places, updates were shared via email, at times hourly. As one person noted "it was impossible for us [supervisors and line staff] to constantly check our email while doing our jobs".

> "Everything relies upon good communication."

At its best, medical, mental health, and custody teams collaborated and communicated well, with one staff member noting that "from the first to the last case, there's been good communication." At several institutions, we were told that the communication between supervisors and administrators was good. One staff member who appreciated this stated, "everything relies upon good communication."

Yet in many institutions, communication was described as inconsistent from the top down, which caused substantial problems for staff in terms of both interpersonal relationships and policy implementation. Staff described how inconsistent messaging led to staff to implement policies in different ways--with all operating on the assumption that they were correctly interpreting the information they were provided. This created unnecessary conflict between staff members, harming interpersonal relationships and team morale.

Among staff, concerns about trust were key, as trust had an impact on, and was impacted by, the quality of communication. The vast majority of the staff with whom we spoke discussed the exceptional importance of communication. When members of different teams (custody, medical, nursing, and mental health) had been successful in building trusting relationships that

allowed them to rely upon one another for communication, everyone felt better off and more informed. When there was limited trust between staff (a scenario that was described with frequency), communication was hindered. For example, several custody officers described difficulty communicating with medical staff, partially due to the lack of trust or previous relationships between healthcare and custody teams.

8.3.3 Communication with Headquarters

While navigating through the uncertainty and fear during the early pandemic, leadership and staff described how disheartening and debilitating it was to reach out to leadership at headquarters with questions and requests for guidance only to receive little or nothing in return. One person stated that "the silence [from headquarters] was deafening." Many institutions described feeling like they were on their own in handling early outbreaks and staff found the lack of both proactive communication and rapid response to outreach in the early months of the COVID-19 crisis frustrating and frightening. Most staff acknowledged that headquarters gave more guidance as the pandemic progressed. When guidance did eventually come, however, it was months later than they needed it and they felt it did not acknowledge or reflect the experience and expertise institutional staff gained through their leadership in the early days of COVID-19.

Additionally, staff noted that there seemed to be disconnects between different departments within headquarters. Several staff reported that from the frontlines it seemed as though the Division of Adult Institutions and CCHCS were operating independently and not communicating at all with one another, particularly at the outset of the pandemic.

At one institution, members of the ICP reported feeling alone and unheard by CDCR. In one institution where a severe outbreak occurred fairly early in the pandemic, staff described feeling as though they were constantly scrambling to acquire enough personal protective equipment and testing to be able to stop the spread without sufficient support or acknowledgement from headquarters. We found that inconsistent communication such as this was more of a problem among the institutions that tasked multiple individuals to share information within the institution. As one staff member described, "they really scrambled through the pandemic" with how to streamline communication, as there really seemed to be "too many cooks," with multiple members of the ICP tasked with sharing the same information across different audiences. In comparison, institutions that delegated one individual to be responsible for sharing information from leadership still had difficulties, but the strategy seemed to improve the efficiency of communication and reduced the likelihood of inconsistent messaging.

Key finding: Many opportunities exist to improve emergency communication between residents and staff, between staff and institutional leadership, and between institutional leadership and headquarters.

Recommendation 8.5: Create streamlined, clear, and centralized pathways for communication during emergencies, including clearly delineating who is responsible for communicating specific content and to which specific groups of recipients.

Recommendation 8.6: Create a clear and consistent structure for communication during an emergency. This could include: (1) providing daily updates for IACs about programming, new institution-level and system-wide policies; (2) increasing residents' access to communication by prioritizing finding ways for the IAC to share information (perhaps via the prison television channel if in-person communication is unsafe or not possible); (3) holding all-staff meetings with the CME at least weekly during medical emergencies, so that staff can get timely answers to their questions and to help reduce uncertainty about how to keep themselves and others safe.

Recommendation 8.7: Emergency communications should provide information about the content of policy changes AND about the underlying logic for their change.

Recommendation 8.8: Consider adding members of all ranks to emergency response teams to optimize pathways of communication throughout the hierarchical chain of each facility's staff.

Key finding: Having family members of residents calling in and showing up in protest was clearly a source of stress for families, residents, and staff/institutional leadership during the pandemic.

Recommendation 8.9: Crisis communication procedures should provide guidance to facilities about how best to share information externally (e.g., with the families and friends of residents). We echo the recommendation of both staff and residents to develop a committee

that is responsible for maintaining a dedicated phone line, email system, and/or other external communication platform during crises. This could enable streamlined communications with families, as well as from the IAC to headquarters, to keep all stakeholders informed during an emergency response.

8.4. Complex Policy Planning During the Pandemic

In the early days of the pandemic, staff and institutional leadership described struggling to keep up with an ever-changing understanding of COVID-19 and scrambling to adjust policies to the developing landscape. Yet throughout our interviews, many people described feeling like they had little or no understanding of *why* protocols were being implemented and changed during this period. This left them feeling unable to effectively address the questions and concerns of residents.

When policies were shared by headquarters, many people described them as being overly broad or impractical given the unique conditions and constraints at the institution level. This meant that policies were often experienced by local leadership and staff as requiring interpretation and discretion in order to be put into practice at each institution. At the same time, many CDCR and CCHCS employees expressed fear of retribution from headquarters if they did not implement the policies as expected – or if they questioned them - and did not feel empowered to make decisions. When they asked for clarification about policies, or for permission to deviate from mandates, they described being unable to get a response quickly enough to enable implementation. The result was that policies were implemented ambiguously and inconsistently.

For example, at one institution medical staff described how their attempts to get complex patients transferred before an outbreak occurred were met with a great deal of resistance from leadership at headquarters. They proceeded anyway based on their conviction that this was necessary to save the lives of these patients. In another example, staff described it taking weeks to convince headquarters to allow them to safely quarantine in place despite having no other available safe quarantine space. In another institution, staff described a directive from headquarters mandating that they have enough celled housing to fill the space of the two largest housing units. Their frustration was that they had exceptionally limited control over releases, as a result, for most institutions with very minimal celled housing, this directive was impossible to follow. However, when they asked headquarters what they should do if they did not have the space available given the size of their population, they were not able to get anyone from headquarters to visit or advise them as to whether they could ask for emergency releases in order to free up the cells required by policy.

Another factor contributing to frustration among staff was the perception that headquarters was focused on the minutiae of policy implementation, rather than the big picture. For example, one mental healthcare professional described a process that required having residents fill out and sign several forms when they were being released. They were subsequently told that headquarters was unhappy with the quality of many of these submissions, stating that "the resident's signature doesn't match across each of these pages; "the pages were sent back to be resigned - this occurred up to four times. This increased the administrative burden for staff who were already experiencing burnout.

Like others throughout the country, CDCR leadership and staff learned and adapted to the best of their ability, but often not quickly enough to ensure that policies and procedures were in place for the next outbreak. In institutions with later outbreaks, residents expressed frustration that institutional leadership and line staff didn't seem to make better use of the earlier period to develop clear protocols and an emergency communication infrastructure that might have better helped them prepare for the outbreaks that were to come.

Policy planning appeared to be most successful when lines of communication were open, there was mutual trust between residents and staff and between staff and leadership, and all involved felt invited to share information and experience. As one officer described it, "We talked with [residents], especially during the pandemic, to plan. If we didn't, things would have got a lot worse."

At one institution in particular, the IAC described staff and residents working collaboratively to keep each other safe; an IAC member noted that during an outbreak there was "no green and blue" but instead everyone banded together to improve outcomes. When we asked custody staff about this, they were quick to give credit to the residents for creating a culture of common respect and mutual responsibility. Custody officers also noted their strong working relationship with mental health staff, saying that they "could not do our job without them."

We found many other examples of institution-specific situations in which staff and residents worked together to find solutions. For instance, one staff food manager described the ways he responded to the pandemic by rotating food stock, using some of the emergency supply so his staff did not have to make everything fresh, and having two feeding plans plus a contingency plan to ensure only minor disruptions in mealtime. In another example, residents reported difficulties going to the pill line during outbreaks and commended medical staff who made rounds to distribute medication. These and other institution-specific solutions that emerged during the pandemic should be documented and shared throughout the department and across all institutions.

Recommendation 8.10: Collect and disseminate examples of institution-specific successful and innovative strategies to use now and in future crises.

Recommendation 8.11: Provide public recognition and gratitude to specific leaders, staff members, IACS, teams and/or institutions for their heroic hard work and efforts to save people's lives and/or improve people's well-being during the pandemic.

Recommendation 8.12: Headquarters staff should make regular in-person visits to facilities to help brainstorm local solutions when unique constraints prevent them from following directives.

Recommendation 8.13: Both headquarters and institutional leadership should consider incorporating a formal "devil's advocate" into strategic decision-making processes. This technique can enable consideration of multiple perspectives when it is difficult for those with minority opinions or contradictory information to speak up.

8.4.1 Adjustments to Operations and Programming

Outbreaks resulted in modified programming, and staff shortages exacerbated problems in maintaining the level of programming, modified or otherwise. Some of these adjustments were drastic, with residents describing that yard time was significantly cut down for well over a month and institutional operations were scaled back to the basics: delivering food to make sure residents ate; and getting residents to the pill line to make sure they got medication. However, as outbreaks subsided and cases returned to zero, the residents at most institutions we visited stated that they were returning to normal programming and yard time.

One of the programs that experienced particularly significant change during COVID-19 was the Medication Assisted Treatment (MAT). As a result of a policy change, residents were able to engage with the MAT (meaning that they would be administered suboxone) regardless of whether they had a documented previous opioid abuse issue. Additionally, residents could only make use of cognitive behavioral therapy (CBT) if they were taking suboxone. Residents informed us that if they refused medication, staff would claim that they had "graduated from the program" and they would no longer be allowed access. As a result, residents described how the deprivation of mental health resources overlapped with growing misuse of suboxone,

with increased sharing of suboxone through "cheeking" (storing suboxone in one's cheek to provide it to someone else later).

8.4.2 Staffing Shortages and Consequences

In most of the institutions we visited, we heard of staff vacancies--sometimes quite profound ones. For example, we learned about a severe shortage of occupational therapists at one institution: mental health staff estimated that slightly more than two-thirds of the total occupational therapist positions were vacant during the pandemic. In some institutions, there were overages for certain positions but shortages for others, which posed significant problems. For example, one institution's custody team had an overage of line staff, but custody staff estimated that approximately 40% of its supervisory positions were vacant. Supervisors described how this added to the stress of the job, increasing their responsibilities to cover for vacant positions. This was particularly true in relation to assigned COVID mitigation tasks. Many staff were also teleworking, especially in mental health teams. This frequently meant more work for staff who were present in the facility with less time to supply mental health care and support to resident populations. On the custody side, work from home options were not available, which officers generally understood but also described as placing unfair disproportionate burden on them relative to other types of employees.

A reported difficulty in addressing staffing shortages was that many positions were for limited term contracts. Staff across several institutions described their perception that limited term hiring was chaotic. At the end of 2 years, the employee would be required to take 30 days without pay and before being allowed to proceed through the hiring process again (which could take another 20 days). Staff experienced frustration that this meant that the institution lost many qualified, experienced short-term staff, because they were unable to wait for two months without pay.

One IAC described a common perception that outside healthcare workers who were brought in to fill vacancies did not seem to be well-trained. A resident described a temporary healthcare worker taking someone's blood pressure on the forearm. Others described seeing or experiencing healthcare staff dismissing symptoms when they were reported or expressing worry about COVID-19 cases being missed when healthcare staff labeled symptoms as "pneumonia". Concerns, such as these, about quality of healthcare provided by short term hires were widespread in some facilities and caused distrust of staff to proliferate.

> "Once people got sick, there were different staff coming in every day."

As a result of staff shortages, staff were often moved to cover shifts in different facilities, or even at different institutions. For example, as CIW reportedly did not have a nursing shortage at one point during the pandemic, some staff were asked to work at CIM to cover vacancies there. One resident remarked that, "Once people got sick, there were different staff coming in every day." Some residents believed that a primary source of the spread of the virus was cross-contamination from staff working across facilities or prisons or because of the way space was used. For example, in one institution, one unit was used for quarantine, another was used for housing those who went out to the hospital, and the gym was used for isolation. Residents noted concern that officers who worked in the quarantine unit then worked their next shift in the isolation unit and so on.

Some institutional leaders described trying to limit or control how, where, and when staff were able to take other shifts, but we were told that on average these attempts were generally unsuccessful. Staff shortages also led to additional days of modified programming; for example, some institutions would modify programming when four staff were off and cancel yard/dayroom when six were out. This was difficult for both residents and staff, and several staff called for updates or review of the current policies to address potential upcoming staffing gaps.

Of note, in our 2020 survey, many staff reported that they would still need to come to work if they were sick (Figure 8.1). Based on officers' available sick leave at the time of the survey, nearly 40% said they would still feel they needed to come to work. Roughly the same proportion reported they would come to work sick even if they had additional sick leave (30.7%). However, the proportion dropped by roughly half (to 14.8%) when respondents were asked if they would feel they needed to come to work sick if they had additional paid administrative leave available to them. This survey was conducted at the outset of the pandemic, so it is possible that covered sick time became clearer to staff over time.

Figure 8.1. Percent of officers who report feeling they would need to work even if sick.

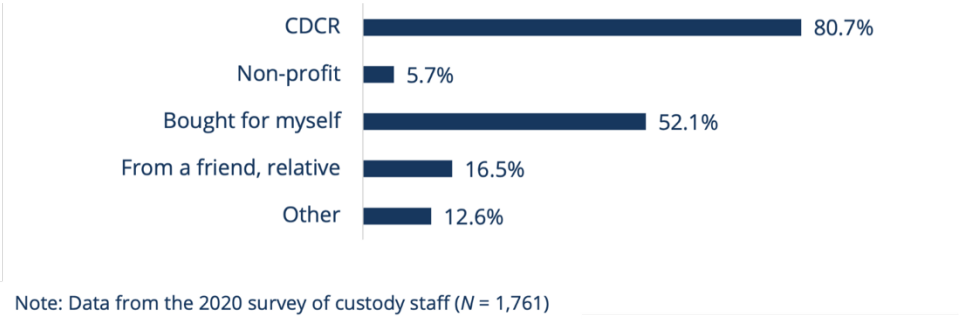
Note: Data from the 2020 survey of custody staff (*N* = 1,761)

8.5. The Experience of Prevention and Mitigation

At the outset of the pandemic, COVID-19 spread quickly in many institutions, and staff described having known little about how the virus spread or how to curb contagion given the density of the population in their facilities. Across the system, institutional leadership, supervisors, line staff and residents related feeling terrified the first days and months of the pandemic. They described the stress and difficulty related to working in a high-risk environment with insufficient and rapidly changing information.

In the early days of the pandemic, there was also significant confusion and frustration about the availability and use of personal protective equipment (PPE). By mid-2020, most officers (86.4%) reported having access to some or all the PPE they need (**Figure 8.2**). However, more than half reported having provided at least some of their PPE themselves (52%) or having gotten supplies from non-profit organizations (5.6%), families and friends (16.4%), or from other sources (12.5%) rather than from institutional leadership or headquarters. Many officers also indicated the need for additional training on how to appropriately use PPE.

Figure 8.2. Percent of officers who report having gotten access to PPE from different sources



Note: Data from the 2020 survey of custody staff (*N* = 1,761)

Note: Percentages total to more than 100% because respondents were asked to choose all that applied.

8.5.1 The Impact of Beliefs about COVID-19

One factor that appears to have made the response to the outbreak difficult for both residents and staff is substantial variation in beliefs about how dangerous COVID-19 is, how to respond to it, and how individuals feel about their responsibility in curbing the spread. Residents described profound fear related to staff who do not seem to believe the virus is real. Residents observed some staff, especially during the early days of the pandemic, who were not compliant with mask-wearing rules. Residents also reported hearing many staff describe being unhappy about having to do extra work to implement COVID protocols, and who therefore cut corners or otherwise did not properly implement COVID policies (e.g., letting residents outside of their cells when sick).

A common theme that emerged in our interviews with staff was concerns for their own health and safety. Many expressed having been fearful about their own safety and for the safety of their peers, family, and loved ones. Many also described having a great concern for the health and wellbeing of the people who were incarcerated and under their care.

> "Better them versus us."

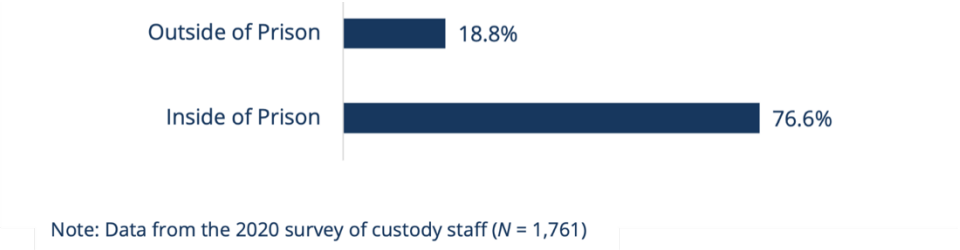
Some staff members described continuing to come to work despite having an immense fear for their well-being, including staying late or working more overtime than they ever had before in an effort to keep residents safe. For others, the fear was debilitating to the point that they refused to engage in their typical duties. Several residents shared their belief that some staff approached COVID as "better them versus us," and cut corners when they believed it would keep them safe-- even at the expense of resident well-being. For example, at one institution, residents and staff alike reported that two doctors refused to see COVID-19 patients, ultimately leading to conflict within the staff and involvement of the union to resolve the issue. This resulted in a persistent undermining of patient trust in the facility's healthcare professionals.

8.5.2 Social Distancing

Social distancing was almost impossible within most institutions, at least in certain areas. For instance, when asked in 2020, roughly 18% of officers reported it was difficult to maintain social distancing outside the prison while roughly 76% described social distancing as difficult while at work, **Figure 8.3**. Custody lamented their difficulty in maintaining social distancing during an emergency situation like a fight. There were also concerns expressed about social distancing and safety when it came to staff-to-resident ratios. One officer described that social distancing

was impossible to achieve in small officer stations, and that achieving 6 feet of distance would require just one officer overseeing 200 residents.

Figure 8.3. Percent of officers reporting difficulty with social distancing inside and outside prison.



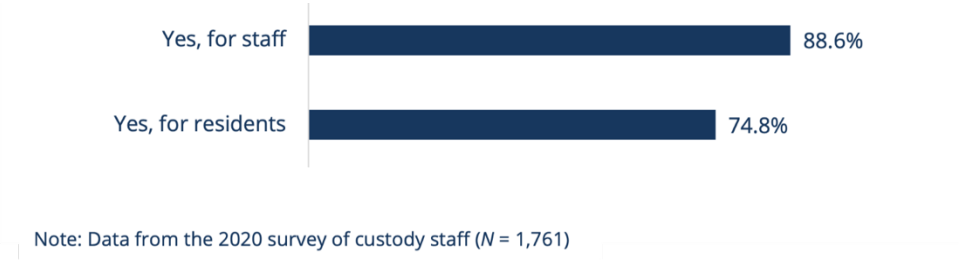
Mental health and medical staff alike reported difficulties related to the need to enforce physical distancing. In particular, members from one IAC described that there was minimal if any social distancing enforced in medical areas. Distancing requirements also meant that critical substance use support groups halted. Some staff expressed concern about the negative effects of distancing, such as it taking longer for them to engage in clinical work with residents due to room capacity limitations. Distancing was also a concern when it was seen as potentially contributing to HIPAA compliance issues; staff reported having to stand in hallways to have appointments with residents, which meant that other residents were sometimes able to overhear discussion of sensitive health-related information.

Despite these difficulties, some residents and staff remained adamant about trying to enforce social distancing when possible. One CEO pressed for masks and social distancing early in the pandemic. This action was criticized by some staff who saw it as excessive, though it was later recognized as having been in line with subsequently established best practice and was credited for having limited the extent of infection early in the pandemic. IAC members in another facility described leadership working to get residents' support regarding social distancing. Another IAC noted that the Warden had approached them to ask their fellow residents to social distance to help reduce spread.

8.5.3 Handwashing and Surface Cleaning

Handwashing practices were reported to be quite good throughout the pandemic by staff and residents alike. In 2020, about 88% of custody staff reported that they had regular access to handwashing, and roughly 75% of staff reported the same was true of the incarcerated population, **Figure 8.4**. However, some interviewees described hurdles to achieving full compliance with handwashing rules, including reports that some staff were resistant to improved hygiene practices, and that access to soap and hand sanitizer for residents was sometimes limited.

Figure 8.4. Percent of officers reporting staff and residents have access to handwashing



Staff reported that both headquarters and Prison Industries distributed hand sanitizer to the institutions, and some food services managers requested – and received – formal handwashing and cleaning practices for their staff. Communal bottles of hand sanitizer were available for residents throughout the facilities. Many residents reported that they would have appreciated access to personal hand sanitizer. However, in many institutions staff were concerned about the potential for misuse, and as a result either did not provide personal hand sanitizer or provided non-alcohol-based hand sanitizer to residents which left residents concerned that they were not adequately equipped to keep themselves safe.

In contrast to washing and sanitizing, surface and other cleaning practices were described as inconsistent across prisons and within institutions. One IAC reported that the three bottles of cleaner per month made available to clean a full block were insufficient. Given this limited supply, residents reported watering down their cleaning supplies to the point where they had concerns about whether it was still an effective sanitizer. Some residents who had experienced incarceration during the SARS outbreak a few decades prior requested bleach (which was given out during that outbreak), but found it was not allowed during this pandemic. In some facilities, residents reported that officers took personal supplies from residents during their regular checks and redistributed them as communal cleaning supplies.

Some residents also described a "cleaning schedule" where brooms, mops, and other supplies were provided on a rotating basis for only about one hour every other day, which was seen as insufficient for being able to properly disinfect space. Residents were not given brooms and mops to have on a regular basis because they were told that they could be used as weapons. In one institution, residents were able to voice their concerns about sanitation with the warden, who then revised policies and allowed for increased cleaning supplies. This gave residents more confidence in the leadership and made them feel more comfortable in their living spaces.

8.5.4 Testing and Contact Tracing

Early in the pandemic, testing was perceived as complex and fraught by many residents and staff. In institutions that experienced early outbreaks, staff described the need to prioritize testing for symptomatic cases because it was too difficult to test at a broader scale. Long delays in receiving results became another factor complicating management of outbreaks for staff. Healthcare staff in particular described frustration over these delays and their perception that these delays made getting ahead of the early outbreaks essentially impossible.

Interviewees also described disorganization in the testing process. At one institution, for example, a resident described being informed of a positive COVID test result just moments after receiving his test. He informed the staff member that he didn't believe this was his test. The staff member threatened him with a physical cell extraction and moved him to the gym with another man in isolation. Staff later realized they had, in fact, mixed up his results with someone else's.

Many residents reported being fearful of testing as a result of poor medical isolation conditions, false positive results, exclusion from programming after a positive test, little information about how a positive test would affect movement and isolation, and the possibility of losing personal items as the result of a move. Fearing the consequences of a positive test, some residents reportedly attempted to avoid being tested, or tried to ensure a negative test result, employing strategies like putting bleach in their nostrils when they knew they would be tested.

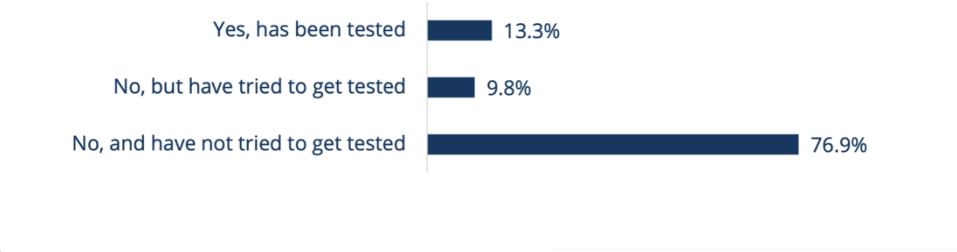
> "Testing positive has negative implications for your whole block."

As one resident noted, "testing positive has negative implications for your whole block." Both staff and residents shared the concern that people were often hesitant to share their symptomatic status for this reason. Because a positive COVID test almost always meant being moved to a new housing unit, some residents began to weaponize the testing process by telling staff that other residents were experiencing symptoms or lying about someone having symptoms in order to orchestrate their move.

For staff, testing in the beginning of the pandemic was especially complicated due to both limited supply and the difficulties of finding time to get tested. Staff noted that early on, the only available free tests were at the institution. For them to go get tested privately, it could cost up to $300. As a result of concerns about privacy and expense, in mid-2020, prior to the imposition of mandatory testing, only about 13% of officers reported having been tested for

COVID. **Figure 8.5** shows the percent of officers who reported having been tested as of May 2020.

Figure 8.5. Percent of officers who reported having been tested for COVID-19, May 2020



Note: Data from the 2020 survey of custody staff (*N* = 1,761)

Once mandates for testing were imposed, compliance was reportedly high, and staff attributed missed testing as an oversight rather than purposeful, reporting that those who were not compliant had generally "forgotten" to do so given their increased responsibilities and workload. At many institutions, free staff testing was available three times per week at the height of the outbreaks.

Institutions also attempted to contact trace through several different methods. However, contact tracing was difficult to implement and involved a great deal of time, extra staff, and planning; it was often perceived to be not effective. Because of this, some institutions relied upon residents to volunteer whether they had been in close contact with a positive case. In others, staff took a great deal of personal initiative to implement comprehensive contact tracing procedures.

8.5.5 Movement of Residents

Many residents reported movement within the institutions as being one of the most terrifying aspects of the pandemic. The uncertainty and lack of control they had over that aspect of their life left them feeling unable to protect themselves. Often, COVID-related movement meant being housed in a different unit or even moving to another facility, away from a cellmate that they had built a relationship with, to be housed with others they did not know or trust. The movement process was therefore described as very stressful by many people.

Among nearly all the residents with whom we spoke, there was widespread frustration that many people had been moved despite not being given their COVID test results. Many staff agreed that this had been a problem and attributed it to HIPAA restrictions as custody officers were often the ones to escort residents to new housing after a positive test and were not given the test results as they were not part of the healthcare team. To address this issue, some institutions later placed both custody staff and medical personnel on the escort team, a practice which seemed to improve the experience of residents.

"We were treated like cattle."

In most facilities, residents experienced movement to new housing as unsafe, citing the frequency of movement, movement across facilities, and the fact that some officers did not wear masks during escort. Many who were moved frequently – expressed the perception that they were being moved until they contracted the virus, and that people were dying as a result of so much movement. In several IAC interviews, we were told that residents felt "we were treated like cattle."

Many residents also expressed concerns about the process for those people being moved in and out of institutions. Residents were informed that the policy for people coming in from other facilities was to test at their original location, then test at the new location and quarantine for 14 days. However, many reported the perception that these guidelines were not followed in practice.

Additionally, many residents reported frustration when a policy change required staff to pack up their personal belongings for a housing move, rather than allowing residents to do this themselves. Some staff implementing this policy were reportedly less diligent or compassionate than others, marking residents' belongings as trash or contraband rather than helping to ensure that they made it safely to the next housing assignment.

As a result of these experiences, some residents (across multiple prisons) described the experience of having developed a disturbing conditioned response to keys jingling down the hall. One resident described how invasive this was - that they could be sound asleep in the middle of the night, hear an officer's keys or even a soft voice as they walked through the unit, and jolt awake for fear of being moved to a new housing unit.

Movement felt constant for staff too, and it reportedly made tracking and contact tracing even more complicated. Uncertainty about how to implement policies resulted in inconsistent, frequent, and chaotic movement. Many staff also shared their experience that once residents had been quarantined a few times, it became far more difficult to get cooperation for subsequent movement.

8.5.6 Quarantine and Isolation

Throughout our interviews, both staff and residents described how space limitations made appropriate responses to outbreaks very difficult. For example, many people described frustration that overcrowded conditions persisted during the pandemic, such as the practice of housing nine or ten people together in cells intended for far fewer people. In other instances, in order to make space for quarantine and isolation, people from different housing units were mixed, or entire housing units were combined, which resulted in the perception of significant overcrowding. In some cases, residents reported the difficulty they experienced when trying to avoid contact with others in their cell when they were not moved after having contact with someone who tested positive.

In every prison we visited, there seemed to be a great deal of confusion about how to use space given the constraints of the movement matrix, and as one resident described it, "no information or communication was being shared about how movement decisions were made." Many said they would rather have been allowed to quarantine in place, rather than lose their housing unit and cellmate. While policies would ultimately allow residents to return to their original housing unit, many residents reported that this policy was often not implemented in practice – even by fall 2021.

With the lack of sufficient or the appropriate types of space, staff had to develop imperfect options to house residents who required quarantine or isolation. Oftentimes quarantine or isolation translated into 24-7 in-cell (or in-dorm) housing without enough books, resources, or other sources of education or entertainment. Many reported an increase in conflict and violence among cellmates who could not escape one another while living under increasingly stressful conditions.

Residents often described the spaces where they were quarantined, isolated, or moved as being dirty and uncomfortable. They reported that at times people were moved into cold spaces with no electricity, or tents without working air conditioning despite 100-degree heat. One institution's IAC reported having found dead birds in the unit where they were quarantined.

Key finding: Staff and residents contended that a lack of space resulted in an inadequate ability for medical staff to ensure appropriate quarantine and medical isolation spaces.

Recommendation 8.14: To increase the amount of available space to quarantine and isolate affected residents, and to help address availability constraints for programming during epidemic emergencies, the state should maintain plans for emergency decarceration, pre-

identifying residents who could be temporarily released immediately without posing undue danger to their communities.

8.6. Experiences with Vaccination

Institutions faced numerous complex obstacles in getting residents and staff vaccinated. In some instances, there was confusion and misinformation surrounding vaccination among both residents and staff. Some residents reported feeling coerced into being vaccinated, as did some staff. In other institutions, overall vaccination rollout reportedly went well, with residents reporting having received reliable information on a regular basis from leadership and staff and being very grateful to have been among the first in the state who received a vaccination.

8.6.1 Vaccine Hesitancy Among Residents

Early in 2021, we had conversations with IAC members who contended that many individuals who had tested positive in the last 90 days were unable to get vaccinated. This led to frustration among residents who were agreeing to testing and were then not able to get vaccinated. As a result, some individuals began refusing testing in order to avoid any barriers to getting vaccinated.

Residents described the existence of many conspiracy theories making their way through the population regarding vaccines. The most common conspiracies included how vaccines are a means of achieving population control or tracking and that they cause sterility as a side effect. Many residents we spoke with described frustration with a lack of access to trusted information about the vaccines. They knew that institutional leadership wanted them to get vaccinated, but they did not feel there was a way to become well-informed about how the vaccine worked or what the potential side effects and benefits were beyond outside experts sending in materials. At one institution we visited, residents shared with us that vaccine information was only provided in English, and so those who were not native English speakers or did not speak English felt uninformed. Others described asking for more information and being given the FDA pamphlet that is inserted in the vaccine box, which was confusing and hard to read and did not help overcome their concerns about the vaccine.

Some residents asserted that some groups of people belonging to racial and/or ethnic minorities experienced concerns over being vaccinated that were grounded in the long history of maltreatment and exploitation experienced by Black/African Americans. In the spring of 2021, residents in some institutions described frustration that there had been little done on the part of leadership to attempt to address these particular concerns. One IAC member offered a potential solution: allow a trusted community member with medical expertise to come and

help share information, listen to their concerns, discuss the benefits, and answer any remaining questions. Such an approach was rolled out in the summer of 2021 and has reportedly been effective thus far.

Recommendation 8.15: There is an opportunity (in those Institutions not already doing so) for leadership to partner with IAC members to elicit suggested solutions for improving vaccine and booster rollout.

8.6.2 Vaccine Hesitancy Among Staff

Among staff, particularly correctional officers, additional factors led to vaccine hesitancy. At one institution, officers described the belief that the vaccination rate was low because of an incident that occurred with one officer who got their vaccination onsite, had a bad reaction to it, and was out on worker's compensation for weeks. News of the incident spread quickly, leading other officers to become more fearful of getting the vaccine. According to staff and leadership, this anecdote was not addressed by leadership or healthcare, questions were not answered, and misconceptions were not addressed. Other staff shared their observation that those who had gotten COVID were less likely to get vaccinated, and confusion as to why people who have already had COVID require vaccination was common.

At the same institution, staff experienced the CMO as having been outwardly judgmental towards correctional staff who were not getting vaccinated, which resulted in officers refusing to get vaccinated as a form of protest. More broadly, several staff across the system believed that many who are still "holding out" are not just hesitant, but ideologically opposed and therefore will not ever agree to becoming vaccinated. As a result, some staff were hesitant to ask for information about the vaccine or to get vaccinated at their institution for fear of judgment from colleagues strongly opposed to the vaccine, perpetuating a cycle of vaccine hesitancy.

Recommendation 8.16: There is an opportunity (in those Institutions not already doing so) for leadership to partner with custody staff to identify rumors and misconceptions about vaccines and boosters to that they can be addressed.

8.7. Mental Health and Wellbeing among Staff and Residents

The toll of the pandemic on the mental health of those who live or work in a CDCR prison was immense.

For residents, reduced contact with families and friends on the outside, insufficient mental health programming and reduced capacity to access mental health services, and lack of information about the pandemic contributed to anxiety, depression, and stress. Many residents described being witness to a range of traumatic experiences. One resident recounted a death that had taken place on the yard, where the body remained for several hours before it was moved. While initially a tarp was placed to cover the body, the cover soon blew off in the wind and was not replaced. He described looking out the window every half hour or so over nearly a full day and seeing the body lying there. Another resident described having a sick friend die in their shared cell. Nearly four hours went by before his body was moved. The resident and his two other cellmates described having to step over the body in order to move around the cell and use the bathroom.

Likewise, for many staff, the mental health toll of working during the pandemic was profound. Staff described feeling helpless and overwhelmed, watching as residents got sick and died while simultaneously struggling with their own fears of getting sick and of potentially transferring disease to their families. One staff member described the extreme uncertainty of what they were facing, and the decision to prepare for the worst-case scenario by moving an extra freezer onto the premises for storage of dead bodies. At another institution, a custody officer described seeing a sick resident having a seizure in his cell and calling for medical help that never came. The officer performed CPR but was unable to save him.

Some staff were able to bond and get through difficulties together, coming out stronger as a result. For others, the stress and isolation were described as exacerbating already high levels of burnout, post-traumatic stress, and even risk of suicide and suicidal ideation.

8.7.1 Mental Health Among Residents

Not being able to visit with or connect with family and friends has been the most difficult part of the pandemic for many residents. Especially amongst women, the inability to regularly check on the well-being of children and family was extraordinarily stressful. Residents spoke about being enormously appreciative of the free 15-minute phone calls per week and the one hour of video visits, especially considering mail delivery delays and difficulty accessing tablets. These phone calls were described as essential to many residents' well-being.

Residents also expressed gratitude for the mental health support that was provided during the height of the pandemic; however, they noted that adequate resources were still severely lacking. Part of the limited mental health support infrastructure was reportedly due to staffing shortages during the pandemic. Mental healthcare staff vacancies, reductions in the time allocated to mental health services, and workers who had shifted to telework were all described (by leadership, staff, and residents) as contributing to reduced access to mental healthcare

services. The reduced availability of mental health professionals meant that the remaining mental health staff took on a lot of other roles throughout the pandemic to be able to care for the resident population, adding to the extra responsibilities they had already taken on pre-pandemic, including suicide prevention, teaching, clinical activities, and more.

COVID-19 also resulted in the shut-down of programs that had provided well-being support to residents. For example, in one of the women's prisons, a popular wellness program that ran in the gym included recreational therapy with spin bikes, yoga, and other classes and equipment. During the pandemic, the gym was used for medical isolation and the program was shut down. Constraints of physical layout and available space were reported to have had a drastic impact on limiting the ability of mental health teams to provide key services to the resident population. For example, one institution's Chief of Mental Health described that pre-pandemic, the rooms where they held mental health programming could hold eight patients; however, with social distancing, they were only able to serve four patients at a time, effectively decreasing capacity to provide services by 50%. One resident, describing the process of waiting for space to open up so he could participate in programming, told us "They can't even give you a number of where you are, which basically means there is no waiting list and you're not getting programming".

Given these constraints, some mental health teams were faced with difficult decisions about which programs (and therefore, which residents) to prioritize. For example, one mental health team--while still making rounds, donning face shields, masks, and other PPE to do sessions with residents in the hallways--was only able to keep one program up and running, specifically the one for individuals with developmental disabilities (the DDP program). To make matters more complicated, at the time of our visit, this team was also facing increases in the population as the reception centers opened back up, meaning that their workload had increased to handle intake.

In response to the pandemic, self-help groups and other crucial programming, such as NA, AA, peer-to-peer groups, and life skills also faced limitations, which was exceptionally difficult for many residents. Many worried that the lack of mental health and other programming jeopardized their recovery from substance use disorders or other issues or might have negative consequences when they came up for parole. While residents noted that some correspondence groups continued, they were experienced as not providing the same utility. Residents shared that self-harm had become an even more pressing issue within the prison, and that there had been an increase in bullying and other stressors. For many residents, the virus outbreak exacerbated an already overwhelming fear: that they would die in prison.

Key finding: The adverse mental health impact of the pandemic on prison residents has been profound. Many described increased feelings of depression, anxiety, and post-traumatic stress symptoms.

Recommendation 8.17: Given the importance of contact with loved ones during an emergency, increase availability of phones in housing units/facilities, provide as many free phone calls as possible, and continue rolling out the tablet program throughout CDCR. Phones, including those for people with hearing disabilities, should also be available to people in quarantine and medical isolation.

Recommendation 8.18: Consider increasing mental health services as soon as possible, screen all residents for serious mental health-related consequences of the pandemic (even those who did not have mental health needs prior to the pandemic), and appropriate the resources needed to offer mental health services to those suffering from the trauma of being imprisoned during the pandemic.

Recommendation 8.19: Ensure that mental health staff are present in person, in sufficient numbers at each institution during emergency situations.

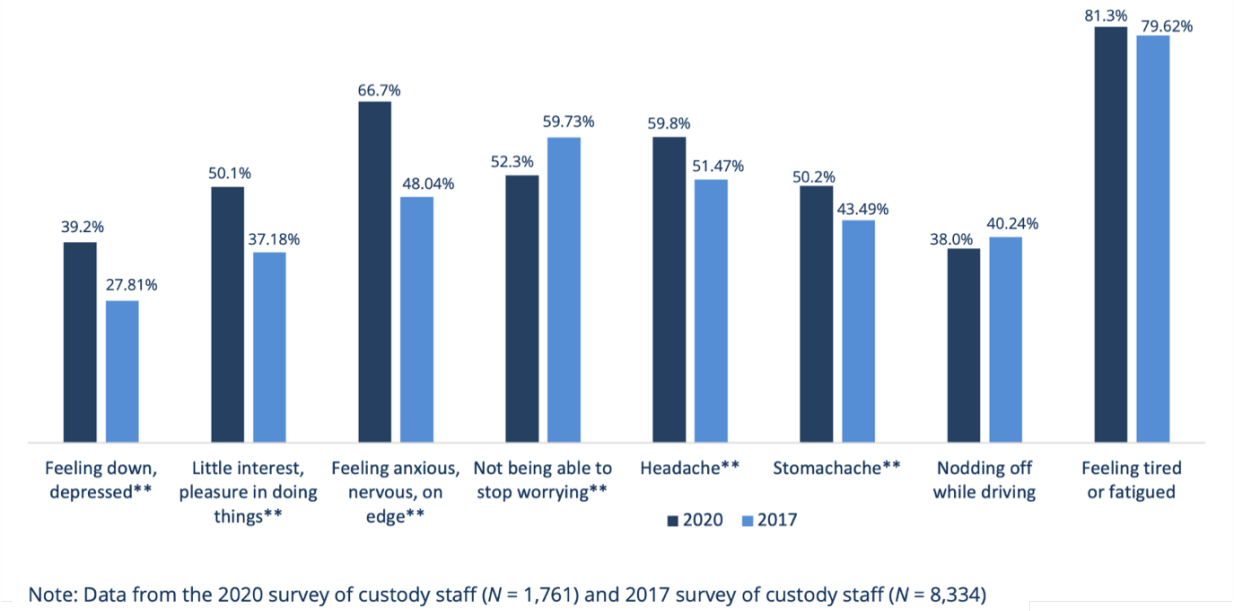
8.7.2 Well-being of Staff

Correctional staff also suffered adverse mental health impacts due to the pandemic. Many staff described having experienced an immense emotional toll related to being asked to make emergency decisions on what felt like a daily basis with very little support. They also described working unprecedented amounts of required overtime and experiencing profound fatigue, yet receiving little gratitude from leadership (in some places), from headquarters, or from the public. These experiences worsened staff well-being and led to feelings of burnout. Staff also reported that when they were exhausted after a shift (sometimes with mandatory overtime), they were frequently asked to review updated policies before returning to work the next day, so many felt that they were basically working around the clock.

Our survey conducted in April and May of 2020, asked a variety of questions related to staff mental health. Many of these questions were drawn from a 2017 survey of the same population, allowing for direct comparison of staff mental health between the pre-pandemic

period and during the pandemic. Across nearly all questions, staff reported higher levels of anxiety and stress-related health concerns in 2020 relative to roughly three years earlier. For instance, compared to 27.8% in 2017, about 39.2% of officers reported symptoms of depression during the pandemic, an increase of about 12 percentage points. Likewise, compared to 48% in 2017, in 2020 the proportion reporting symptoms of anxiety increased by more than 18 percentage points to about just over 66%, **Figure 8.6**.

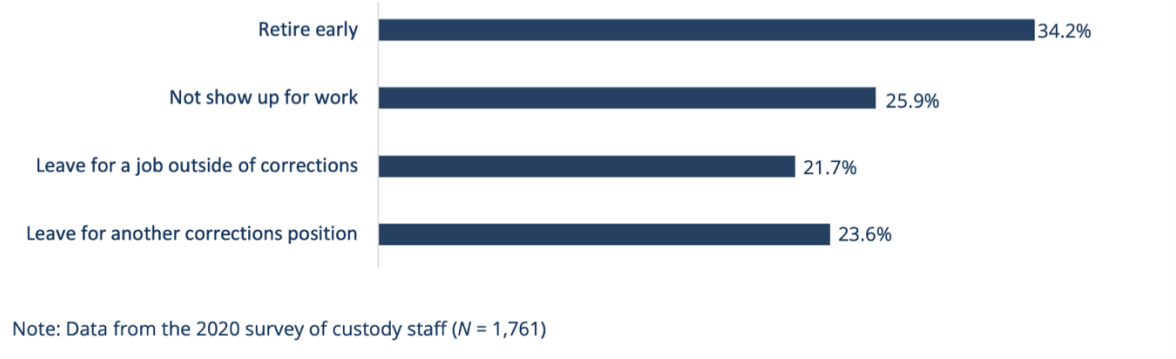
Figure 8.6. Percent of officers reporting mental health symptoms in 2017 compared to 2020.



Note: Data from the 2020 survey of custody staff (*N* = 1,761) and 2017 survey of custody staff (*N* = 8,334)

These results suggest that the high levels of stress which were already prevalent prior to the pandemic became heightened during the pandemic. This suggests the need for specific, trauma-informed care in the wake of the pandemic. At the same time, these data are concerning as they suggest high levels of burnout among a wide range of correctional staff which, if left unaddressed, may lead to increased staff turnover. Indeed, when asked in the 2020 survey, more than one-third of officers said that experiences during COVID had make them more likely to retire early, and nearly a quarter said COVID had made them more likely to leave CDCR for a job outside of corrections (21.7%) or for another correctional position (23.5%).

Figure 8.7. Percent of officers indicating that the virus has made them more likely to retire early, not show up for work, and leave their job.



Note: Data from the 2020 survey of custody staff (*N* = 1,761)

Key finding: The adverse mental health impact of the pandemic on prison staff has been profound.

Key finding: Large-scale correctional staff turnover in coming months or years is likely in the wake of trauma related to the experience of working in prisons during the pandemic.

8.8. Addressing Trauma and Mental Health

As described above, there is an overwhelming need for mental health support among staff due to stress experienced by many who worked in prisons during the pandemic. Yet in our interviews, officers expressed concerns over confidentiality when making use of the Employee Assistance Program (EAP). We heard similar concerns about confidentiality within the peer support program, especially with the introduction of body-worn cameras – officers expressed fear that they will be recorded when they approach a peer support specialist to connect about potentially sensitive issues.

Recommendation 8.20: Consider implementing a confidential peer support program that allows staff to share advice and stories anonymously, perhaps in partnership with the California Correctional Peace Officers Association (CCPOA) as one potential strategy to foster trust and buy-in in the program. Low-cost interventions such as this have been shown

to reduce employee burnout and decrease turnover in high-stress occupations within law enforcement.

Recommendation 8.21: Develop an emergency employee needs committee that can be activated during emergency situations to identify and address immediate basic needs as well as emergent mental health needs related to the emergency situation. Basic needs might include those that correctional staff who responded to our 2020 survey indicated would be most useful, including more or better food options, having a place to change after work, access to laundry services, and having a place to shower after work.

"The system needs to be in place when you really need it."

8.9. Preparing for Future Outbreaks

Many individuals, including both residents and staff, believed that the correctional system was unprepared to respond to an emergency at the scale of the COVID-19 pandemic. As one staff member noted, "The system needs to be in place when you really need it."

As CDCR and CCHCS move develop and refine their future emergency preparedness plans, it will be important to ensure that the voice of a wide range of internal and external stakeholders are represented. Throughout our conversations, we heard from staff and from residents who shared that they "...would like to be more involved in [their] own safety." The best way to ensure that policies are reflective of the needs of different populations within the system is by directly seeking their input, which can help improve decision-making and empower both staff and residents.

Of equal importance to engaging stakeholders in emergency planning is taking a data-driven approach to optimizing emergency responses. A core challenge in planning for a pandemic response is that there are many questions to which we do not have answers. For instance, we know little about how best to successfully overcome vaccine resistance, how to encourage uptake of mental health services among correctional staff, or what policies can best facilitate communication with family members during times of crises. To identify solutions, **systematic**

collection of attitudinal and experiential data can be integrated as a regular part of the department's data and policy infrastructure.

Both residents and staff expressed a desire for opportunities to continue sharing their thoughts and feedback about what worked and what didn't work over the past 18 months, with the goal of improving the way their institutions and the department operate. This might include annual surveys of residents and staff, as well as developing a formal a way for teams external to CDCR to collect information in the prisons on a regular basis. This would allow headquarters and institutional leadership to hear from stakeholders about their thoughts, understand their needs, develop a report or action-plan, get review of this action-plan from residents and staff, and then share this community-sourced feedback. An example of a data-driven experiment that we conducted with staff from CCHCS staff and CCPOA leadership is described in the box below.

A Randomized Vaccination Information Experiment: An Example of a Data-Driven Approach to Driving Policy Responses Related to Behavioral Science

In partnership with Liz Gransee (Deputy Director of Healthcare Communications) and her team, as well as with Gregg Adam, David Sanders, and staff from CCPOA, we conducted an experiment in April 2021 to test the effects of different vaccination email messages designed to increase uptake of vaccines among CDCR staff.

Emails were sent to 24,607 CDCR employees, with employees randomly assigned to receive one of three possible message texts (a method that is sometimes referred to as "rapid A/B testing" of different messaging). The same email text was sent to each recipient twice: once in the morning on Tuesday April 6th, and again on the morning of Thursday April 8th. Some custody staff were also randomized to receive the same message either from CDCR or instead from CCPOA. We then measured two outcomes: (i) aggregate click-throughs to a sign-up page, and (ii) individual-level vaccination data.

We found significant differences in the return on these distinct messages, suggesting that the message focused on loss aversion, or "missing out" on the opportunity to get vaccinated, had greater potential to increase vaccinations, especially among non-custody staff (e.g., medical, custodial, administrative).

Recommendation 8.22: The department should continue to take an empirical, data-driven approach to solutions whenever feasible. This could include future randomized controlled trials for testing intra-departmental communications, including those related to health. The department should also continue investing in building infrastructure and research staff to expand capacity for innovation and data analysis and to draw on best practices from existing research with the goal of achieving quick learning, optimization, and the scale-up of solutions once they have been proven to work.

"There's no COs and residents on this yard. We just do what we can to take care of each other."

8.9 Moving Forward

The COVID-19 pandemic has given CDCR and CCHCS an unfortunate but important opportunity to identify and shore up their organizational strengths, and to rectify and address their deficits and pressing needs. In the coming months and years, it will be critical to build on what has been learned in order to foster a healthier and safer correctional environment. Across institutions, we heard stories of staff and residents who displayed heroic actions. It is critical that both headquarters and local institutional leadership recognize and show appreciation for these exceptional acts during the pandemic.

The end of the pandemic could mark an important turning point in the ways that prisons operate in California. Rather than focusing on punishment, for instance, CDCR could make a clear and comprehensive effort to focus on the reintegration of individuals to society. This would mimic the type of wholesale reform effort that was undertaken in Norway in the 1990s, when the country turned to a model that would prove to substantially reduce recidivism.[5] In the long run, this will be crucial to fostering a more positive correctional culture and ensuring stronger, healthier institutions overall.

9. Other CalPROTECT efforts related to optimizing health in CDCR institutions during the COVID-19 pandemic

Over the course of CalPROTECT's work with CDCR and CCHCS, we were asked to provide additional educational support about the care of incarcerated patients to community healthcare professionals, and about COVID-19 vaccines to people incarcerated in CDCR facilities. This section describes three of these efforts.

9.1. Educating community healthcare professionals about incarcerated patient care

9.1.1. Background

Community clinicians typically receive little to no training in the care of incarcerated patients, and research demonstrates that they have knowledge deficits in the critical areas of shackling, surrogate decision makers, and presence of correctional staff at bedside.(1) The lack of guidance available to non-correctional healthcare professionals regarding the care of incarcerated patients is a significant gap given that such materials could help ensure proactive, consistent, and clear channels of communication between healthcare staff in prisons and admitting community hospitals. Furthermore, such guidance could help to clear up erroneous assumptions about the healthcare rights of incarcerated patients in the acute care setting.

9.1.2. Educating Community Health Care Providers During the COVID-19 Pandemic

Large COVID-19 outbreaks in California's correctional facilities (and around the nation) resulted in the transfer of dozens of patients to community hospitals in the surrounding communities. Community hospitals accustomed to receiving incarcerated patients one or two at a time periodically faced the challenge of managing a dozen or more patients at once who were seriously ill with COVID-19 and transferred from CDCR facilities. During the pandemic, from March 1, 2020 to October 9, 2021, a total of 6,542 (4.4%) CDCR patients were transferred to community hospitals throughout California (1,049 of whom were hospitalized due to COVID-19). With CDCR patients being admitted to acute care settings in the community, anecdotal reports from CCHCS healthcare professionals and community healthcare professionals made it increasingly clear that confusion and discomfort regarding the care of incarcerated patients was common among staff in community hospitals.(2,3)

Early in the pandemic, the CalPROTECT team began fielding inquiries from community clinicians about providing humane, ethical care to incarcerated patients. In response, we

developed and distributed a wide variety of educational and informational materials to address this vast knowledge gap. CalPROTECT's written materials, articles and presentations addressed common questions in the care of incarcerated patients, such as:

- Incarcerated patients' rights to make their own medical decisions
- Incarcerated patients' rights to name surrogate decision makers
- Guidelines regarding communication between community clinicians and non-incarcerated surrogate decision makers and family members
- Contact between incarcerated patients and their loved ones
- Ethical considerations around participation in clinical trials and/or the use of treatments that had not received full Food and Drug Administration (FDA) approval

Our approach to addressing these knowledge gaps resulted in the following areas of work:

1. One-to-one consultation with community health care professionals and hospital ethics boards to answer their pressing questions and to connect them with CCHCS leaders
2. Development of written materials for community healthcare professionals ("Providing Acute Care for Seriously Ill Incarcerated Patients: Frequently Asked Questions," **Supplemental Text S9.1)** which we designed specifically to address the most common concerns and questions arising from community clinicians taking care of CCHCS patients. These written materials were reviewed by CCHCS legal counsel and developed in consultation with CCHCS medical leaders. We also developed materials intended to support CCHCS healthcare professionals around the care of seriously ill people prior to transfer to community acute care facilities, entitled "Advance Care Planning (ACP) in Prison or Jail: Resources for Correctional Clinicians and Patients During COVID-19" (**Supplemental Text S9.2)**
    a. These materials were distributed in a variety of ways, including:
    b. To anyone requesting consultation
    c. To all California hospitals that receive CCHCS patients
    d. To CCHCS medical leadership to support their efforts to provide written guidance to community clinicians receiving their patients or to their own staff regarding engaging in advance care planning conversations with patients prior to community hospital transfers
3. Development of a webinar to improve clinician knowledge about care of incarcerated patients – which can be viewed at: https://vimeo.com/436990602
4. Giving lectures to diverse audiences of community healthcare professionals, with a focus on palliative medicine and critical care clinicians.
5. Publication of an article in the medical literature entitled "Providing Ethical and Humane Care to Hospitalized, Incarcerated Patients With COVID-19" (4), see **Supplemental Text**

S9.3, which can also be accessed here:
https://journals.sagepub.com/doi/full/10.1177/1049909121994313

9.1.3 Key finding and recommendation

Key finding: Many community healthcare partners are unfamiliar with navigating the legal and ethical issues surrounding the care of incarcerated people in community healthcare settings. This lack of knowledge has profound implications for patient care as well as potential significant moral injury to community healthcare professionals

Recommendation 9.1.1. CCHCS should consider using or adapting CalPROTECT materials on the care of incarcerated people in community healthcare settings. These materials could be distributed with each CCHCS patient transferred to a non-CCHCS health care facility.

9.2. Educating residents of correctional facilities about COVID-19 vaccines

9.2.1. Background

Although incarcerated people are at increased risk of contracting COVID-19, vaccine hesitancy was elevated among incarcerated people at the outset of the pandemic. For example, one study found that among Black/African American prison and jail residents surveyed from September through December 2020, only 36.7% would be willing to receive a COVID-19 vaccine.(1) Respondents stated this was because they wanted more information about the vaccine and had concerns about COVID-19 vaccines' safety and efficacy. One in five survey respondents stated they would refuse the vaccine outright due to mistrust of health care, correctional, or government personnel or institutions.(1)

9.2.2. Educating Residents of Correctional Facilities about COVID-19 Vaccines

As vaccine distribution began in CDCR in December 2020, faculty in CalPROTECT were contacted by numerous community partners asking for creation of high quality, science-based materials about the COVID-19 vaccine from a trusted source for people who are incarcerated in CDCR. In response, we developed a wide variety of materials to address common questions about the COVID-19 vaccines. These materials, structured as a Frequently Asked Questions (FAQ) handout about vaccines are available in English and Spanish (see **Supplemental Text S9.4**),(2) were created in consultation with currently and recently incarcerated people as well as community stakeholder groups. They have been periodically updated as new developments emerge (e.g., the availability of new vaccines, new concerns, or boosters).

The CalPROTECT COVID vaccine FAQ addresses topics such as:

- Vaccine safety of all three available vaccines: mRNA-1273 (Moderna), BNT162b2 (Pfizer), and Ad26.COV2.S (Janssen / Johnson & Johnson)
- Anticipated vaccine side effects
- Safety of the vaccine for people with chronic medical conditions
- Myth regarding effect of the vaccines on fertility
- Utility of getting the vaccine given the presence of variants
- Mask-wearing after vaccination

The FAQ also features logos from more than 20 community partners who participated in the drafting and distribution of the document which has helped engender trust among people who receive the materials. These materials were iteratively updated over the course of the pandemic. When concerns arose regarding the safety of the Johnson & Johnson vaccine,

because of this vaccine's particular use in the jail setting and in response to requests from our community partners, we also developed a specific 1-page FAQ with pointed safety information.

- These materials were widely distributed throughout both CDCR and the nation, including distribution of hard copy materials to each CDCR facility through Initiate Justice, a partnering community organization throughout the Los Angeles County Jail system to anyone who directly requested a copy from us.

Dr. Leah Rorvig from the CalPROTECT team also participated in several live and recorded presentations about the COVID-19 vaccine and hesitancy among incarcerated people:

- The Marshall Project's video COVID-19 and Vaccine Mistrust Behind Bars,(3) a 20-minute film addressing vaccine hesitancy among currently incarcerated people
- The Anti-Recidivism Coalition's Fireside Chat: Dispelling Concerns: Distribution of the COVID-19 Vaccine Inside Prisons, Jails & Detention Centers(4)
- Mt. Tamalpais College's next Community Dialogs event on COVID-19 vaccination and the incarcerated community in California(5)

9.2.3. Recommendation

Recommendation 9.2.1: Trusted community partners can serve a critical role in providing high quality, science-based, community-driven educational materials to incarcerated people. CCHCS should consider continuing to engage community consultants in the development of such materials when the need emerges.

9.3. COVID-19 vaccine education event at Salinas Valley State Prison

9.3.1. Background

Modelling studies suggest that COVID-19 vaccination rates over 90% are critical for lowering the risk of outbreaks, particularly as prisons resume in-person activities (e.g., group education, visitation).(1) Thus, efforts to achieve widespread vaccination among incarcerated people are crucial. However, vaccination rates in U.S. prisons have been widely variable, and it is estimated that just 64% of incarcerated adults received at least one vaccine as of August 29, 2021, compared to the national average of 74%.(2) The limited data on vaccine hesitancy in this population suggests that common concerns include safety or efficacy (19.6%) and distrust of health care, correctional, or government institutions (20.1%).(3) Little, if anything, is known about how to address the concerns and the desired educational needs of people experiencing incarceration who are still deliberating whether or not to get vaccinated.

California has the nation's second largest prison system, and vaccination rates are among the highest in the nation with rates for full vaccination at 80% among people who are incarcerated as of December 30, 2021.(4) These relatively high rates can be attributed to early vaccine availability and widespread internal education efforts on the part of California Corrections Health Care Services (CCHCS), including direct counseling by correctional health care staff. This section describes one vaccine education event targeted toward people residing in CDCR facilities who continue to experience vaccine hesitancy.

9.3.2. Description of the Event

In mid-July 2021, the healthcare department for California state prisons CCHCS conceived of and hosted a COVID-19 vaccine education event at Salinas Valley State Prison (SVSP), one of its high-security prisons, for most of its approximately three thousand residents. During the three-day event, a multi-disciplinary group of internal and external stakeholders came together to provide vaccine education. This group included CCHCS and prison staff, a meditation teacher, a representative from the Prison Law Office, and a physician from CalPROTECT at the University of California, San Francisco (UCSF). The group hosted the main education event in a large gymnasium for all people in the general population units and met individually or in small groups with residents housed in higher security settings. At the time of the event, over 60% of residents were already vaccinated. During the event, over 110 residents received vaccinations, and many more accepted education and written materials. This has been subsequently repeated at a second CDCR facility with similar success and will likely become a model for vaccine education in CDCR going forward.

9.3.3. Recommendations

Below we highlight lessons learned from this event.

1. **Make vaccination education enjoyable:** The vaccine education event included vaccine trivia with candy prizes, an art contest (**Figure 9.3.1**), and informal question and answer sessions with healthcare professionals. Food donations from a community organization (donuts and pizza) also attracted residents to the event. Vaccine visibility was emphasized, as all vaccinated residents could wear a decorative "I'm vaccinated" sticker. Having multiple stations and games facilitated a casual environment and allowed for informal small group conversations to emerge organically. This approach also allowed people to engage in conversation with an educator of their choice (including professionals who work for the California Department of Corrections and Rehabilitation, CDCR) to address their individual questions and concerns.
2. **Strategically optimize participation:** The event was co-located with a pre-existing popular food sales event to increase participation. In order to maximize attendance and flow of participants, all general population housing units were assigned a scheduled time to attend the event.
3. **Make vaccines available and offer options:** To enhance vaccination acceptance, nurses were on site at the education event and were prepared to give any unvaccinated person their choice of two vaccines: mRNA-1273 (Moderna) or Ad26.COV2.S (Janssen / Johnson & Johnson). Vaccine choice was valuable, as different individuals weighed the benefits of each differently.
4. **Diversify sources of information:** Many incarcerated people experience distrust of the people working in the facilities where they are, and for some people this experience was exacerbated by the COVID-19 pandemic. Therefore, bringing in outside clinicians, public health experts, trusted mentors or advocates, and peers, such as formerly incarcerated people, can be critical for ensuring that residents of correctional facilities can access multiple sources of trustworthy information.
5. **Engage formal and informal leaders:** During the vaccine education event, community leaders in the prison, including "shot-callers" or influential leaders of identity or affiliation groups, openly voiced their support for vaccinations, which may have contributed to the event's success. Although their support was not intentionally pursued, other sites might consider proactively engaging prison community leaders prior to scheduled community vaccine education events to answer questions, address concerns, and gauge possible support for vaccinations.
6. **Ensure access to high-quality information:** Access to information about COVID-19 within prisons varies from site to site. In some facilities, information access can be scarce due

to limited (or no) access to internet, television, or radio. Many facilities distribute vaccination information from the Food and Drug Administration. However, people who are incarcerated have among the nation's lowest literacy levels making the utility of this approach questionable. Furthermore, even people with high levels of literacy prefer to read health information in easy-to-understand language. To address this need, Amend at UCSF, a university-based program that advances health-focused prison culture change partnered with community organizations to collect and answer questions about vaccines from incarcerated people and their loved ones.(5) These documents were made available to people at the vaccine education event, are available online in Spanish and English, and have been distributed by correctional leaders and community organizations across the U.S.

7. **Continue to offer the vaccine after the event:** Prison staff performed another round of vaccine outreach to all unvaccinated residents approximately one week following the educational event (and routinely since then) to ensure that people who wanted additional time to consider their options were not overlooked. Those who were still not ready for vaccination were instructed on how to request a vaccine appointment if they become interested.

As vaccination against COVID-19 continues to be a critical method for optimizing the health and safety of people living in congregate living environments, interventions that increase trust and acceptance of vaccines in correctional settings are of paramount importance. The successful vaccination event at a California state prison holds important lessons for other correctional institutions and congregate living facilities seeking to disseminate vaccine information and encourage COVID-19 vaccine uptake. At its core, the event's success stemmed from dedicated staff who were motivated to marshal community resources and use multiple engagement strategies to facilitate information exchange between residents, custodial staff, educators, and medical professionals.

This education event is now being replicated across CDCR facilities. At the second vaccine event at a prison with over 2,600 residents, 19% of the unvaccinated (over 160 individuals) received their first COVID-19 vaccine. Future events should assess what information unvaccinated participants believe would be most beneficial in their decision-making process and whether the event delivered that content. Innovative public health interventions in correctional facilities that are designed to promote vaccine uptake will continue to be critically important until vaccination rates are high enough to mitigate the morbidity and mortality of COVID-19 within our prisons systems. This approach at California state prisons offers a potential blueprint for success.

Recommendation 9.3.1: Continue to refine and replicate the highly successful CDCR vaccination events at all prisons. These events draw upon multiple principles of successful vaccination campaigns including: making the event enjoyable, optimizing participation, offering immediate vaccines with choices available, providing a diversity of sources of information (including from community leaders), ensuring access to high-quality information, and continuing to provide vaccination opportunities following the event.

Figure 9.3.1. Art contest winners at vaccine education event in California state prison.

Photo credit: Ike Dodson Information Officer at California Correctional Healthcare Services. (Individuals consented to sharing their photos.)

10. Effective Reproduction Numbers in COVID-19 Transmission in CDCR Institutions

10.1. Introduction

This report presents results of digital reconstruction of probable routes and timing of transmission of the SARS-CoV-2 virus between prison residents in CDCR's institutions. This analysis is centered on estimation of *effective reproduction numbers* per day and housing unit in each institution. Reproduction numbers are a key indicator to monitor the spread of an infectious disease in a population, describing the number of new cases who acquire the virus from a given infected person. Sustained spread of a disease requires a sufficient fraction of cases' reproduction numbers to be greater than one (indicating that the disease is spreading in the population, as each person transmits the disease to at least one other person). An *effective* reproduction number, often denoted by the symbol Rt, is a snapshot of the state of the outbreak describing the reproduction number at one moment in time. An Rt value expresses how many cases a given case would cause if the current conditions were to persist unchanged throughout the entire infectious period of that case.

In this analysis of California state prisons, reproduction numbers can be used as an estimate of the amount of SARS-CoV-2 transmission occurring on a given day in a given housing unit. Here we present a comparison of estimated reproduction numbers across different types of housing, given by the "room type" provided by CDCR describing residents' locations within the housing units, and how they vary by date and by time elapsed since the start of an outbreak. Analysis of the relationships between reproduction numbers and other variables, including building architecture and medical and demographic factors, is detailed in Section 11.

The differences between locations within a prison with respect to facilitating or preventing COVID transmission are of paramount interest. Case detection can occur at a substantial delay from infection, and residents can be moved from location to location during an outbreak, making it important to pinpoint the timing of transmission events as accurately as possible in order to attribute effective reproduction numbers to locations correctly. For this reason, we have ensured that our estimation accounts for the timing of transmission events in the days before detection of any case, using current information on the timing and sensitivity of reverse transcription polymerase chain reaction (RT-PCR) and antigen tests for SARS-CoV-2, and used that information together with the daily movements of residents recorded by CDCR to pinpoint as accurately as possible the time and place of transmission, distinguishing the likely times and places of an individual's infection from the place where they may be housed when first

detected by a positive test result. This information is used in the construction of effective reproduction numbers for each day in each housing unit, accounting for movements and likely delays between transmission and case detection.

10.2. Methods

10.2.1 Data sources and variables

Data collected by CDCR recorded the locations of individual prison residents in the prison's multiple housing units on each day, and the type of room in which they were housed. For all SARS-CoV-2 cases, both residents and staff members, it also included dates of symptom onset where available, as well as dates and results of all RT-PCR and antigen tests administered to residents at all CDCR institutions. Only deidentified data were made available for analysis.

While the locations of prison residents at the institution (prison) level were identified by institution names, housing units (e.g., buildings) within institutions were identified only by anonymized numbers. We report results by housing unit using these numerical identification numbers (IDs). Room types are identified using the following identifiers, which were provided in the dataset: Cell, Dorm, 180 Cell, 270 Cell, 270 Dorm, Room, Closed Ward, Other. We do not use the room type classifications discussed in **Section 6** but refer the reader to that section for more discussion on detailed classifications. Utilizing the CDCR room types, the classifications Cell and Dorm (without descriptors) are understood to not include the other cell and dorm types. The label Closed Ward did not arise in our use of the data in this section. For some analyses, we combined the cell and dorm types into categories All Cells and All Dorms.

Rooms of type Room were very sparsely represented in this dataset compared to the other types, and Rt estimates for those settings were low but likely heavily influenced by chance variation due to the small sample size. In this case, some data visualizations were hard to read due to outlying values in some cases. For this reason, the Room type has been omitted in some figures and presentations of results, though it is included in all statistical analyses.

10.2.2 Analytic approach

We conducted a computational process of Bayesian estimation to estimate effective reproduction numbers for SARS-CoV-2 transmission in each housing unit of the CDCR institutions on each day (see **Supplement S10.1** for details).

Data Limitation: CalPROTECT's access to CCHCS administrative data contains anonymized yard, building, and room identifications with classification of room types (i.e., 270 cell, 270

dorm, 180 cell, other cell, other dorm, room, etc.). Having identified housing data would provide an opportunity to link observations and data collected from CalPROTECT site visits to CDCR administrative data in order to better examine the risks of transmission in different CDCR environments. Furthermore, CCHCS administrative data does not include whether double and single cells are open/barred or closed-front cells which has the potential to affect the risk of COVID-19 transmission.

We used CDCR's data set to provide dates and results of all RT-PCR and antigen tests administered to residents at all CDCR institutions, dates of onset of symptoms reported for residents, and daily locations of residents at the institution and housing unit levels.

We estimated the likelihood that each resident was infected on a particular day by combining several sources of information. Established estimates of the performance of RT-PCR and antigen tests for the virus were used to combine all positive and negative test results recorded for an individual, together with reported symptom onset dates where available, to construct a probabilistic estimate of date of infection and duration of incubation period for each infected individual. This allowed us to estimate how likely each resident was to have been infected on each day, and how likely they were to transmit the virus to others on each subsequent day.

We used these estimates together with residents' daily locations to estimate how likely transmission between individual pairs of residents was to occur on each day. From this, we generated estimates of how many new cases were infected by each infected resident each day, allowing us to estimate effective reproduction numbers (Rt) by housing unit by day, and the number of cases infected in each housing unit each day. This estimation process operates on all cases in an institution together and is applied to each institution in the CDCR system, generating housing unit-level estimates of Rt for all outbreaks in all institutions in the time period studied.

These estimates account for the daily movements of residents between housing units and provide a description of the dynamically changing conditions in each housing unit by day as individuals become infected, recover, and shift locations. Because these estimates take into account where individuals were day by day when they were likely to have been infected, where they were day by day when they were likely to be infectious, and which individuals were in proximity and infectious on days when each other individual at the institution may have become infected, they provide an estimate of which locations within an institution were more likely to have been sites of transmission each day.

Because higher reproduction numbers can be understood to reflect local conditions conducive to spread of the disease, these estimates can be used to evaluate the relative safety of different settings and the effectiveness of control measures such as masking and ventilation.

For example, Rt values that are greater than one indicate a growing outbreak, whereas Rt values less than one indicate an outbreak that is slowing. Statistical analysis of the relationships between location, control measures, and other observed quantities and reproduction numbers is not detailed in this section but reported in **Section 11**.

In this section, we present summaries of the results over the 35 prisons of the CDCR system. In **Supplement S10.1**, we present the results from each institution in detail, in one figure per CDCR institution. **Supplement S10.2** documents the estimation methods in further detail.

10.2.3 Identification of outbreaks

Some CDCR institutions have undergone multiple outbreaks separated in time. We used COVID testing results by date to identify distinct outbreaks at each institution, defined consistently with the California Department of Health's definition as a series of cases at intervals of 14 days or less (1). Cases were considered to be detected on the date of their first positive test. We defined the start of an outbreak at an institution as the detection date of the first case after such a gap and define the "outbreak day" for each day to be the number of days since the start date of the current outbreak in the institution. For days occurring between the last case of one outbreak and the first of the next, we defined the outbreak day to be a negative number of days, counted backwards from the start date of the upcoming outbreak, because inferred transmission events belonging to the outbreak can, and generally do, occur before the detection of the first case. This identification of outbreaks was used when calculating statistics involving time since the start of an outbreak at an institution.

10.2.4 Summary statistics

After generating the estimates for each institution in the CDCR system described above, we combined them to provide a summary of estimates across the system of prisons. We visualized the distribution of effective Rt values pertaining to infectious individuals over the entire system and time span studied, stratified by room type, and by days since outbreak start. More complete statistics describing the relation of Rt and other quantities to a range of variables including room type are to be presented in **Section 11**.

10.2.5 Effect of transfer within institutions on R_t

Movement of residents within institutions has been one policy measure in use that may attenuate spread of the disease. Infected or suspected infected individuals may be relocated to reduce their exposure to uninfected people, while uninfected people may be moved to reduce their exposure to infectious people. The effectiveness of relocation of infected people hinges on their infecting fewer people in the destination location than they would in the original location, that is, on their being moved to a setting where their reproduction number is smaller

than it would have been without the move. The effectiveness of relocation of uninfected people hinges on their being less likely to be infected than they would have been without the move, and a comparison of effective reproduction numbers between the original and destination locations can be used as an indicator of the exposure risk in the two locations. For these reasons, we use a comparison of effective reproduction numbers between the original location and destination locations of an individuals' move to assess the effectiveness of movement in stemming transmission. A sign of effectiveness would be that reproduction numbers tend to be smaller in the locations where individuals arrive from a move than in the locations they left.

For each movement of an individual from one housing unit to another within an institution, we calculated the average Rt over 14 days beginning the day of the move, in the housing units where they were housed before the move and after. These averages were compared for all moved individuals, regardless of whether they were moved together with others. We tested for an overall change in Rt across all such moves of individuals by a paired t-test comparing the difference in 14-day average Rt from the origin to the destination location.

10.3. Results

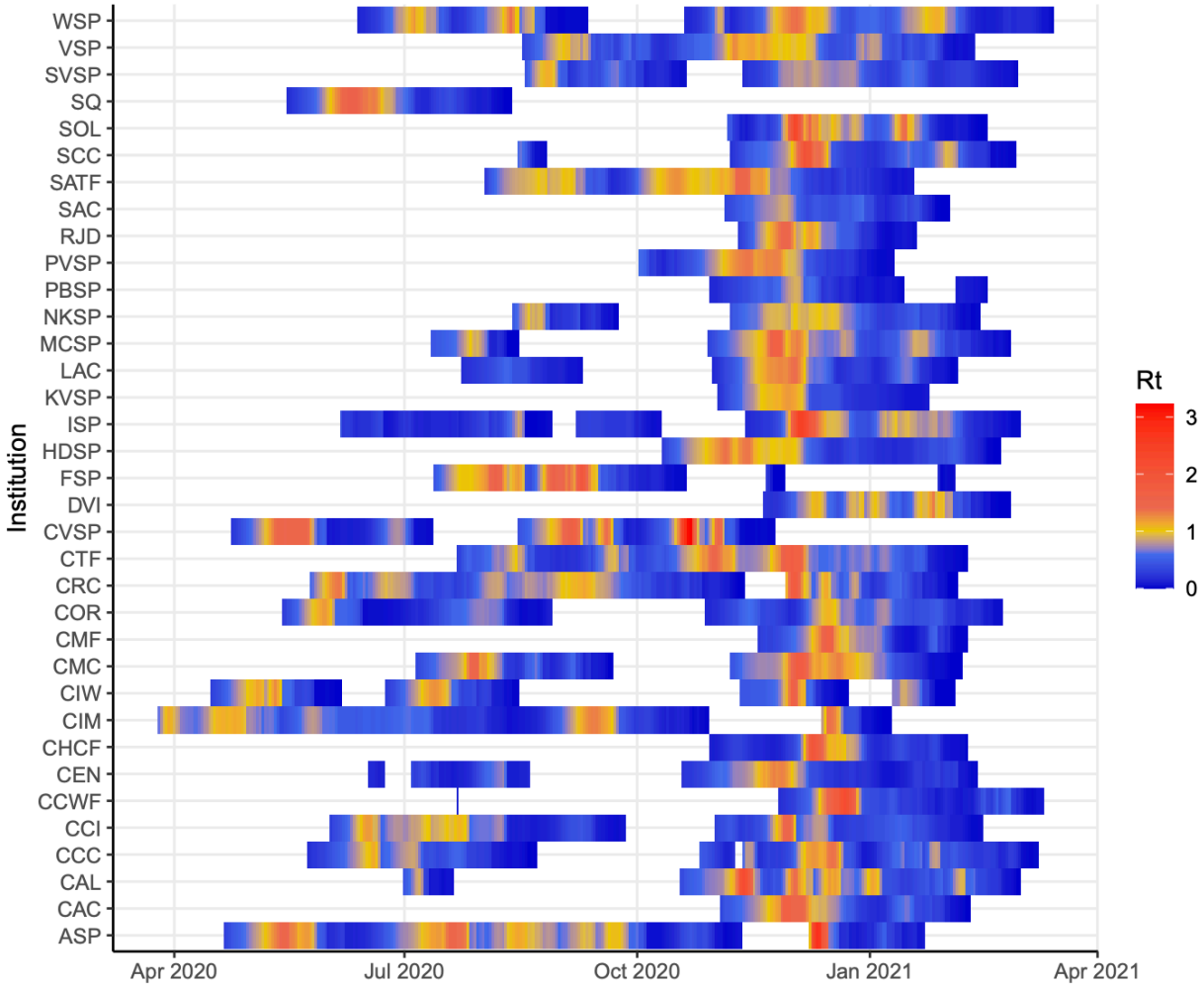
We estimated daily effective reproduction numbers by housing unit in each of the CDCR's prisons, across the date range May 1, 2020 to March 19, 2021. This procedure also yielded daily probabilistic estimates of the number of cases infected each day (incidence) by housing unit. These results are visualized in **Supplement 10.1** with estimated incidence and daily Rt values by day and housing unit in each institution (in alphabetical order).

10.3.1 Summary statistics

We summarize average estimated reproduction numbers by day in the 35 CDCR institutions, providing a look at the overall course of the pandemic in the prisons (**Figure 10.1**). Outbreaks are characterized by reproduction numbers greater than one (red in the figure) as the outbreak spreads, followed by reproduction numbers dropping below one after the outbreak reaches its peak and begin to shrink (blue in the figure). Thus, the peak of each outbreak occurs around the time when the plot shifts from red to blue at an institution, reading from left to right in the figure. An early outbreak in March/April 2020 at CIM can be seen first when reading from left to right, followed by the outbreaks at CIW, CVSP, and ASP, and then several other sites including SQ. Outbreaks continue to arise at multiple institutions, including second and third outbreaks in some places, and there is a large wave of outbreaks across the CDCR system at the end of 2020.

Estimates are then summarized by room type across the CDCR system. The distribution of estimated Rt values across all infectious individuals in the CDCR system in the time span modeled displays some difference between room types (**Figure 10.2**). Notably, the Rt values seen in celled housing are not systematically lower than those in dorm housing, an important finding given that celled housing has been assumed safer and less conducive to transmission than dorms (see **Section 11** for statistical analysis of this question).

Figure 10.1. Daily weighted average estimated Rt values by institution. Plot includes all days on which estimated expected number of infectious individuals was at least 0.5.

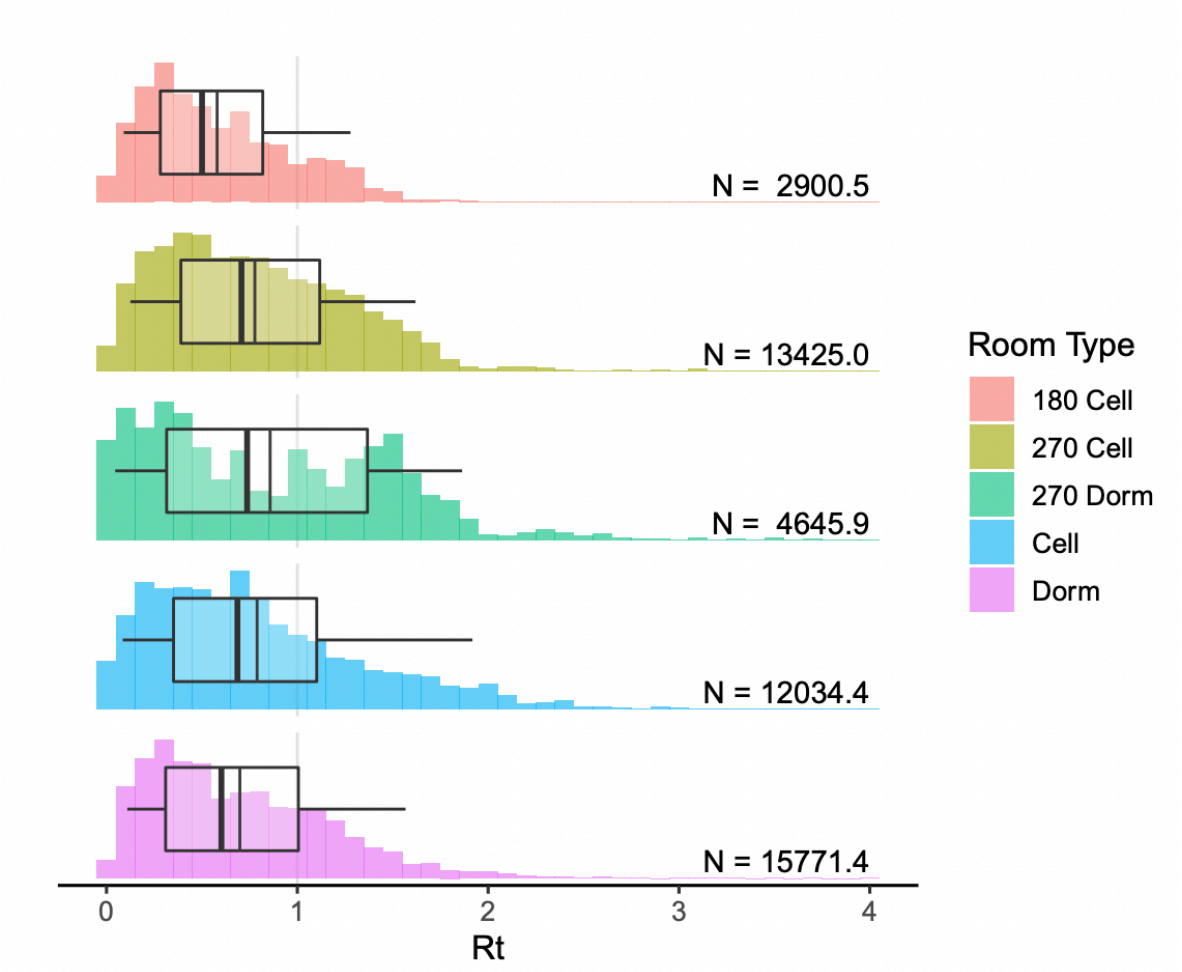


Note: Detailed estimates of daily Rt by housing unit within each institution are plotted in **Supplement S10.1.**

Key finding: In aggregate, celled housing has overall not been clearly protective compared to dorm housing, an important finding given that celled housing has been assumed safer and

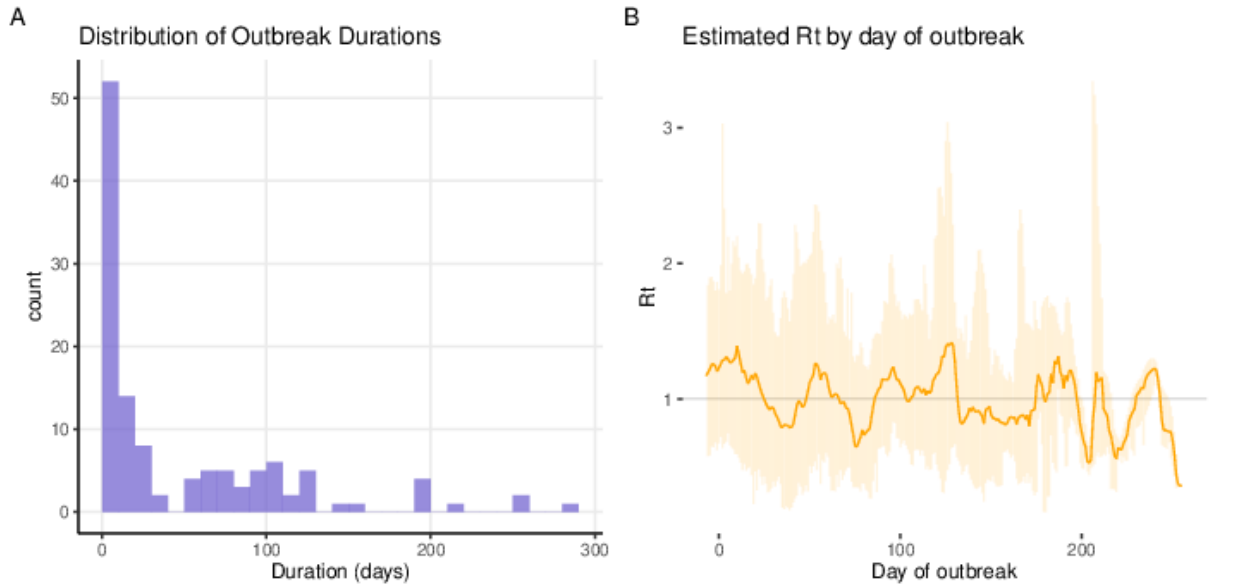
less conducive to transmission than dorms. Housing identified as "Cell," as distinct from 180 cells and 270 cells, had slightly higher hazard of test positivity than "Dorm" when controlling for other factors. At the same time, "270 Dorm" had higher infection risk than all other room types. (Note: These room type metrics are directly from CDCR/CCHCS and do not include the more detailed features as they are reported in Section 6. Refer to Section 6 for an evaluation of the risk of infection based on a more nuanced description of cell and dorm housing types using a different analytic approach.)

Figure 10.2. Distribution of estimated Rt values by room type. In the box plots, the heavy line marks the median value, and the lighter line marks the mean. Box limits mark the interquartile range of estimates, and whiskers mark the 95% central interval. See second report for full statistical analysis of difference between room types when controlling for other differences. Numbers (N) provide the total estimated number of infectious individuals located in each room type, accounting for daily movements during their infectious period, as an estimate of sample size for the histograms and box plots.



Overall, 112 distinct outbreaks were identified from the dates of resident cases, including 68 outbreaks of 4 or more cases (**Figure 10.4A**). Average estimated reproduction numbers by time from the start of each outbreak (**Figure 10.4B**) have relatively high initial values in the first days before and after an outbreak is detected, and then show a pattern of decline over time, possibly reflecting the impact of increased protective measures after an outbreak is detected and/or slowing of transmission as residents who have not been infected become less common. Note that the distinction between these mechanisms is examined formally in **Section 11** using statistical regression. Apparent secondary surges after 100 days or more in some outbreaks may reflect what are effectively multiple outbreaks without a 14-day gap between them, which would be counted as a single outbreak, or may reflect that some outbreaks were reignited as community transmission surged in Winter 2020–2021 or at other times.

Figure 10.4. (A) Distribution of outbreak durations, in days from first to last case detection, inclusive. (B) Estimated Rt values by day of outbreak across institutional outbreaks. Curves depict daily weighted mean values, shaded areas depict 95% central intervals of ensemble of estimates. Values from 1 week or more prior to start of outbreak are omitted due to potential inaccuracy caused by sparsity of available data.



10.3.2 Effect of transfer within institutions on R_t

We estimated the difference in the average Rt of the resident's location associated with movement of residents between housing units within an institution. There were 127,920 such

movement events recorded. The average difference in the per-housing-unit Rt estimate over the 14 days following a move was a reduction of 0.0014 in Rt. A paired t-test rejected the null hypothesis of no difference in Rt with $p < 10^{-15}$ (95% CI: 0.0011, 0.0016).

10.4. Discussion

In this report we have presented estimates of daily effective reproduction numbers at all CDCR institutions, indicating the strength of transmission at differing times and places within each institution.

Our estimates of reproduction numbers fall in the range between 0 and 4 (see for example **Figure 10.2**), in contrast to some early estimates of higher reproduction numbers in congregate settings (e.g., 8.44 in a jail (95%CI: 5.0, 13.13) (2), up to 11.2 in a cruise ship (3)). While not reaching such extreme values, our estimates of effective reproduction numbers here do in some cases exceed many estimates of basic reproduction numbers in community transmission of the early dominant strains of SARS-CoV-2 (for example, 2.87 (95% CI, 2.39–3.44) (4)). We note that basic reproduction numbers (R_0, the number of new cases generated by a case *in the first moments of an outbreak* before any individuals have lost susceptibility or control measures have begun) tend to be higher than effective reproduction numbers, and of course the extent and duration of community transmission attest to the danger posed by reproduction numbers in the range found there. We note also that because of smoothing induced by uncertainty in timing of transmission events—see below for details on this point—our methods may underestimate the upper extremes of true Rt values somewhat.

One implication of peak values of Rt falling in an intermediate range rather than at the higher values seen in early estimates is that realistic interventions, if they could reduce transmission events by a factor of 50%–80%, could have had a profound impact on outbreak control by bringing reproduction numbers below 1, where more extreme measures would be required to make that possible if Rt were higher.

We have provided a simple unadjusted comparison of reproduction numbers by type of housing, as indicated by the room type. We observe that reproduction numbers do not appear to be overall reduced in celled housing compared to dorms, a meaningful finding given that cells have been assumed protective due to the smaller room size.

Reproduction numbers are seen to decline gradually with time following the detection of an outbreak in an institution. This effect may be attributable to changing conditions including protective policies and individual protective behaviors, or to exhaustion of the number of remaining residents in a building who have not yet been infected.

A fuller treatment of these and other correlates of reproduction number is presented in **Section 11**. We assessed the impact of movement of individuals on reproduction number, as a means of assessing whether movement has tended to limit transmission. We found a statistically significant but remarkably small effect of movement on the reproduction number averaged over the 14 days beginning the day of the move, indicating that while movement of particular infected individuals may have substantially limited transmission to others and movement of particular uninfected individuals may have substantially limited transmission to them from others, the benefit of movement taken across all individual moves seems to have been relatively small overall.

Key finding: Reproduction numbers declined very quickly after the start of an outbreak and less rapidly over time, when controlling for the fraction of people still susceptible in each housing unit. This suggests that control measures taken in the immediate wake of an outbreak onset such as quarantine and isolation and/or protective changes in individual behaviors have had an effect on limiting outbreaks. At the same time, there is a significant and substantial correlation between the fraction susceptible and reduction in reproduction number, when controlling for time passed, suggesting that outbreaks may have to some extent been limited by accumulation of naturally acquired immunity.

10.4.1 Estimated incidence vs. Reported cases

In addition to the effective reproduction number, our model estimates the true daily incidence of cases each day in each housing unit. This quantity is similar to the daily number of new cases detected per housing unit, which is already known to CDCR and CCHCS, but is distinct in several ways. First, cases are infected some number of days before they can be detected by either a positive test or a report of symptoms, so true incident infections occur earlier than reported incident cases. Second, while case detection dates, defined here as the date of the first positive test for each individual, are known, the date of infection is unknown, and its uncertainty is reflected in smoothing of the probabilistic estimate of incidence across multiple days. Secondly, because of movement of residents, infection of a resident can occur in a different housing unit or even a different institution from where the resident was first detected as a case. For this reason, the estimated true incidence in a single housing unit may in fact not resemble a smoothed version of the reported incidence shifted to earlier dates, as some cases may be incident in different locations from where they were detected. Details in this difference between estimates may be useful in identifying movement of residents relevant to the spread of the outbreak.

10.4.2 Limitations

This study has several limitations. The inference of Rt and incidence used here uses CDCR's reported individual testing and symptom report data to identify cases, with the consequence that any cases that were not identified by positive tests or symptom reporting are not included. As a result, daily incidence and overall case numbers may be underestimated (to the same degree as in any other reporting of CDCR's numbers, including the CDCR public COVID dashboard). While reproduction number estimates are likely to be relatively robust to undercounting of cases at a consistent rate through time (since the ratio of new cases to existing cases is robust to that difference), if there are changes in the proportion of cases detected through time, or changes in the time from infection detection, reproduction numbers may be biased by those differences. There may have been an increase in case detection over time due to limited availability of testing early in the pandemic, which could cause an upward bias in Rt estimates; however, if the change is gradual, the impact on Rt estimation is likely minimal as the difference from one generation of cases to the next is slight.

While we estimate effective reproduction numbers for each infected individual on each day that they may be infectious, the estimation procedure treats all residents in a given housing unit on a given day as having effectively the same exposure to other residents. For this reason, individuals' Rt estimates are not effectively distinguished within housing units, and the estimated Rt should be treated as a housing-unit-level descriptor. This consideration is discussed further in our treatment of correlations between individual characteristics and Rt values in **Section 11**. These and other limitations are discussed further below.

Smoothness

The exact date on which specific residents became infected is not known and cannot be known in general. We constructed probabilistic estimates of these dates based on their history of test results and symptom reporting, reflecting what is known about their disease course, and equally reflecting the intrinsic uncertainty imposed by the limitations of available data. This uncertainty is reflected in our estimates, which take the form of a smooth curve of probability of, for instance, dates of infection of a case, which rises from zero over several days to a peak at the most likely day, and then gradually declines again.

This uncertainty in dates of infection and infectiousness, appearing as smoothing of estimates over several days, is reflected by a corresponding smoothing of the estimated Rt and aggregate incidence over time.

It may be that true reproduction numbers changed abruptly on specific dates in certain places, for example because of crowding caused by movement of many residents at once, or because

of changes in HVAC system operation. While we would expect our estimates to reflect that a change in Rt occurred, the intrinsic smoothing caused by granularity of the testing and symptom data is likely to cause the estimates to change gradually over several days from an earlier to a later value, even if the true change occurred all at once.

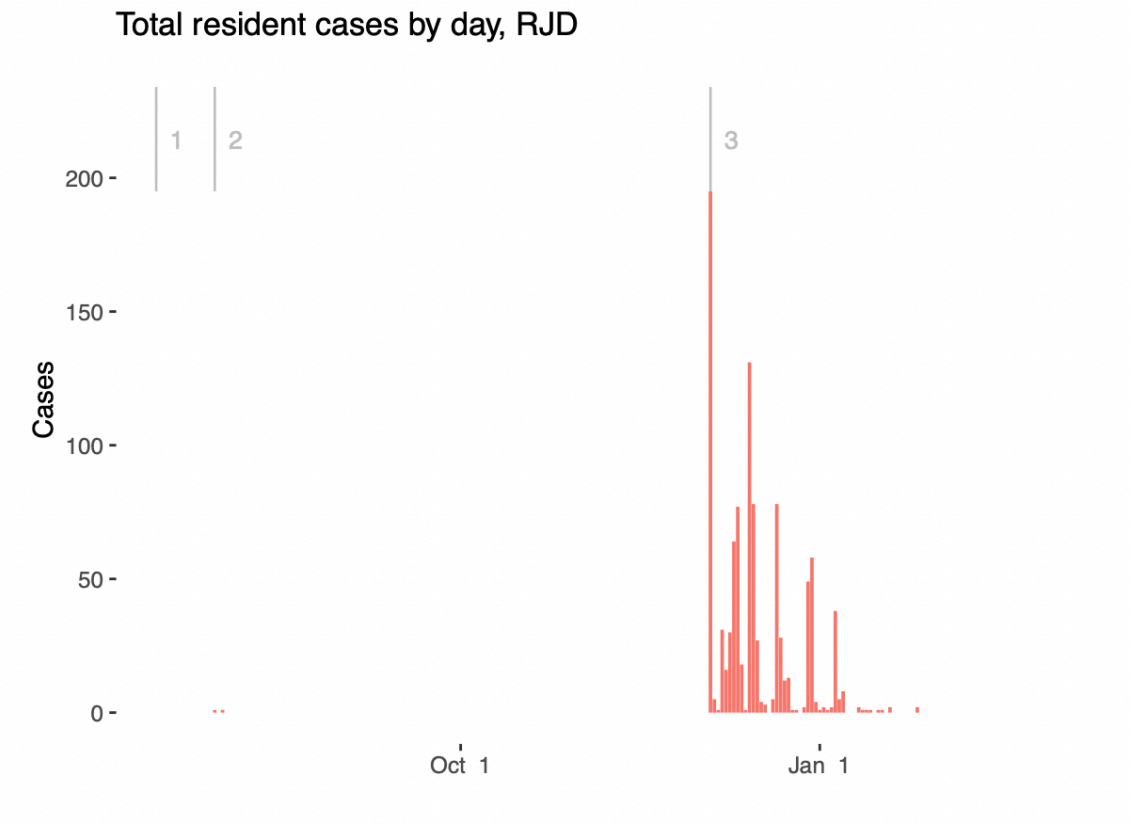
Missingness of information about the true timing of early cases appears to drive low estimates of Rt on days well before the first case detection of an outbreak, resulting from details of the model's assumptions about the likelihoods of late case detection and early infectiousness. This is a subject for further research. Because of this effect, the estimated Rt may take on small values very early in the outbreak during the smooth transition from low to high estimates, which are visible for example as blue areas at the start of outbreaks in **Figure 10.1**. These small values may be caused by this smoothness rather than by a true low rate of transmission early in the outbreak.

Additionally, if there were to be a sudden, brief moment of dangerous conditions, characterized by a quick spike in reproduction number, because of uncertainty in inferring timing from test data, the estimated Rt would likely appear as a longer, smoother rise and fall, with the peak not as high as the true spike.

Missingness of timing data at the beginning of outbreaks

Several outbreaks in the CDCR system displayed a pattern in which the first, or nearly first, cases are detected by a large number of positive test results all on a single day. This pattern is seen, for example in the large Fall/Winter 2020–2021 outbreak at RJD (**Figure 10.5**). A vertical bar marks the beginning of the large outbreak (labeled "3" for 3rd outbreak at RJD). Nearly 200 cases are detected on a single day, after many days of no case detection, and then smaller numbers of cases are detected on subsequent days.

Figure 10.5. Cases detected per day at RJD. Gray lines mark the start of each outbreak.



Our method of estimation of reproduction numbers requires estimation of when transmission events occurred, in order to infer which individuals were source cases for others. A set of cases appearing all at once like this almost certainly represents multiple generations of transmission, but the data can provide very little indication of how many generations from the data, since the timing of transmission is obscured by the lack of earlier test results. For this reason, estimates of reproduction numbers at the beginning of these outbreaks may be less accurate than estimates for other time spans.

11. Correlates of COVID-19 Transmission Risk in CDCR Institutions

11.1. Introduction

As congregate settings generally have been shown to be an important part of seeding ongoing community transmission due to the close proximity and prolonged contact in such settings (1), it is vital to understand the particular circumstances and conditions that may have helped fuel continued transmission in the prison setting, and also to assess the efficacy of steps taken to prevent and control transmission. Control measures, such as those undertaken during the San Quentin outbreak, have included transfer of infected residents to isolated cells and from dormitory-style housing and housing units characterized by open barred doors and large, stagnant shared airspaces to units with separate cells separated by solid doors. Efforts to understand the value of these control measures are critically important, as well as any insights into broader prison conditions that both controlled and supported ongoing transmission. These insights will help inform future steps to control future transmission. Here, we undertake an analysis not only to evaluate the impact of control interventions, but to identify the presence of any other potential influences on transmission, including seasonality and underlying patient risk, as well as any demographic characteristics that may have been associated with a person's particular vulnerability to transmission, including age (a significant risk factor for severe COVID (2)), disability, sex, and race/ethnicity.

Along with these individual-level descriptors, we examine associations of several reported variables describing the prison environment with transmission, including occupancy, COVID control measures and/or individual protective behaviors, seasonality, and building information. Seasonality may serve as a partial proxy for the impact of seasonal use of heating, ventilation, and air conditioning (HVAC) systems on transmission, as is discussed in Section 7.3.

We report the association of these variables with occurrences of detected SARS-CoV-2 cases, and also on estimated rates of transmission by housing unit. For the latter, we use estimated effective reproduction numbers, generated from dynamic estimates of times and locations of transmission in each institution (see Section 10 on estimation of reproduction numbers). Reproduction numbers are a key indicator to monitor the spread of an infectious disease in a population, describing the number of new cases who acquire the virus from a given infected person. Sustained spread of a disease requires a sufficient fraction of cases' reproduction numbers to be greater than one (indicating that the disease is spreading in the population, as each person transmits the disease to at least one other person). An *effective* reproduction

number, often denoted by the symbol Rt, is a snapshot of the state of the outbreak describing the reproduction number at one moment in time. Effective reproduction numbers can be used as an estimate of the amount of transmission occurring on a given day in a given housing unit. Here we employ time series and survival regression analyses to investigate the role and impact that these various factors have had in supporting or interrupting spread in the prison setting.

11.2. Methods

11.2.1. CDCR Data and Covariate Descriptions

Data collected by CDCR records the locations of individual residents in each prison's multiple housing units on each day, reported dates of symptom onsets where available, and dates and results of all reverse transcription polymerase chain reaction (RT-PCR) and antigen tests administered to residents at all CDCR institutions. In addition to the testing and location data, CDCR also shared demographic variables, health status and underlying conditions, bunk and housing capacities, and other variables of interest describing residents and housing units (e.g., buildings) within the 35 prisons. These data were shared with us in a de-identified form. We used many of these variables and processed them as described below.

The location data included the categorizations of all housing units as either dorm or cells or subtypes of these categories, as well as information on room capacity (which refers to the total number of available beds and is unrelated to design or staffed capacity), occupancy, and capacity and occupancy within rooms and bunks. Room types were identified to include the following identifiers: Cell, Dorm, 180 Cell, 270 Cell, 270 Dorm, Room, Other (further description on room types are in Section 6, however note in this section we utilize the room type designations provided to us by CDCR and do not use the CalPROTECT categories descripted in Section 6 for analysis). A room location and its room type were listed for each resident on each day, as they moved during the time period of the analysis. We also generated a room occupancy proportion for each room on each day, calculated as the day's reported room occupancy divided by reported room capacity. If the room capacity was unreported, room occupancy level was assumed to be 100%.

Timing data was also used to generate a seasonal variable, where cases and transmission were categorized into the four seasons: fall, summer, spring, and winter, according to the astronomical seasonal dates.

Each institution in the prison system was also identified as housing predominantly men or women, or mixed. CIW and CCWF only house residents who identify as women, FSP houses both men and women, and all others house men. While a sex variable was provided for each resident, described by CDCR as "phenotypic sex", because of the large overlap between the

phenotypic sex of residents and the gender of residents housed in a given prison, we used the institution-wide variable, to allow for a comparison between the men's and women's prisons. We acknowledge that there is both a differential susceptibility to severe COVID outcomes by sex (3–6), and also potential individual or systemic differences in behavior or institutional setting that may drive differential transmission dynamics between these prison types. Thus, we have chosen to conservatively identify this variable as a feature of the institution rather than the individual and also to avoid a potential deductive disclosure.

Health and demographic characteristics were also provided for all residents. These include the following variables:

i. Age (calculated from year of birth),
ii. Race/Ethnicity which was collapsed into Asian, American Indian/Alaskan Native, Black/African-American, White/Caucasian, Hispanic/Latino(a) (non-Mexican), Hispanic/Latino(a) (Mexican), and Other. Race/ethnicity is systematically collected in great detail for the purposes of managing safety in prison populations and categories were collapsed only enough to ensure adequate cell size for analysis (also see Data Limitation description on race/ethnicity in Section 4.1.2),
iii. COVID–19 risk score (range: 0–18), an aggregate summary measure of underlying medical susceptibility to disease as assessed and calculated by the prison system for each resident, which was updated monthly in the system to reflect any changes to a resident's health status (see Supplemental Text S4.1 which details the COVID-19 risk score),
iv. A field indicating mental health condition, which was aggregated to reflect the presence of "any mental health disability",
v. Any impairment, measuring the presence of "mobility disability," "hearing impairment," "visual impairment" or "speech impairment" (range 0-4),
vi. Presence of a "cognitive disability" ever between January 2020–March 2021.

Due to limitations in the reporting of the mental health, cognitive and other disability variables, and to improve the parsimony of the model, all of these variables were collapsed to a single value for each individual evaluating whether they ever reported any of these conditions during the period of interest from January 2020–March 2021. By collapsing these variables, we hope to avoid model overspecification, improve power in the detection of the variables of greater interest, and for convenience due to the similarity in their ascertainment.

We used COVID testing results by date to identify unique outbreaks within each institution, defined consistently with the California Department of Health's definition as a series of cases at intervals of 14 days or less (7). We defined the start of an outbreak within an institution as the

detection date of the first case after such a gap, and define the "outbreak day" for each day to be the number of days since the start date of the current outbreak in each institution. For days occurring between the last case of one outbreak and the first of the next, we defined the outbreak day to be a negative number of days, counted backwards from the start date of the upcoming outbreak, because these inferred transmission events belonging to the outbreak can, and generally do, occur within an institution before the detection of the first case. In order to assess the possible impact upon transmission of the institutional responses in the immediate wake an outbreak being reported, we also included the natural logarithm of outbreak day. This should identify if there are any sudden large changes to Rt shortly after the onset of an outbreak in an institution that might be attributable to policy and behavioral level changes.

11.2.2. Summary of the Extension of Wallinga-Teunis Technique with Timing of Transmission Events

We used a previously described digital reconstruction of probable routes and timing of transmission of the SARS-Cov-2 virus between prison residents in CDCR's 35 institutions to estimate effective reproduction numbers by day and housing unit within each outbreak at each institution (see **Section 10**). An *effective reproduction number* is a description of the rate of creation of new cases from existing cases, such that if the number were to remain constant over an infected individual's infectious period, it would equal the total number of individuals infected by that case.

The differences between locations within a prison with respect to facilitating or preventing COVID transmission are of paramount interest. Case detection can occur at a substantial delay from infection, and residents can be moved from location to location within an institution during an outbreak, making it important to pinpoint the timing of transmission events as accurately as possible in order to attribute changes in effective reproduction numbers to locations correctly.

We have extended the Wallinga-Teunis technique (8) in several ways to meet the needs of this project (see **Supplement S10.2** from **Section 10** for details). First, whereas the standard Wallinga-Teunis technique uses serial intervals to infer probabilistic transmission links, we used multiple reports of positive and negative tests and symptom onset dates to infer probability distributions of dates of infection and infectious periods for all individual residents, and used these distributions to infer probabilistic transmission links and estimate daily effective reproduction numbers by individual and by housing unit.

Specifically, known estimates of the sensitivity of RT-PCR and antigen tests as a function of time since the end of the incubation period are used to infer likely infection dates and incubation

periods from test data, combined with a contribution from reported symptom onset dates where available, allowing for error in symptom reporting.

Second, daily location data placing residents in housing units is used in inference of contact patterns. Likelihood of transmission for all pairs of residents in each institution is derived from estimated timing of infection and infectiousness, and is then used to estimate likelihood for the source and infection date of each case. Residents located in the same housing unit are assumed more likely to transmit to each other than those in different units, on each day. At the same time, residents in different units may still make contact with each other, and this is assumed less likely than those sharing a unit by a factor $\alpha<1$ (as was done previously in (9,10)), as they may be exposed to each other during meals, yard time, work assignments, or programmatic events.

We used this estimation procedure to construct estimated effective reproduction numbers (Rt) and fraction susceptible per housing unit of each institution per day. The reproduction number estimates by day are used as a measure of transmission intensity for our time-series regression. The fraction susceptible in each housing unit is constructed for each day from an individual-level estimate of the probability of each individual having been infected as of each day, and defined as the expected number who have not yet been infected, as a proportion of the total number present in each housing unit each day, taking into account daily movements. The fraction susceptible over the course of these outbreaks is used to control for the effect of depletion of susceptibles on ongoing transmission and to estimate the degree to which underlying population susceptibility is driving limitation of ongoing transmission compared to control measures and behavioral adjustments.

11.2.3. Incidence Rates

Unadjusted incidence rates per person-year for the overall prison system were calculated by room type, demographic characteristics, and underlying health conditions and disability status. These are used as a baseline assessment of case burden in the prison system, and may also provide some insight into case ascertainment rates. The Cox survival analysis described below can be viewed as a more sensitive look at these questions, including adjustment for multiple factors affecting incidence at the individual level.

11.2.4. Cox Survival Analysis

A survival analysis was performed using a Cox regression to measure the time-varying hazard of testing positive for each individual. The date of first positive test result was used as the outcome of interest, with the index case(s) being identified as testing positive on day 1 within each prison, and the follow-up time for each individual starting when they are present in a prison at which at least one positive case has been detected. If an individual is transferred

between institutions after their follow-up time has started, they retain their follow-up timing into the new prison setting without resetting or adjusting their clock. Covariates considered for the Cox survival analysis were those variables as described above, including (i) outbreak characteristics (outbreak day, logarithm of outbreak day, percent susceptible, seasons), (ii) prison environment (room type, institution's sex, random effect for institution, room occupancy level), and (iii) individual demographics (age, race, COVID risk score, COVID quarantine or isolation status, mental health issue, cognitive impairment, and disability). The Cox survival analysis regression equation is:

$$\begin{aligned}\text{FirstPositiveTest} \sim\ & CovidHousing + RoomType + Room.Occup.Rate + Institution.Sex + MentalHealth \\ & + Cognitive + Mobility\_Hearing\_Vision\_Speech + Race + Age + Covid\_Risk\_Score\end{aligned}$$

We also performed a secondary analysis without COVID quarantine due to concern that this variable would appear to strongly associate with COVID diagnosis, as residents are moved into quarantine post-exposure but pre-diagnosis, and that this association might swamp others.

11.2.5. Time-Series Regression

We fit a linear mixed effects time-series regression model to assess the relationship between time-varying and invariant exposures and estimated effective reproduction numbers (Rt). The outcome of interest was Rt estimated on each day for each person, with each observation weighted by the person's infectiousness on each day, to focus the regression on the Rt values measured during outbreak and transmission events, focusing the analysis most on the times most relevant to transmission dynamics. The covariates considered in this analysis are many of the same characteristics presented in **Section 11.2.4** from the Cox regression: (i) prison outbreak characteristics (outbreak day, logarithm of outbreak day, percent susceptible, seasons), (ii) prison environment (room type, institution's sex, random effect for institution, room occupancy level), and (iii) individual demographics (age, race, COVID risk score, COVID quarantine or isolation status, mental health impairment, cognitive impairment, and aggregated other disabilities). While Rt values are estimated for each person, the estimation model is limited by the assumption that all residents in a given housing unit have effectively the same contacts, causing them to have highly correlated estimates of Rt. Thus, the Rt estimates should be considered to be effectively housing-unit-level quantities. The first and second group of variables named above are well understood to act at the level of the rooms, housing units or prisons, and will have fairly directly interpretable effects on the housing unit level transmission. However, the third group of demographic variables' effect estimates are best understood in this regression to represent the effect of one resident's status, COVID risk score, for example, on the housing unit's estimated *R* value. The effect sizes for these are expected to be small as each individual's demographic characteristics will have a fairly marginal impact on

unit-level Rt, and there is a great deal of individual variability within each housing unit. We decided against doing an aggregate level of a descriptor in a unit as the multi-level categorical variables such as race/ethnicity would not be directly comparable to each other, and any age cutoff chosen would necessarily dichotomize risk that is known to be a spectrum. The time series analysis regression equation is:

$$R_t \sim MentalHealth + Cognitive + Mobility\_Hearing\_Vision\_Speech + Covid\_Risk\_Score + Institution.Sex + Age + Race + RoomType + Season + Fraction.Susceptible + Outbreak.Day + log(Outbreak.Day) + CovidHousing + Room.Occup.Rate + (1|Institution)$$

To adjust for autocorrelation in the time series, we performed a block time-series bootstrap (block size = 7 days) to adjust the standard errors of the estimates for each specified time period (11,12). We considered a *p*-value<0.05 as statistically significant.

11.3. Results

11.3.1. Unadjusted Incidence Rates

We performed multiple analyses of the correlation between various institutional environment characteristics and demographic characteristics and infection with COVID–19. We start with an unadjusted analysis of incidence rates by populations and prison covariates by time spent in each institution (**Figure 11.1, Table 11.1**).

Overall, there were 124,027 residents included in this analysis. 49,066 were identified as infected with the SARS-CoV-2 virus during the period of our analysis. The incidence rate across all residents in the period of analysis was 0.52 cases per person-year. The average time of follow-up was 196.13 days.

The highest observed unadjusted incidence rates were in 270 Dorms with 0.84 cases per person-year, with the room type Dorms having the second highest rates of 0.57 cases per person-year. The 270 Cells and the "other" cells had incidence rates comparable to "other" dorms, with 180 Cells appearing to have the lowest unadjusted incidence rate of 0.27 cases per person-year. Unadjusted incidence rates were found to be much higher among those in "COVID Housing" than those in regular housing, with incidence rate highest in quarantine with 0.90 cases per person year, and still elevated in isolation with an incidence rate of 0.77 cases per person year versus only 0.29 cases per person year in general housing. This elevated incidence is likely driven by residents being moved post-exposure, but prior to testing positive, creating a possibly misleading appearance of causation of incidence by the COVID housing rather than by exposure prior to movement. Our further analysis of Rt and movement attempts to recreate these movements and appropriately assign transmission events to their location,

but it does appear as if at this point that there was some success in accurately identifying exposed residents and moving and isolating them, though this does not rule out the possibility of continued transmission post isolation or quarantine from those with whom they are sharing quarantine. Overall, in an unadjusted analysis incidence surprisingly appeared to increase with decreasing room occupancy rate, though as quarantine and isolation housing often have lower occupancy rates, this may be driving the association.

There is a large difference in incidence rate by institutions' sex, with men's prisons reporting a much larger unadjusted incidence rate of 0.52 cases per person year versus women's prisons reporting an incidence rate of 0.4 cases per person year. (Due to there only being one prison (FSP) of the mixed type, we refrain from drawing conclusions distinguishing it from others.) There also appears to be a strong influence of season on unadjusted incidence rate, with Fall and Winter having high reported incidence rates of 0.89 and 0.62 cases per person year relative to Spring, which only had 0.19 cases per person year.

It appears that the unadjusted incidence rates substantially increased by age through age sixty, with a slight dip in the 70+ years age group which showed a slightly lower incidence rate than the 60–69-year-old age group. This could potentially reflect an under detection of cases in younger age groups. Similarly, the reported unadjusted incidence rates appear to increase with higher COVID risk scores with a risk score of 5+ having an incidence of 0.48 cases per person-year versus those with a COVID risk score of zero showing an incidence rate of 0.24 cases per person-year, though not linearly, as any COVID risk score over zero appeared similar. Age and COVID risk score are highly correlated (indeed age is a part of the COVID risk score), and some of this association may be driven by age, or vice versa.

Overall, the reported unadjusted incidence rates for those ever reporting impairment were higher than those without, save for in those who ever reported having a cognitive or a speech impairment showing a slightly lower unadjusted incidence rate than those without.

11.3.2. Survival Analysis and Time Series Regression Analysis

We performed a multivariate survival analysis to estimate the fully adjusted associations between our covariates of interest and the instantaneous hazard of testing COVID positive (**Figures 11.2 and 11.3, Table 11.2**). We also performed a fully adjusted time-series regression with our estimates of Rt over time, as our best estimate of recreating when transmission events occurred (**Figure 10.4, Table 10.3**).

We see a similar pattern for the association of room type in both the Cox survival analysis and the time-series regression that the highest observed transmission was in the 270 Dorms units with an estimated increase in Rt of 0.13 (95% CI: −0.15, 0.40) relative to Dorms, and an

increased hazard rate of testing positive relative to dorms of 2.58 (2.49, 2.67). The three highest risk units appear to be in agreement with those from the Cox regression, namely 270 Dorms, Dorms, and Cells. Both the Dorms and the Cells appear to be performing very similarly as Cells show a 0.019 (−0.12, 0.078) increase in Rt and 0.90 (0.88, 0.92) increase in the hazard ratio relative to Dorms (Dorms are the referent).

The time spent in isolation or quarantine was found to be an elevated risk for COVID incidence with increased hazard ratio of testing positive of 4.44 (4.23, 4.66) for isolation and 2.18 (2.13, 2.22) for quarantine relative to being in the general population. This is expected and consistent with some success in identifying potential cases or exposed individuals and isolating them prior to testing positive.

Outbreak day and the susceptible fraction were both found to be significantly correlated with estimated transmission even after controlling for the other. Rt is predictably estimated to decrease with the passage of time from the start of an institution's outbreak, and it appears to be driven both by depletion of susceptibles as well as by the passage of time, but particularly driven by the immediate passage of time following an outbreak being discovered. We found that for every 10% reduction in population level susceptibility, there is a 0.044 (0.037, 0.052) reduction in estimated reproduction number. However, even after controlling for reduced population susceptibility, we found a still significant association of outbreak day with reduction in estimated Rt values, with the logarithm of outbreak day dominating the effect, indicating that most of the reduction in transmission occurs in the immediate wake of an outbreak detection within a prison, which likely reflects the impact of policy and behavioral changes after case detection. At one week post first positive case test result, there was a difference in Rt of −0.583 (−0.883, −0.283), and at two weeks there was −0.631 (−1.021, −0.241) change in Rt. The fraction susceptible may be influenced by policy as infected and exposed people are moved together, though a separate analysis of movement did not show a significant change in Rt estimates before and after movements.

The association of institutional sex on transmission and time to testing positive were consistent with the unadjusted incidence rates, both showing a reduced risk in women's prisons, significant in the Cox regression (HR: 0.67 (0.64, 0.71) hazard rate ratio for testing positive; RR: −0.024 (−0.132, 0.0847) change in average Rt). However, there are only two women's prisons in the system of 35 different institutions, so chance alone may have led to these results, but they also may be due to behavioral, policy, or other differences.

The influence of season on transmission indicates that Fall has the highest reported transmission. Winter appears to have the lowest transmission rate, in contrast to the unadjusted incidence rates, showing an 0.214 (0.152, 0.277) reduction in estimated transmission Rt relative

to Fall, with Summer and Spring having estimated Rt relative to Fall of −0.089 (−0.209, 0.032) and −0.17 (−0.364, 0.0157) respectively. The attribution of this to the overall transmission is challenging, and it may reflect both community impacts on Rt, and the impact of the cycling on of central air systems for heating in the fall weather.

These next regression estimates from the time-series need to be interpreted in a slightly different fashion from the variables above, as they should be understood to be the effect of one individual's demographic characteristics on the estimated Rt for their housing unit. As such, the estimated effect estimates will be rather small as each individual's contribution to their housing unit is relatively minor. The mean housing unit size is 51 residents, with an inter-quartile range of 5–63 residents. We found a significant association of age with developing COVID in the survival analysis, showing that as age increased ten years, there was a 1.06 (1.055, 1.072) increase in the hazard rate for testing positive. However, we did not find a significant association age with reproduction number in the Rt time-series regression analysis, finding an effect of −0.000043 (−0.00045, 0.00036) on reproduction number per year of age, meaning that as the average age of the housing unit increases, the transmission decreased marginally as well, though this effect was not found to be statistically significant.

This survival analysis result is likely the result of increased probability of case identification due to increased severity and viral load, as it provides a broader window of opportunity for catching the infection as the infectious period is longer for more severe cases and time between tests is long enough to allow for cases to go undetected. It could also reflect a true increase with age in the probability of being infected with a viral dose large enough to produce viral colonization, as has been shown in studies (13,14). Additionally, there is a possibility that health seeking behaviors make testing more likely as disease severity increases. Similarly, the reported unadjusted incidence rates appear to increase with every unit increase in COVID risk scores. The lack of identification of this risk in the Rt time series regression may be a distinction between being more likely to be infected in a survival analysis and not being significantly more likely to contribute to or be in an environment with higher ongoing transmission at the housing unit level, which is an important part of the Rt estimations. This risk score confers a 1.04 (1.03, 1.05) increase in the hazard rate ratio for testing positive per each unit increase in COVID risk score (but note that the Cox regression without the association of quarantine reverses the direction of this association, which is difficult to account for), and an association with Rt of 0.0023 (0.000028, 0.0046) per unit of COVID risk score. This may be because COVID risk scores are highly correlated with age, both because age is a large risk factor, and also because health issues that increase risk are also more prevalent with age.

Lastly, we have looked at the effect of disabilities on COVID risk, and somewhat surprisingly it appears to be protective against risk of testing positive and also Rt. We did not find an effect

on Rt (−0.0072; −0.016 to 0.0011) for the disability variables though in the Cox regression this appeared protective, finding a hazard rate ratio of 0.84 (0.82, 0.86). These apparently protective effects are in contrast to the increases that were observed in raw incidence rates in this population, suggesting that these elevated incidence rates may be largely explained by age and COVID risk. The potential interaction here is complex.

Table 11.1. Table of unadjusted incidence rates

A. Incidence Rate by Room Type

RoomType	Person Years	Cases	Inc. Rate
180 Cell	10625.87	2856	0.27
270 Cell	29115.14	14446	0.5
270 Dorm	5353.19	4497	0.84
Cell	23859.79	12639	0.53
Dorm	25620.76	14625	0.57

B. Incidence Rate by Race

Race	Person Years	Cases	Inc. Rate
Asian	1264.64	664	0.53
Black	27657.1	12097	0.44
Hispanic/Latino	29202.46	15801	0.54
Amer. Ind./Alask. Ntv.	1132.44	646	0.57
Mexican	12659.8	7078	0.56
Other	3908.41	2163	0.55
White	18757.12	10617	0.57

C. Incidence Rate by Institution Sex

Institution.Sex	Person Years	Cases	Inc. Rate
Female	3121.52	1315	0.42
Male	89084.63	46380	0.52
Mixed	2396.61	1370	0.57

D. Incidence Rate by Age

age.class	Person Years	Cases	Inc. Rate
18-29	18498.02	8356	0.45
30-39	28387.18	13596	0.48
40-49	21165.59	11328	0.54
50-59	15798.21	9330	0.59
60-69	8264.48	5021	0.61
70+	2493.16	1435	0.58

E. Incidence Rate by Season

season	Person Years	Cases	Inc. Rate
Fall	24590.69	21851	0.89
Spring	20689.46	3889	0.19
Summer	26546.7	9207	0.35
Winter	22779.8	14119	0.62

F. Incidence Rate by Mental Health Impairment

MH.Impairment	Person Years	Cases	Inc. Rate
False	61937.78	32735	0.53
True	32668.87	16331	0.5

G. Incidence Rate by Cognitive Impairment

Cog.Impairment	Person Years	Cases	Inc. Rate
False	56232.95	29762	0.53
True	38373.69	19304	0.5

H. Incidence Rate by Mobility Impairment

Mob.Impairment	Person Years	Cases	Inc. Rate
False	84463	43822	0.52
True	10143.64	5244	0.52

I. Incidence Rate by Hearing Impairment

Hearing.Impairment	Person Years	Cases	Inc. Rate
False	91412.31	47220	0.52
True	3194.33	1846	0.58

J. Incidence Rate by Vision Impairment

Vis.Impairment	Person Years	Cases	Inc. Rate
False	93927.53	48752	0.52
True	679.11	314	0.46

K. Incidence Rate by Speech Impairment

Spch.Impairment	Person Years	Cases	Inc. Rate
False	94563.65	49050	0.52
True	43	16	0.37

L. Incidence Rate by COVID-19 Risk Score

risk.class	Person Years	Cases	Inc. Rate
0	19808.34	4797	0.24
1	65551.44	40115	0.61
2	3804.57	1629	0.43
3	1765.34	778	0.44
4	1139.05	533	0.47
5+	2537.91	1214	0.48

M. Incidence Rate by COVID Housing

CovidHousing	Person Years	Cases	Inc. Rate
Isolated	7827.36	6042	0.77
none	57201.25	16459	0.29
Quarantined	29578.03	26565	0.9

N. Incidence Rate by Room Occupancy Proportion

occup.bin	Person Years	Cases	Inc. Rate
0.1	360.04	309	0.86
0.2	746.01	921	1.23
0.3	1253.18	1100	0.88
0.4	1806.86	1258	0.7
0.5	17599.17	10678	0.61
0.6	3943.16	3049	0.77
0.7	4842.7	3332	0.69
0.8	6444.26	4014	0.62
0.9	3651.13	1623	0.44
1	52106.06	22007	0.42
>1	1834.05	735	0.4

Figure 11.1. Unadjusted incidence rates in cases per person-year by outbreak, population and prison characteristics across all persons present in entire CDCR system from February 2020–March 2021. See Table 11.1 for numerical values.

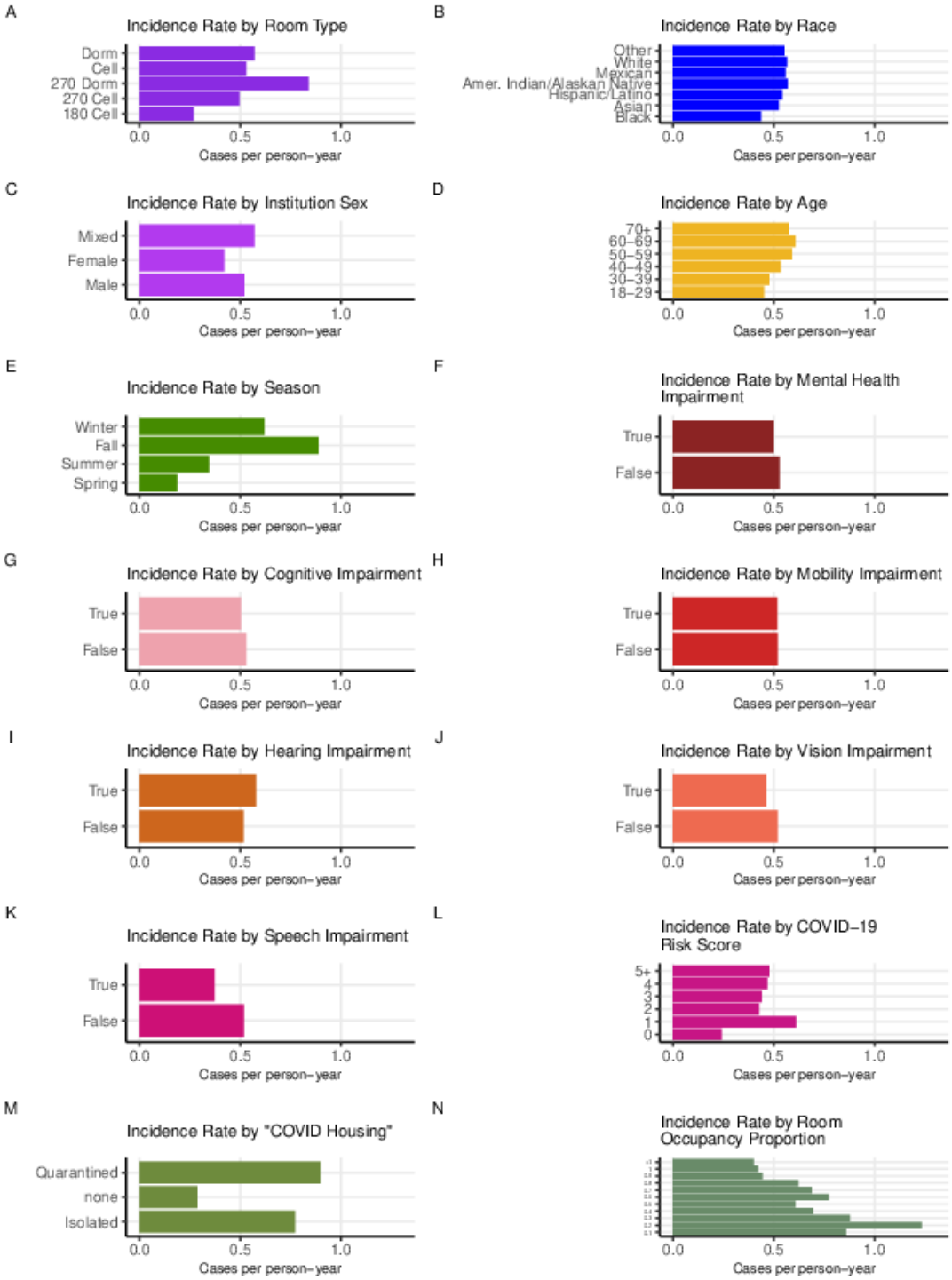


Table 11.2. Adjusted associations between prison, environmental and demographic variables and relative hazard of COVID positive test per person-day estimated by Cox survival analysis. Reference categories are in boldface.

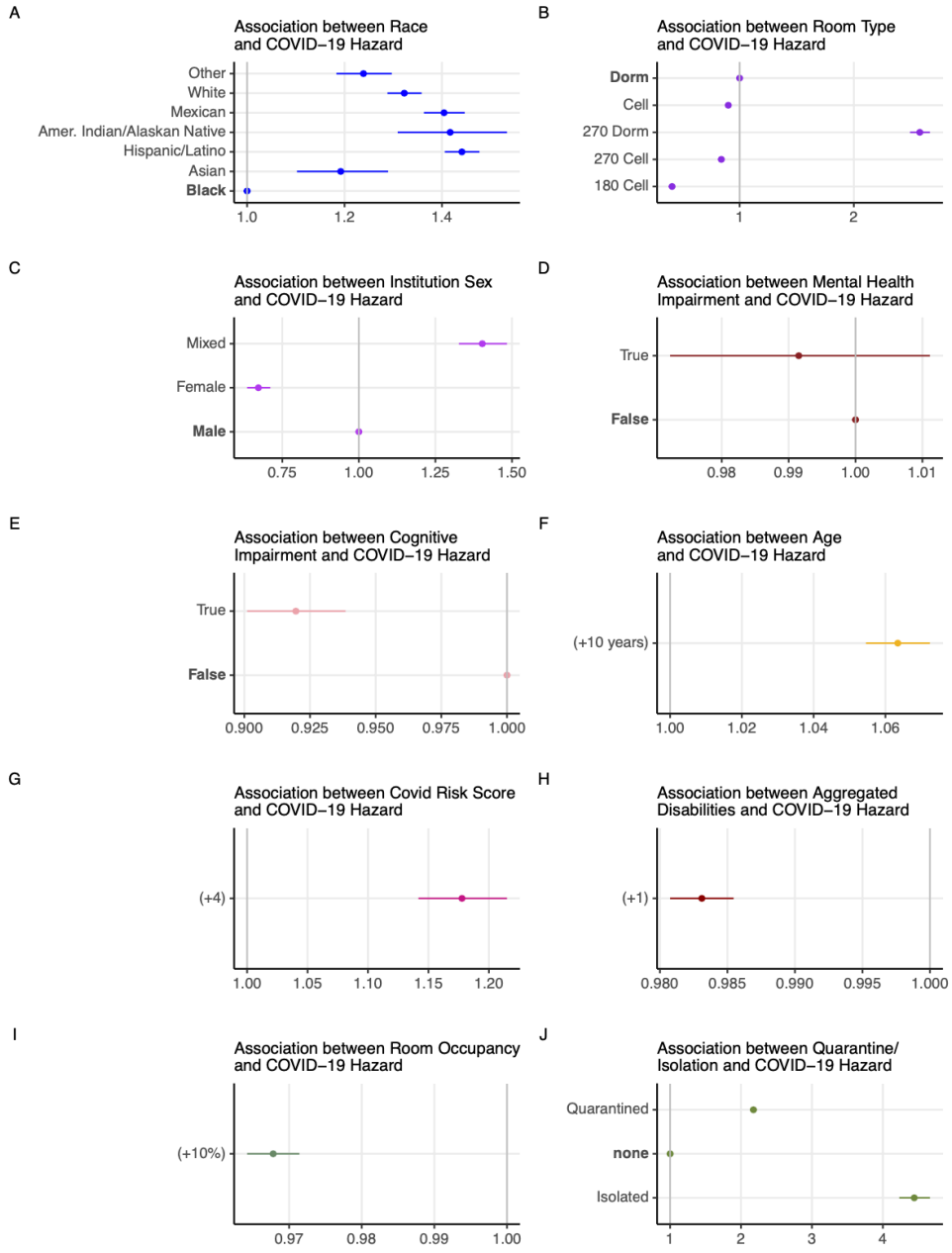
A. Survival analysis with quarantine housing

Term	Hazard Ratio	95% CI
Covid Housing: none	**1**	–
Covid Housing: Isolated	4.443	4.232, 4.664
Covid Housing: Quarantined	2.175	2.131, 2.221
Room Type: Dorm	**1**	–
Room Type: 180 Cell	0.408	0.391, 0.426
Room Type: 270 Cell	0.840	0.819, 0.861
Room Type: 270 Dorm	2.578	2.492, 2.667
Room Type: Cell	0.901	0.877, 0.924
Room Occupancy Proportion	0.721	0.695, 0.748
Institution Sex: Male	**1**	–
Institution Sex: Female	0.672	0.635, 0.711
Institution Sex: Mixed	1.403	1.327, 1.484
Mental Health Impairment: True	0.992	0.972, 1.011
Cognitive Impairment: True	0.920	0.901, 0.939
Aggregated Disabilities	0.843	0.823, 0.864
Race: Black	**1**	–
Race: Asian	1.192	1.102, 1.289
Race: Hispanic/Latino	1.441	1.406, 1.477
Race: Amer. Ind./Alask. Ntv.	1.417	1.309, 1.533
Race: Mexican	1.404	1.363, 1.447
Race: Other	1.239	1.183, 1.297
Race: White	1.323	1.288, 1.358
Age	1.006	1.005, 1.007
Covid Risk Score	1.042	1.034, 1.050

B. Survival analysis without quarantine housing

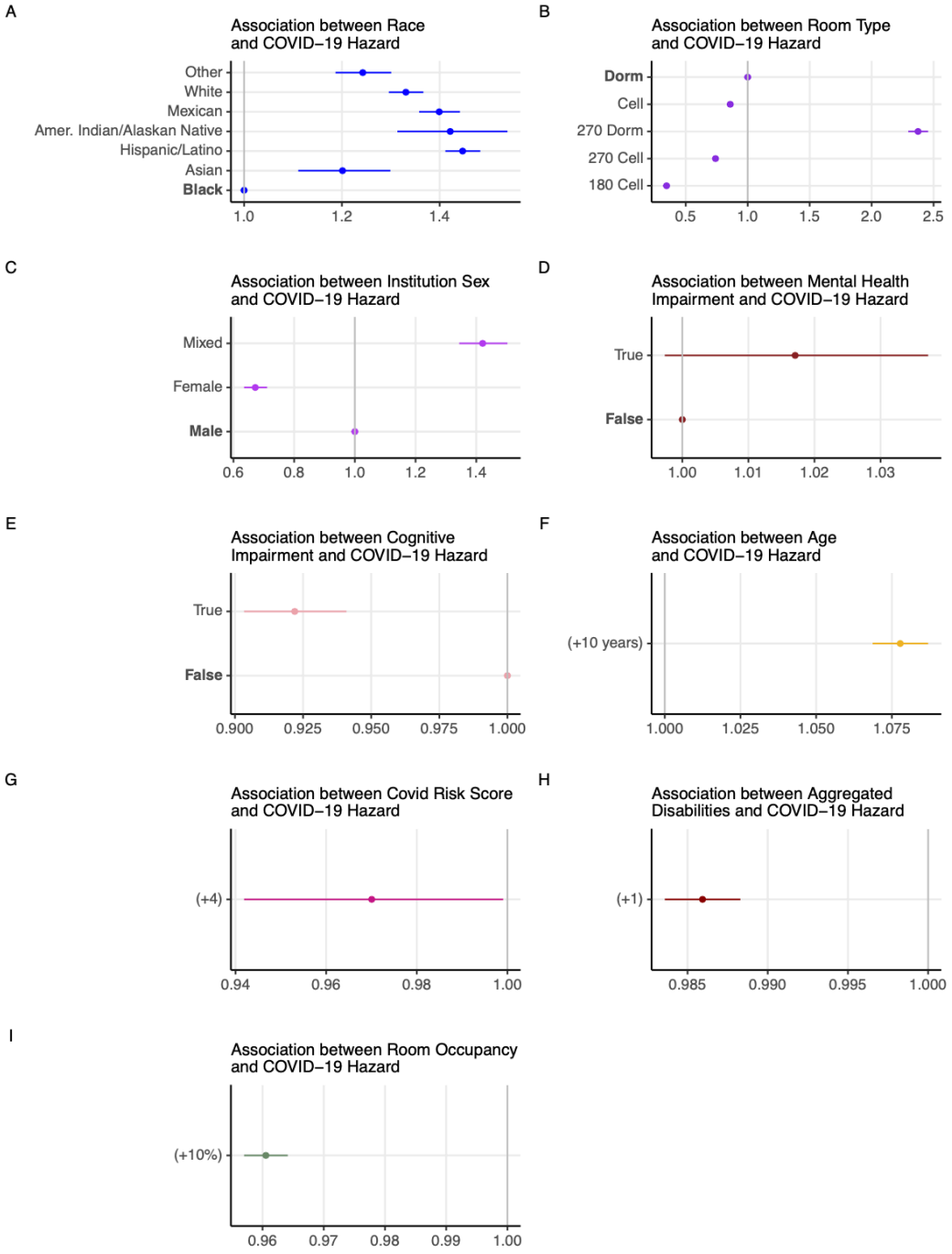
Term	Hazard Ratio	95% CI
Room Type: Dorm	**1**	–
Room Type: 180 Cell	0.345	0.331, 0.360
Room Type: 270 Cell	0.740	0.722, 0.759
Room Type: 270 Dorm	2.374	2.296, 2.456
Room Type: Cell	0.859	0.837, 0.881
Room Occupancy Proportion	0.669	0.644, 0.694
Institution Sex: Male	**1**	–
Institution Sex: Female	0.672	0.635, 0.711
Institution Sex: Mixed	1.421	1.344, 1.503
Mental Health Impairment: True	1.017	0.997, 1.037
Cognitive Impairment: True	0.922	0.903, 0.941
Aggregated Disabilities	0.868	0.847, 0.889
Race: Black	**1**	–
Race: Asian	1.201	1.111, 1.299
Race: Hispanic/Latino	1.447	1.412, 1.483
Race: Amer. Ind./Alask. Ntv.	1.422	1.313, 1.539
Race: Mexican	1.399	1.358, 1.441
Race: Other	1.243	1.187, 1.301
Race: White	1.331	1.296, 1.367
Age	1.008	1.007, 1.008
Covid Risk Score	0.992	0.985, 1.000

Figure 11.2. Cox proportional hazards regression on the fully adjusted associations of a range of outbreak, population, and prison characteristics against time to first positive test result across the entire CDCR system.



Note: The association of these variables over COVID identification, underlying sensitivity, and individual demographics and prison environment on the estimated transmission dynamics over the entire CDCR system of prisons from February 2020–March 2021. Reference categories are indicated by boldface labels. See **Table 11.2** for numerical values.

Figure 11.3. Cox proportional hazards regression on the fully adjusted associations of a range of outbreak, population, and prison characteristics against time to first positive test result across the entire CDCR system, excluding the quarantine status variable.

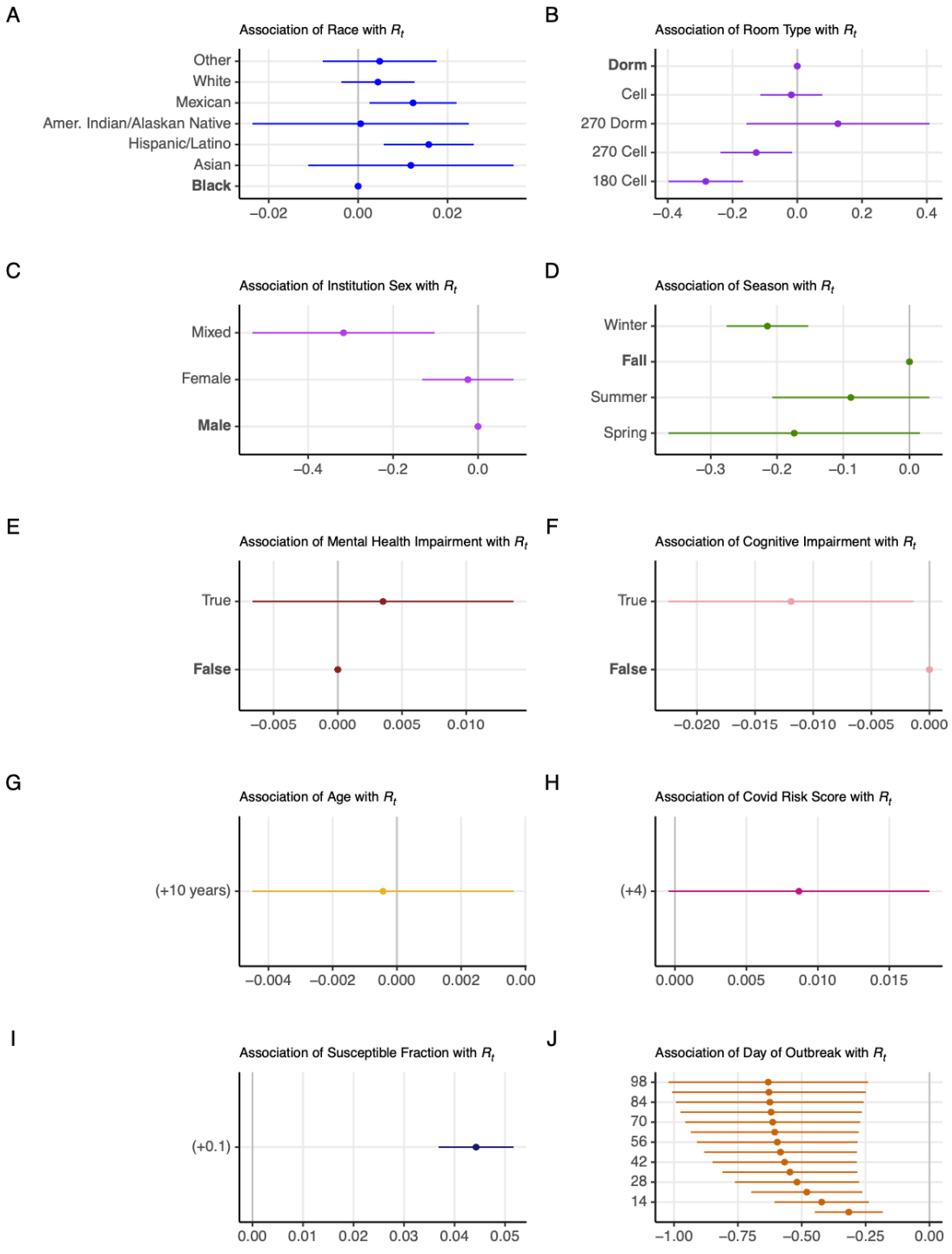


Note: The association of these variables over COVID identification, underlying sensitivity, as well as individual demographics and prison environment on the estimated transmission dynamics over the entire CDCR system of prisons from February 2020–March 2021. Reference categories are indicated by boldface labels. See **Table 11.2** for numerical values.

Table 11.3. Associations estimated by time-series regression on Rt. Reference categories for categorical variables are included in boldface.

Term	Effect	95% CI
(Intercept)	1.059	0.832, 1.286
Mental Health Impairment: True	0.00352	−0.00664, 0.0137
Cognitive Impairment: True	−0.0119	−0.0225, −0.00137
Aggregated Disabilities	0.00725	−0.00151, 0.016
Covid Risk Score	0.00217	−0.000114, 0.00445
Institution Sex: Male	**0**	–
Institution Sex: Female	−0.0239	−0.131, 0.0836
Institution Sex: Mixed	−0.317	−0.531, −0.102
Age	−0.0000433	−0.00045, 0.000363
Race: Black	**0**	–
Race: Asian	0.0118	−0.0112, 0.0348
Race: Hispanic/Latino	0.0158	0.00573, 0.0259
Race: Amer. Ind./Alask. Ntv.	0.000568	−0.0236, 0.0248
Race: Mexican	0.0123	0.00254, 0.022
Race: Other	0.00482	−0.00792, 0.0176
Race: White	0.00443	−0.00376, 0.0126
Room Type: Dorm	**0**	–
Room Type: 180 Cell	−0.283	−0.398, −0.167
Room Type: 270 Cell	−0.127	−0.237, −0.0161
Room Type: 270 Dorm	0.126	−0.157, 0.408
Room Type: Cell	−0.0185	−0.114, 0.0773
Season: Fall	**0**	–
Season: Spring	−0.174	−0.364, 0.0158
Season: Summer	−0.0885	−0.207, 0.0302
Season: Winter	−0.214	−0.276, −0.153
Susceptible Fraction	0.443	0.368, 0.517
log(Day of Outbreak)	−0.167	−0.232, −0.102
Day of Outbreak	0.00138	0.000438, 0.00233
Covid Housing: none	**0**	–
Covid Housing: Isolated	−0.234	−0.298, −0.170
Covid Housing: Quarantined	−0.0201	−0.0786, 0.0383
Room Occupancy Proportion	0.103	0.0703, 0.136

Figure 11.4. Time series regression on the fully adjusted associations of various outbreak, population, and prison characteristics on Rt across the entire CDCR system. Reference categories for categorical variables are included in boldface.



Note: We performed a time-series regression with a bootstrap to adjust for autocorrelation looking at the effect of the course of the institution's outbreak, underlying sensitivity, and individual demographics and prison environment on the estimated transmission dynamics over the entire CDCR system of prisons from February 2020–March 2021. Reference categories are indicated by boldface labels. See **Table 11.3** for numerical values.

Key finding: Residents identified by CDCR as Mexican Hispanic/Latino, non-Mexican Hispanic/Latino, Asian, and American Indian/Alaskan Native had the highest infection hazard and/or reproduction numbers, mirroring disparities seen in California COVID-19 transmission overall. The per capita association of Black/African American race with transmission risk was lower than for all other races. However, because of the high proportion of Black/African American prisoners, it must be noted that these outbreaks produced a relatively higher proportion of Black/African American cases in the prison setting than seen in California's community transmission.

11.4. Discussion

In this section, we performed time series and survival regression analyses to investigate the role and impact that broader prison conditions and environmental considerations may have had in supporting or interrupting spread in the prison setting. It appears that broadly speaking non-pharmaceutical interventions (NPIs) in the prison setting have been at least somewhat effective given that Rt appears to decrease by 0.44 (0.37, 0.52) two weeks after the onset of an outbreak within an institution, even after controlling for the reduction in the fraction susceptible. Institutional responses to outbreaks, such as mask wearing, which is not explicitly measured in this analysis, and reduced population mixing, as well as possible individual level behavioral changes, may all contribute to the reduction in transmission risk following an outbreak. However, the association of depletion of susceptibles with Rt is also significant and substantial, at 0.044 (0.0362, 0.0509) reduction in Rt per 10% reduction in the fraction susceptible, suggesting that control of outbreaks in these settings is at least partly being achieved by naturally acquired herd immunity. This suggests that a roughly equivalent portion of the decline in Rt may be due to a reduction in susceptibles and to the impact of NPIs in this setting.

We have also undertaken to identify the presence of any other potential influences on transmission, including seasonality and underlying risk, as well as any demographic characteristics that were associated with particular vulnerability to transmission. Broadly speaking, increased age was strongly associated with increased risk of infection, though not higher transmission, as was being in a men's institution, and having a higher COVID score. Having a disability seemed protective, which we will discuss below. The highest risk racial/ethnic group for hazard appeared to be the Mexican Hispanic/Latino(a) group, followed by Alaskan/American Indian and non-Mexican Hispanic/Latino(a) groups. In contrast the highest risk racial/ethnic groups for increased transmission appeared to be first Asian, then Hispanic/Latino (non-Mexican and Mexican). While there are several potential explanations here, from behavior, chance, or similar, this analysis is not able to identify such causes. These higher rates of COVID infection in Hispanic and Latino(a) communities are consistent with

community trends in California (15) and continue to contribute to the disproportionate burden that these communities have faced. Black/African American residents carried one of the lowest per capita burden of disease in the prison population as compared to other races. However, these outbreaks produce a high proportion of Black/African American cases relative to the general population due to the high proportion of Black/African American residents in the prison populations.

We also looked at the influence of season on transmission showing that the fall season had the highest reported transmission while the winter season appears to have the lowest transmission rate. However, given the probable seasonality of the virus (16–18), and temporal change in dominant strains of the virus, but also the reality that in the prison setting it may in large part act as a proxy for the timing of central heating and air conditioning (HVAC) systems being turned on which has been anecdotally linked to outbreaks at least in SATF, it will be hard to disentangle the impact of operating HVAC and central air systems from community-level seasonality.

There are several limitations to this study. In our estimations of time-varying Rt, we assume that there are no missing cases. Case missingness could potentially bias our Rt estimates if cases become more or less likely to be identified over the course of an outbreak, or bias in how quickly they are detected over time could lead to inaccurate Rt estimates. We know that many outbreaks in prisons are detected as large cluster events, meaning that there are several outbreaks that are detected first symptomatically and followed by mass testing that identifies tens or hundreds of cases all at once, making initial outbreak Rt values difficult to estimate precisely. Furthermore, the difference in the attack rates in residents by age, with detection notably more likely in older cohorts, may reflect the fact that younger cohorts are more likely to have a mild or asymptomatic disease course, making them less likely to be identified and seek care, and also have detectable levels of viral load for a shorter period of time, making them less likely to be identified by routine testing events. This strongly suggests that we are, in fact, missing many cases, possibly also as younger individuals' desire to avoid quarantine, disruption and isolation following a positive test may overwhelm their impetus to report and seek care. Missing cases can also bias our survival analysis, regardless of timing of missingness. This also impacts our estimates of the fraction susceptible, which we derive directly from identified positive cases. This would possibly lead to inaccurate estimates of the effect of population susceptibility on Rt. Furthermore, our reconstruction of event times is imprecise by its nature as we allow for a broad range of possibilities for when cases are detected during their disease course, which limits the precision of these regression associations, though we do believe that these represent the best estimates of what can be extrapolated from the data available.

With respect to housing unit types in particular, we have used the categorizations that we were given but there still remains a lot of residual variation in these housing units, most notably by the age of the building, which may reflect more modern ventilation and HVAC systems which we were unable to measure and include here. Additionally, we are limited to the resolution of Rt estimates assuming homogeneous mixing at the housing unit level. These estimates might be more informative or precise if performed at the dorm or room level, and housing unit occupants almost certainly have heterogeneous mixing, though we believe they are still more likely to mix with each other than those outside of their housing unit. We also do not model heterogeneous mixing between residents between housing units. We account for this only by assuming a background rate of mixing between all residents in addition to greater mixing within housing units. We additionally do not account directly for time-varying levels of interunit mixing due to lockdowns and NPIs undertaken in prisons as a response to outbreaks. We account for this indirectly by including the outbreak day variable, which shows some significant reduction in Rt as an outbreak progresses, and given the dominance of the logarithm of outbreak day, it would appear that the immediate impact of these interventions or behavioral changes can be observed. This outbreak day variable provides our best insight into the effect that prisons take in instituting NPIs, including masking, cancelling mixing events such as outdoor mixing, dining in halls, etc., redistributing residents to increase evenness in dispersion or to move those at highest risk to a lower risk setting, however we are not able to speak directly about the effectiveness of any individual intervention, or the degree to which behavioral differences by the residents affect this, such as handwashing, and reliable mask wearing.

The ability to make meaningful inference for observed differences between men's and women's prisons are limited as there are few women's prisons in the CDCR prison system, and with only one mixed prison it is impossible to separate prison specific circumstances from larger trends. Women's institutions may have had strong early testing, which could drive the observed differences, but given the sample size, it is impossible to eliminate chance and highly heterogenous transmission in interpreting the observed differences. Also, we cannot rule out potentially different attitudes or behavior, or administration differences.

All of the mobility, speech and general disability variables appear to be protective and correlated with lower transmission, which may be due to individuals having housing accommodations that reduce contact or may generally mix less with the general population due to difficulties. However, the main purpose here was to investigate the role that these disabilities may play in predisposing them to risk, which has been reported elsewhere.

The cells and dorms behaved in ways that were not consistent with expectation, and there remains a lot of residual variation, but celled housing does not appear to be overall protective

against transmission. It does appear that the interventions taken were at least somewhat effective in reducing spread and transmission, but more remains to be done, as it appears that the overall population susceptibility played a large role as well in controlling ongoing transmission.

12. Case Studies

At the request of the California Prison Receivership, members of the CalPROTECT team visited 10 CDCR adult institutions in total (an increase from the 4 CDCR institution visits planned initially) between June 2020 and December 2021. The environmental assessment team visited 6 of these 10 sites, and the behavioral science team visited 8 of these 10 sites.

Institutions were selected in collaboration with the CPR and were chosen for being (i) geographically diverse; (ii) a mix of architecturally newer and older facilities; and (iii) a mix of prisons housing men (n=8) and women (n=2). There was also prioritization for visiting some of the prisons with residents of an older average age (CIM, CMF, RJD, SQ, SOL, CMC, CIW). These site visits were a large part of the CalPROTECT effort, and the methodologies implemented at each visit were fairly consistent across each site, although we honed our approach in response to each visit with considerations to the institution and its situation with regards to the COVID-19 pandemic at the time of the visit. Each visit began with pre-visit virtual meetings with facility leadership (from healthcare and custody), followed by in-depth interviews and conversations with key stakeholders identified by local leadership both before and during the visits. Key stakeholders comprised of institutional leadership, and healthcare, custody, plant operations, and engineering staff.

We also conducted on-site data collection at each institution. This included holding focus groups and conversations with residents (generally from the Inmate Advisory Council, IAC), custody staff, and healthcare staff; physical observation of facilities (including spatial observation and indoor air quality assessments); and collection of institution-specific announcements and policies.

Across all institutions we visited, we endeavored to share information and the knowledge we gained upon our arrival and departure. These occurred in several phases:

- Between June 2020 and August 2020, several team members visited CMC and SQ. We then produced a report on a small outbreak that had been contained at CMC and an urgent memo about SQ describing the potential for a large-scale outbreak.
- Between December 2020 and March 2021, our team visited SATF, CMF and CTF. Our team produced a report in the form of a presentation to describe an ongoing outbreak at SATF, a memo on CMF with urgent recommendations, and a brief memo on CTF.
- During the summer of 2021, our team visited several more institutions (CCWF, RJD, CIM, CIW, SOL), including several others whose leadership allowed us to visit more than once (SQ, CMF, SATF).

- Between October and December 2021, we conducted virtual debriefings with headquarters and separately with leadership from each site at 7 of the 10 sites (CCWF, CIW, RJD, SQ, SATF, CMF, SOL, CIM). Our team re-visited one institution during this period (SOL).

The post-visit memos, brief reports, and presentation reports can be found in the **Section 12 Supplement** in the order each document was produced by the CalPROTECT team:

CMC, California Men's Colony

- Supplemental Presentation S12.CMC
  Note: This was the first CalPROTECT presentation report and was made earlier in the pandemic. Thus, it has a longer introduction with more general information on SARS-CoV-2 and the COVID-19 pandemic and more specific information on prison populations. The reader will find this report has a slightly different format than the other presentation reports.

SQ, San Quentin State Prison

- Supplemental Memo S12.SQ
- Supplemental Presentation S12.SQ

SATF, Substance Abuse Treatment Facility and State Prison, Corcoran

- Supplemental Presentation S12.SATF1
- Supplemental Presentation S12.SATF2

CMF, California Medical Facility

- Supplemental Memo S12.CMF
- Supplemental Presentation S12.CMF

CTF, Correctional Training Facility

- Supplemental Memo S12.CTF

CCWF, Central California Women's Facility

- Supplemental Presentation S12.CCWF

RJD, Richard J. Donovan Correctional Facility

- Supplemental Presentation S12.RJD

CIM, California Institution for Men

- Supplemental Presentation S12.CIM

CIW, California Institution for Women

- Supplemental Presentation S12.CIW

SOL (California State Prison, Solano)

- Supplemental Presentation S12.SOL

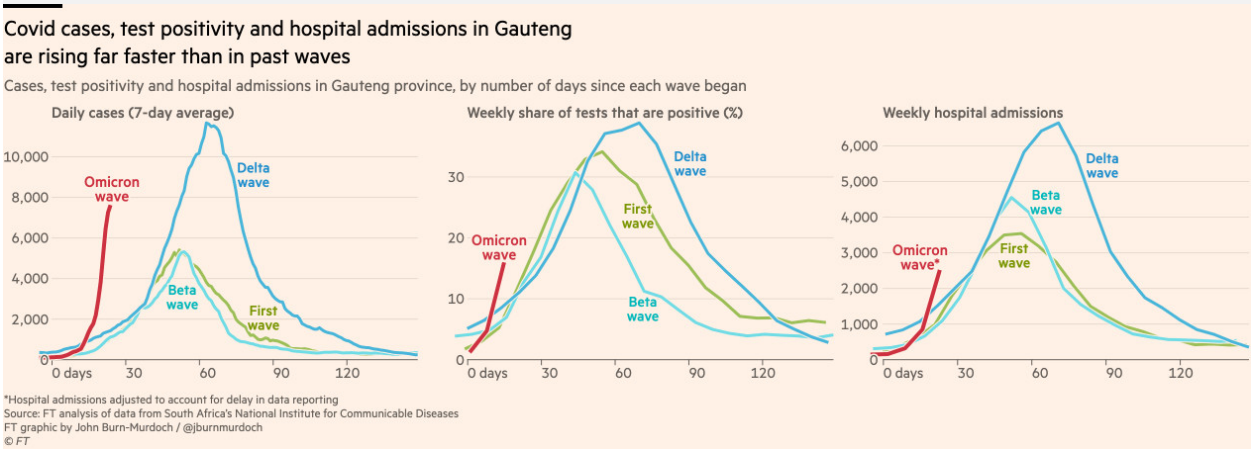
13. Emergence of the Omicron Variant of Concern

Note: *Information in this section is current as of December 16, 2021.*

On November 26, 2021, the World Health Organization (WHO) designated the variant B.1.1.529, named Omicron, a variant of concern.(1) Omicron cases have been suspected when polymerase chain reaction (PCR) tests return positive but—owing to substantial mutations in the spike protein gene—select PCR assays fail to amplify the S-gene target in the viral genome (referred to as S-gene target failure).(2) Relevant to CDCR is that the PCR assay at Quest Diagnostics (where most CDCR PCR testing is performed) is not one of the tests expected to lead to S-gene target failure meaning that whole genome sequencing (WGS) or a single nucleotide polymorphism (SNP) assay will be needed to detect the Omicron variant.

Compared to the original SARS-CoV-2 isolate, Omicron has over 60 mutations and *in vitro* data suggest that these mutations enable more efficient cell entry and transmission.(3,4) Epidemiologic studies, primarily from the Gauteng Province in South Africa, have shown that Omicron spreads much more rapidly than the highly transmissible Delta variant (**Figure 13.1**) with a *Re* (average number of secondary cases per infectious case) in the Guateng Province of South Africa of 3-3.5 (compared to 1.5 for Delta) and a 3.4 day doubling time of new cases.(5,6) Early data suggest there may be a modest decrease in hospitalizations following infection with Omicron but further study is needed to determine if this is truly the case.

Figure 13.1. Daily cases, test positivity, and weekly hospital admissions from the emergency of the Omicron variant compared to three other waves of infection in Gauteng Province, South Africa.



Note: Source: https://www.ft.com/content/d315be08-cda0-462b-85ec-811290ad488e)

Of additional concern is that re-infections have been common in the Guateng Province, and the rapid spread of Omicron there was among a population with high levels of prior infection with the Delta variant.(7) Preprint studies have also shown substantial reductions in neutralization from the serum of vaccinated individuals.(8,9) One study did show that while the sera of individuals who had received two doses of the Pfizer BNT162b2 vaccine demonstrated near-absent neutralization of Omicron, there was a strong neutralization response following a booster dose or—in those with prior SARS-CoV-2 infection—at least a single dose of the BNT162b2 vaccine.(10) In a real-world scenario, another pre-print study, found that the Pfizer BNT162b2 vaccine had an efficacy against symptomatic disease from Omicron of 76% beginning two weeks after a booster dose (95% CI 56% - 86%), compared to 34% following the two-dose series.(11) These studies suggest that vaccination, particularly with booster doses, may provide significant protection against symptomatic disease from Omicron and efforts should be made to rapidly deploy booster shots or the primary immunization series to residents and staff. For COVID-19 prevention and mitigation procedures CDCR should reclassify its definition of fully vaccinated to only include individuals who have received a primary immunization series (2 doses of an mRNA vaccine or one dose of the Janssen/Johnson & Johnson vaccine) followed by an mRNA booster and, potentially, those who have completed a primary immunization series (with or without boosting) and have also been infected.

Regarding treatment, the monoclonal antibodies casirivimab + imdevimab and bamlanivimab + etesevimab are unlikely to have significant activity against the Omicron variant, but sotrovimab may retain efficacy based on preprint studies.(12,13) Oral antiviral therapies—if given early in the course of infection—have shown extraordinary promise in two clinical trials that did not involve the Omicron variant: molnupiravir demonstrated a 30% relative risk reduction in hospitalization or death (14) and nirmatrelvir/ritonavir demonstrated an 88% relative risk reduction in hospitalization or death.(15) While neither drug has been studied against the Omicron variant, both are expected to retain activity based on their mechanisms of action but how effective they will be in preventing meaningful clinical outcomes remains to be determined. Both drugs are awaiting FDA approval.

Recommendation 13.1: Rapidly identify variants causing any new outbreaks through CDCR partnerships with laboratories at the California Department of Public Health, MiraDx, and academic institutions (particularly as the Quest COVID-19 PCR assay does not lead to the S-gene target failure that can be a marker of Omicron).

Recommendation 13.2: Current data suggest that mRNA vaccines are preferable to the Janssen/Johnson & Johnson vaccine and that boosting is particularly beneficial in protecting

recipients from the Omicron variant, thus heightening the importance of efforts to continue to offer primary vaccination and boosters to all eligible residents and staff.

Recommendation 13.3: Where policies call for different approaches for individuals who are fully vaccinated vs not fully vaccinated, define full vaccination as those who completed a primary immunization series (2 doses of an mRNA vaccine or one dose of the Janssen/Johnson & Johnson vaccine) followed by an mRNA booster (if eligible) and, potentially, those who have completed a primary immunization series (with or without boosting) and have also been infected.

Recommendation 13.4: Activities allowing for increased mixing among vaccinated residents will also need to be reevaluated until more is known about Omicron transmission and virulence.

Recommendation 13.5: If individuals infected within the previous 90 days with a non-Omicron variant are then exposed to the Omicron variant, they should be managed similarly to those who have not been infected in the previous 90 days. This includes testing for infection within the 90-day window (which as of January 2022, was being done for transfers). Do not, however, place individuals who test positive within 90 days into group isolation unless they are confirmed to have a new infection.

Recommendation 13.6: Ensure access to the monoclonal antibody sotrovimab for the early treatment of COVID-19 and preemptively identify individuals at high risk for severe disease who may benefit if infected. Sotrovimab currently appears to be most likely to retain activity against the Omicron variant. (According to CDCR/CCHCS, this was already the protocol as of January 2022.)

Recommendation 13.7: Preemptively identify individuals who may benefit from oral antiviral medications and plan to operationalize their delivery. The oral antiviral treatments nirmatrelvir/ritonavir (Paxlovid) and molnupiravir have been granted EUA by the FDA. Both will likely retain activity against Omicron. While molnupiravir and nirmatrelvir/ritonavir have not been compared head-to-head, data for nirmatrelvir/ritonavir are more encouraging. (According to CDCR/CCHCS, this was done in November 2021.)

14. Closing

The continued COVID-19 outbreaks across California's State Prisons have infected extraordinary numbers of prison residents and staff. They have also constituted a profound trauma for many incarcerated patients and have led to extreme occupational stress among correctional staff, CCHCS healthcare professionals, and CDCR/CCHCS leaders.

Against this backdrop, our CalPROTECT team has witnessed true heroism on all sides. People incarcerated in California prisons, IAC members, and family and friends in the community have dedicated themselves to advocating for the health, safety and wellbeing of prison residents. Frontline officers and healthcare professionals have reported to work – often working double shifts – despite the uncertainty of what continued exposure could mean for their family, their friends, and themselves. We have been on the phone at all hours of the day and night, joined emergency meetings with national experts called upon by CCHCS leaders, and had countless meetings with leaders from individual institutions and headquarters as they searched for evidence-based paths to help protect the health and safety of the staff and residents under their care (oftentimes at the expense of their own physical and mental health). We believe these sacrifices have blunted the degree of destruction and lives lost that the pandemic could have produced, but the psychological toll of these nearly two years should not be underestimated for all who live or work in our state prisons and their loved ones.

Despite the sacrifice and hard work of so many, there remains an extraordinary amount left to do. The old (and in some cases antiquated) infrastructure of many California state prisons and their HVAC systems, coupled with overcrowding, has meant that even the most evidence-based efforts to change the course of the pandemic often were not possible to implement. The reluctance of our society to engage in a true reckoning with the racism that exists within our criminal justice system has led to the disproportionate incarceration of people of color who have, in turn, been disproportionately exposed to crowded, institutional prison conditions during this pandemic. Additionally, the reluctance of our society and, as a result, our policy leaders, to achieve true population reduction that focuses on early parole, release, or furlough (rather than relying mostly on closing intake from jails and natural attrition) to drive down the numbers of incarcerated people in the state, has meant that nearly two years into the pandemic—and in the face of looming concerns about the highly infectious Omicron variant—our state prisons are still subjecting approximately 150,000 Californians to overcrowded living and working conditions that are on average 13% beyond design capacity (with 9 prisons over 130% design capacity) as of December 15, 2021.

Yet, the design capacity of prisons was not determined with a respiratory pandemic in mind. Even achieving the reduction in population required to reach 100% design capacity will likely still result in institutions that are too crowded to create safe living and working environments that can withstand the pressures of current or future pandemics or other natural disasters. As a result, planning for future pandemics should include an emergency evacuation plan for high-risk housing units, a determination of what level of expected morbidity and mortality would be high enough to trigger emergency decarceration and a concomitant commitment from other state agencies to assist with emergency reentry planning. Additionally, over the longer term, the California Committee on the Revision of the Penal Code is providing California's state leadership with consensus, evidence-based recommendations that are designed to improve public safety and reduce unnecessary incarceration across the state.(1) Following this committee's recommendations, coupled with meaningful investment in correctional and healthcare staff training and mental healthcare, are of profound importance now more than ever.

Several years before the onset of the COVID-19 pandemic, Amend at UCSF was contracted by the Office of the Federal Receivership to assess healthcare policies and procedures with the goal of creating a more "healthy healthcare system" in California's state prison system. When COVID-19 began, we pivoted to create CalPROTECT (California Prison Roadmap for Targeting Efforts to Address the Ecosystem of COVID Transmission), a joint effort of the University of California, San Francisco and the University of California, Berkeley which draws on expertise across many disciplines including clinical medicine, public health, epidemiology, economics, environmental and exposure science, public policy, infectious disease, health systems, geriatrics, and palliative care. We hope the themes included in this report will help CDCR and CCHCS adapt to whatever comes next in the pandemic, to create a healthier healthcare system, and to develop a safer and healthier living and working environment for patients and staff. We are grateful to have been given this opportunity to partner with you to help make California's prisons safer.

California State Prisons During the COVID-19 Pandemic

A Report by the CalPROTECT Project

SUPPLEMENTAL APPENDICES

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California **P**rison **Ro**admap for **T**argeting Efforts to Address the **E**cosystem of **C**OVID **T**ransmission

LAST UPDATED: MAY 1, 2022

Section 3 Supplement

Supplemental Text S3.1. Resources for Policy Related to COVID-19 in Prisons

CDCR/CCHCS Policy Resources

1. Memos, Guidelines & Messaging: https://www.cdcr.ca.gov/covid19/memos-guidelines-messaging/
2. CDCR Updates: https://www.cdcr.ca.gov/covid19/updates/
3. CDCR COVID-19 Response Efforts: https://www.cdcr.ca.gov/covid19/covid-19-response-efforts/
4. CDCR COVID-19 Roadmap to Reopening: https://www.cdcr.ca.gov/covid19/

Other Prison Policy Resources related to COVID-19

5. UCLA School of Law COVID Behind Bars Data Project directed by Dr. Sharon Dolovich: https://docs.google.com/spreadsheets/d/1X6uJkXXS-O6eePLxw2e4JeRtM41uPZ2eRcOA_HkPVTk/edit#gid=1197647409

Section 4 Supplement

Supplement Table S4.1. Descriptive statistics across cohorts: room type, institutional characteristics, room characteristics, and other comorbidities.

	Full Cohort N = 148,488		Continuous Cohort N = 73,318		Recent Cohort N = 97,740		Cases N = 50,575		Deaths N = 240	
	Freq	Mean or %	Freq	Mean or %	Freq	Mean or %	Freq	Mean or %	Freq	Mean or %
Room type										
Ever resided: 180 cell	20,454	13.8%	14,993	20.4%	17,238	17.6%	5,515	10.9%	17	7.1%
Ever resided: 270 cell	61,631	41.5%	37,481	51.1%	47,966	49.1%	22,872	45.2%	66	27.5%
Ever resided: Other cell	77,085	51.9%	31,960	43.6%	54,250	55.5%	24,127	47.7%	139	57.9%
Ever resided: 270 dorm	11,247	7.6%	7,066	9.6%	8,394	8.6%	7,069	14.0%	21	8.8%
Ever resided: Other dorm	74,816	50.4%	27,208	37.1%	43,339	44.3%	27,141	53.7%	102	42.5%
Ever resided: Room	2,595	1.7%	2,259	3.1%	2,350	2.4%	1,298	2.6%	1	0.4%
Ever resided: Closed ward	22	<0.1%	11	<0.1%	19	<0.1%	7	0.0%	0	0.0%
Institutional characteristics										
Security Level (First)										
Unknown	2,773	1.9%	24	<0.1%	1,646	1.7%	79	0.2%	0	0.0%
I	17,561	11.8%	1,323	1.8%	5,682	5.8%	2,828	5.6%	9	375.0%
II	60,988	41.1%	23,245	31.7%	34,711	35.5%	21,921	43.3%	125	5208.0%
III	34,095	23.0%	22,404	30.6%	26,797	27.4%	14,443	28.6%	50	2083.0%
IV	33,071	22.3%	26,322	35.9%	28,904	29.6%	11,304	22.4%	56	2333.0%
Security Level (Last)										
Unknown	2,773	1.9%	24	<0.1%	1,646	1.7%	79	0.2%	0	0.0%
I	25,825	17.4%	4,057	5.5%	8,827	9.0%	5,721	11.3%	17	7.1%
II	69,765	47.0%	35,803	48.8%	46,993	48.1%	29,675	58.7%	158	65.8%
III	20,819	14.0%	11,019	15.0%	15,269	15.6%	6,707	13.3%	15	6.3%
IV	29,306	19.7%	22,415	30.6%	25,005	25.6%	8,393	16.6%	50	20.8%
Custody Score (First)	148,488	45.6	73,318	60.8	97,740	53.7	50,575	46.8	240	47.5
Custody Score (Last)	148,488	43.2	73,318	57.8	97,740	51.5	50,575	39.4	240	42.3
Room characteristics										
Had in residence: CPAP/BiPAP device	4,069	2.7%	2,899	4.0%	3,189	3.3%	1,813	3.6%	36	15.0%
Had in residence: Tracheostomy	38	<0.1%	24	<0.1%	28	<0.1%	12	0.0%	0	0.0%
Had in residence: Nebulizer	113	0.1%	89	0.1%	95	0.1%	78	0.2%	1	0.4%
Had in residence: Oxygen therapy device	690	0.5%	444	0.6%	517	0.5%	485	1.0%	24	10.0%

Supplement Table S4.1 (continued).

	Full Cohort N = 148,488		Continuous Cohort N = 73,318		Recent Cohort N = 97,740		Cases N = 50,575		Deaths N = 240	
	Freq	Mean or %	Freq	Mean or %	Freq	Mean or %	Freq	Mean or %	Freq	Mean or %
Comorbidity										
Any mental health condition	73,089	49.2%	38,422	52.4%	49,832	51.0%	25,613	50.6%	150	62.5%
Acute	4,399	3.0%	2,755	3.8%	3,341	3.4%	1,072	2.1%	9	3.8%
CCCMS	70,671	47.6%	37,206	50.7%	48,254	49.4%	24,991	49.4%	147	61.3%
DSH	1,861	1.3%	1,263	1.7%	1,460	1.5%	529	1.0%	2	0.8%
EOP	18,399	12.4%	11,406	15.6%	13,588	13.9%	5,759	11.4%	54	22.5%
EOP Mod	4,986	3.4%	3,383	4.6%	3,934	4.0%	1,373	2.7%	20	8.3%
ICF	5,659	3.8%	3,548	4.8%	4,303	4.4%	1,389	2.7%	12	5.0%
MHCB	18,432	12.4%	11,464	15.6%	13,656	14.0%	5,939	11.7%	49	20.4%
Any cognitive impairment	1,934	1.3%	1,106	1.5%	1,341	1.4%	551	1.1%	7	2.9%
DDP1	976	0.7%	575	0.8%	680	0.7%	298	0.6%	4	1.7%
DDP2	1,148	0.8%	668	0.9%	813	0.8%	321	0.6%	6	2.5%
DDP3	185	0.1%	110	0.2%	132	0.1%	39	0.1%	0	0.0%
Any mobility impairment	13,978	9.4%	9,057	12.4%	10,362	10.6%	5,748	11.4%	126	52.5%
Any speech, hearing, vision impairment	5,194	3.5%	3,543	4.8%	3,985	4.1%	2,324	4.6%	43	17.9%
With speech impairment	178	0.1%	107	0.1%	117	0.1%	60	0.1%	1	0.4%
With hearing impairment	4,327	2.9%	3,002	4.1%	3,350	3.4%	2,023	4.0%	39	16.3%
With vision impairment	985	0.7%	622	0.8%	735	0.8%	366	0.7%	7	2.9%
General Clinical Risk Score										
Low	77,113	51.9%	33,991	46.4%	48,293	49.4%	24,429	48.3%	17	7.1%
Med	50,082	33.7%	25,857	35.3%	33,855	34.6%	17,391	34.4%	46	19.2%
High 1	8,192	5.5%	5,347	7.3%	6,102	6.2%	3,453	6.8%	116	48.3%
High 2	13,087	8.8%	8,112	11.1%	9,478	9.7%	5,301	10.5%	61	25.4%
Unknown	14	<0.1%	11	<0.1%	12	<0.1%	1	<0.1%	0	0.0%
COVID Risk Score (Last)	140,609	1.3	73,229	1.6	97,644	1.4	50,542	1.6	231	5.8
BMI (Last)	147,043	29.4	72,449	29.4	96,787	29.4	50,107	29.6	239	30.8
BMI Category										
Underweight (BMI < 18.5)	542	0.4%	268	0.4%	369	0.4%	167	0.3%	4	1.7%
Normal Weight (18.5 ≤ BMI < 25)	22,443	15.1%	10,779	14.7%	14,665	15.0%	6,829	13.5%	33	13.8%
Overweight (25 ≤ BMI < 30)	62,262	41.9%	30,886	42.1%	40,767	41.7%	21,420	42.4%	76	31.7%
Obese (BMI ≥ 30)	61,796	41.6%	30,516	41.6%	40,986	41.9%	21,691	42.9%	126	52.5%
Unknown	1,435	1.0%	859	1.2%	943	1.0%	468	0.9%	1	0.4%
Advanced liver disease	3,938	2.7%	2,565	3.5%	2,866	2.9%	1,659	3.3%	39	16.3%
Asthma	17,198	11.6%	8,943	12.2%	11,489	11.8%	6,017	11.9%	40	16.7%
CKD	18,776	12.6%	12,397	16.9%	13,941	14.3%	8,345	16.5%	137	57.1%
COPD	3,384	2.3%	2,137	2.9%	2,453	2.5%	1,545	3.1%	62	25.8%
CVD	6,676	4.5%	4,074	5.6%	4,802	4.9%	2,691	5.3%	58	24.2%
Cancer	3,817	2.6%	2,311	3.2%	2,665	2.7%	1,616	3.2%	38	15.8%
Connective tissue disorder	904	0.6%	602	0.8%	684	0.7%	377	0.7%	12	5.0%
Dementia or Parkinson's	675	0.5%	394	0.5%	464	0.5%	191	0.4%	5	2.1%
Diabetes	11,169	7.5%	6,924	9.4%	8,181	8.4%	4,802	9.5%	96	40.0%
Dialysis	98	0.1%	53	0.1%	65	0.1%	38	0.1%	2	0.8%
Endocrine disease	163	0.1%	96	0.1%	112	0.1%	76	0.2%	3	1.3%
HIV	1,206	0.8%	526	0.7%	735	0.8%	367	0.7%	4	1.7%
HTN	30,132	20.3%	18,447	25.2%	21,975	22.5%	12,798	25.3%	131	54.6%
Hemoglobulin	1,139	0.8%	750	1.0%	846	0.9%	412	0.8%	1	0.4%
Immunocompromised	1,802	1.2%	1,201	1.6%	1,351	1.4%	748	1.5%	15	6.3%
Lung disease	191	0.1%	104	0.1%	127	0.1%	84	0.2%	6	2.5%
Neurological disease	147	0.1%	97	0.1%	105	0.1%	45	0.1%	0	0.0%
Pregnant	61	<0.1%	11	<0.1%	26	<0.1%	14	0.0%	0	0.0%
Vasculitis	36	<0.1%	24	<0.1%	27	<0.1%	19	0.0%	2	0.8%

Note: CKD: chronic kidney disease. COPD: chronic obstructive pulmonary disease. CVD: cardiovascular disease other than hypertension. HTN: Hypertension.
For MentalHealth:
CCCMS: resident has a diagnosis or provisional diagnosis of a serious mental illness or exhibitionism and requires outpatient care
EOP/EOPMod: resident has a diagnosis or provisional diagnosis of a serious mental illness or exhibitionism and requires enhance outpatient care
MHCB: resident requires inpatient mental health crisis treatment
Acute: resident has a diagnosis or provisional diagnosis of a serious mental illness and requires short-term inpatient mental health treatment, longer than MHCB
ICF: resident has a diagnosis or provisional diagnosis of a serious mental illness and requires longer-term inpatient mental health treatment, longer than Acute
DSH: resident was determined to need treatment in a state mental hospital.
For Cognitive: DD1: Cognitive and/or developmental impairment wherein resident may need adaptive supports when under stress or in new situations. DD2: Cognitive and/or developmental impairment wherein resident requires occasional prompts to initiate/complete ADLs, and/or has victimization concerns: requires housing in a designation DDP building/unit/wing, consistent with case factors. DD3: Cognitive and/or developmental impairment wherein resident requires frequent prompts to initiate/complete activities of daily living. Heightened risk of victimization.

Supplemental Table S4.2 COVID-19 outcomes across CDCR institutions and California counties

County	Institution	Tests per 100k	Cases per 100k	Ratio of institution to county case rate	Deaths per 100k	Ever had ER visit per 100k	Ever Hospitalized per 100k	Ever ICU per 100k
Alameda		238,092	6,949		86			
Alpine		206,535	9,221		0			
Amador		418,435	13,817		166			
Amador	MCSP	2,439	45,846	3.32		42,118	21,396	1,507
Butte		147,411	9,054		134			
Calaveras		143,575	8,510		183			
California		242,398	11,401		178			
Colusa		109,299	10,831		84			
Contra Costa		206,567	8,366		88			
Del Norte		507,816	12,893		138			
Del Norte	PBSP	4,416	17,561	1.36		18,478	8,662	985
El Dorado		141,889	7,966		80			
Fresno		171,903	12,824		204			
Fresno	PVSP	43,754	47,148	3.68		13,691	6,332	342
Glenn		117,507	11,347		109			
Humboldt		162,999	6,453		79			
Imperial		212,973	16,853		400			
Imperial	CAL	7,015	29,466	1.75		22,645	8,163	727
Imperial	CEN	6,447	24,403	1.45		23,606	9,145	385
Inyo		131,832	10,459		217			
Kern		167,560	13,109		178			
Kern	CAC	47,802	39,974	3.05		13,988	4,652	64
Kern	CCI	40,227	39,471	3.01		28,132	12,041	432
Kern	KVSP	35,034	24,453	1.87		46,250	22,079	1,176
Kern	NKSP	24,543	14,119	1.08		7,661	3,493	297
Kern	WSP	23,402	13,525	1.03		6,142	3,016	157
Kings		323,550	19,469		204			
Kings	ASP	9,259	61,799	3.17		12,444	6,968	134
Kings	COR	8,629	31,197	1.60		30,429	15,930	1,079
Kings	SATF	6,445	56,359	2.89		29,078	15,662	837
Lake		158,690	9,915		163			
Lassen		656,707	21,899		130			
Lassen	CCC	6,771	42,309	1.93		14,012	3,483	274
Lassen	HDSP	4,300	53,219	2.43		23,888	10,316	423
Los Angeles		334,099	13,759		257			
Los Angeles	LAC	585,548	44,192	3.21		42,437	22,555	2,134
Madera		227,981	13,614		177			
Madera	CCWF	8,036	24,446	1.80		20,197	9,514	554
Madera	VSP	7,260	57,191	4.20		25,869	12,740	445
Marin		267,313	6,584		94			
Marin	SQ	11,795	54,515	8.28		23,286	14,437	1,837
Mariposa		186,682	6,243		17			
Mendocino		167,877	8,028		94			
Merced		181,528	14,006		212			
Modoc		73,604	5,277		53			
Mono		189,456	11,654		29			
Monterey		176,858	10,552		138			
Monterey	CTF	10,264	55,936	5.30		19,387	11,030	486
Monterey	SVSP	14,223	24,067	2.28		43,653	19,922	1,425

Supplemental Table S4.2 (continued).

County	Institution	Tests per 100k	Cases per 100k	Ratio of institution to county case rate	Deaths per 100k	Ever had ER visit per 100k	Ever Hospitalized per 100k	Ever ICU per 100k
Napa		259,804	9,101		66			
Nevada		163,429	8,869		99			
Orange		161,316	9,327		174			
Placer		155,528	8,837		108			
Plumas		170,506	8,049		37			
Riverside		165,765	14,281		208			
Riverside	CIW	275,899	31,232	2.19		29,346	16,500	1,355
Riverside	CRC	125,187	41,963	2.94		16,502	5,563	481
Riverside	CVSP	148,635	66,095	4.63		24,476	9,619	159
Riverside	ISP	163,478	47,905	3.35		21,124	7,437	244
Sacramento		185,732	9,762		143			
Sacramento	FSP	79,586	38,933	3.99		14,781	6,555	324
Sacramento	SAC	114,774	16,139	1.65		41,769	21,603	935
San Benito		180,697	11,235		102			
San Bernardino		188,980	15,586		261			
San Bernardi	CIM	93,469	42,311	2.71		32,403	21,965	1,312
San Diego		216,237	10,786		125			
San Diego	RJD	198,181	30,364	2.82		48,757	30,364	3,085
San Francisco		316,900	5,766		74			
San Joaquin		189,059	12,339		226			
San Joaquin	CHCF	30,338	31,631	2.56		64,038	51,110	6,572
San Joaquin	DVI	-	-	-				
San Luis Obispo		249,111	10,218		119			
San Luis Obi	CMC	11,004	68,620	6.72		25,025	14,416	1,137
San Mateo		307,339	6,741		73			
Santa Barbara		191,900	9,482		114			
Santa Clara		297,523	7,283		96			
Santa Cruz		232,758	7,243		80			
Shasta		175,555	11,241		180			
Sierra		134,703	5,169		0			
Siskiyou		101,947	7,280		109			
Solano		220,669	10,039		75			
Solano	CMF	19,198	35,332	3.52		45,437	30,704	3,781
Solano	SOL	13,951	39,611	3.95		22,033	13,172	971
Sonoma		207,490	8,090		80			
Stanislaus		167,819	13,488		214			
Sutter		143,802	12,735		161			
Tehama		130,345	11,942		159			
Trinity		80,298	5,384		127			
Tulare		167,293	13,331		207			
Tuolumne		276,262	12,787		162			
Tuolumne	SCC	4,236	43,828	3.43		12,782	3,662	69
Ventura		229,698	11,261		136			
Yolo		370,922	8,548		113			
Yuba		138,291	12,255		76			

Note: Counties with CDCR institutions in table below include counts from CDCR institutions.

Supplement Text S4.1. CDCR Risk Score Definitions

1. General medical risk score

a. **High Risk Priority 1 and Priority 2** is based on high risk selection criteria that include (i) diagnoses/conditions associated with current or future risk for adverse health event, (ii) multiple higher level of care events in past 12 months, (iii) prolonged medical bed stays, (iv) patients on 10 or more medications, (v) two or more high risk specialty consultations in past 6 months, (vi) 65 years or older, (vii) any comorbid medium risk diagnoses/conditions that may increase risks for future adverse health events; Chronic conditions constitute any that do not meet the selection criteria for high risk, including patients enrolled in mental health services delivery system and patients with permanent disabilities (ADA) affecting placement. **High risk priority 1** is assigned to patients who trigger at least two risk factors from the criteria stated. **High risk priority 2** is assigned to patients who trigger only one risk factor from the criteria stated.
b. **Medium risk** is assigned to patients with at least one chronic condition who do not meet the criteria for high or low risk.
c. **Low risk** is assigned to patients who do not meet the selection criteria for high or medium risk categories. This includes some patients with medical conditions considered to be well controlled, inactive or otherwise at low risk for adverse health events.

2. Weighted COVID risk score. The COVID risk score is a sum of weights assigned to healthcare condition specifications for any given incarcerated person. According to CDCR's data dictionary, "While most risk factors were assigned a base value of one point, some conditions were given increased weight, based on scientific literature available at that time." As of April 2021, weights as defined by CDCR were applied as follows.

a. A weight score of 4 is assigned for: having age 65 years or above.
b. A weight score of 2 is assigned each for: high risk cancer, COPD, immunocompromised (any of the following conditions: aplastic anemia, histiocytosis, immunosuppressed, organ transplant, other transplant), on dialysis, has advanced liver disease (cirrhosis/end stage liver disease as defined by the CCHCS advanced liver disease condition specifications).
c. A weight score of 1 is assigned each for: active pregnancy, persistent asthma (moderate or severe), chronic lung disease (any of the following: cystic fibrosis, pneumoconiosis, or pulmonary fibrosis), diabetes, high risk diabetes, heart disease (any of the following: cerebrovascular, congestive heart failure, congenital heart disease, ischemic heart disease, peripheral vascular disease, thromboembolic disease, valvular disease), high risk heart disease, HIV/AIDS, poorly controlled HIV/AIDS (HIV with CD4 count <200), morbid obesity (BMI of 40 or above), other chronic conditions.

As of July 2020, the following were added.

d. A weight score of 1 assigned to: chronic kidney disease, advanced chronic kidney disease / renal failure (stage 5 chronic kidney disease or is identified as currently receiving hemodialysis, hemoglobin

disorder (separated as its own comorbidity, previously under other chronic conditions), hypertension, neurologic conditions (previously under other chronic conditions), obesity (adjusted to include BMI of 30 or above, previously was 40 or above).

Section 4 Supplement References

1. California Correctional Health Care Services. CCHCS clinical risk scoring. Available from: https://cdcrdata.miraheze.org/.
2. California Correctional Health Care Services. CCHCS criteria for COVID related severe morbidity & mortality: Based on literature reviewed as of 3/29/2020 and discussions with experts. Available from: https://cdcrdata.miraheze.org/.
3. California Correctional Health Care Services. CCHCS criteria for COVID related severe morbidity & mortality: Based on literature reviewed as of 7/26/2020 and discussions with experts. Available from: https://cdcrdata.miraheze.org/.

Supplement Table S5.1. Monthly number of unique staff in shift-level data and active roster.

	Nursing, Custody, or Healthcare Staff Working Shifts		Roster of Active Staff			
	35 CDCR Institutions Only		35 CDCR Institutions Only		35 CDCR Institutions w/ Other Location	
Month	*No. Staff*	*Total Shifts*	*Freq.*	*Percent*	*Freq.*	*Percent*
2020-05	35,319	453,829	-	-	-	-
2020-06	38,327	710,360	-	-	-	-
2020-07	51,333	700,793	-	-	-	-
2020-08	50,514	654,630	-	-	-	-
2020-09	51,109	663,310	-	-	-	-
2020-10	51,470	710,927	-	-	-	-
2020-11	51,621	705,208	-	-	-	-
2020-12	56,101	762,965	52,254	8.8	62,041	8.81
2021-01	57,518	674,192	52,972	8.93	62,904	8.93
2021-02	58,045	626,843	53,085	8.94	63,045	8.95
2021-03	57,470	683,773	53,517	9.02	63,522	9.02
2021-04	57,630	658,982	54,152	9.12	64,235	9.12
2021-05	56,750	741,108	54,254	9.14	64,339	9.13
2021-06	56,196	705,848	54,255	9.14	64,342	9.13
2021-07	56,672	723,403	54,601	9.2	64,720	9.19
2021-08	58,381	703,784	54,700	9.22	64,840	9.21
2021-09	58,381	608,822	54,884	9.25	65,234	9.26
2021-10	56,858	169,798	54,837	9.24	65,171	9.25
Unique No. of Staff:	**41,445**		**59,458**		**70,277**	

Supplement Table S5.2. Table 5.3 extended to include the 17% of non-missing staff-reported race/ethnicity data. (Content not shown in Table 5.3 shaded in blue.)

	Full Cohort (N = 69,144)					
	(1) Unadjusted Estimates			(2) Adjusted Estimates (with Race/Ethnicity covariate)		
	Unadj. Odds Ratio	*95% CI*	*p-value*	**Adj. Odds Ratio**	*95% CI*	*p-value*
60 or older	**1.00**			**(Ref)**		
Younger than 30	2.21	(2.02 - 2.41)	0.000	1.61	(1.46 - 1.76)	0.000
30 to 39	2.09	(1.93 - 2.26)	0.000	1.49	(1.37 - 1.61)	0.000
40 to 49	1.94	(1.79 - 2.09)	0.000	1.39	(1.28 - 1.51)	0.000
50 to 59	1.44	(1.32 - 1.55)	0.000	1.17	(1.07 - 1.27)	0.000
Unknown	0.00	(0.00 - 0.00)	0.000	0.00	(0.00 - 0.01)	0.000
Women	**1.00**			**(Ref)**		
Men	1.82	(1.75 - 1.89)	0.000	0.98	(0.93 - 1.03)	0.460
Filipino	**1.00**			**(Ref)**		
White	1.76	(1.30 - 2.36)	0.000	1.59	(1.17 - 2.14)	0.003
Asian	0.82	(0.54 - 1.22)	0.334	0.97	(0.64 - 1.46)	0.891
Pacific Islander	1.01	(0.47 - 2.13)	0.982	0.95	(0.44 - 2.04)	0.902
Black/African American	1.35	(0.96 - 1.87)	0.081	1.35	(0.96 - 1.88)	0.085
Hispanic/Latino(a)	2.17	(1.60 - 2.93)	0.000	1.83	(1.34 - 2.48)	0.000
American Indian/Alaskan Native	1.92	(1.11 - 3.32)	0.019	1.53	(0.87 - 2.67)	0.132
Other	1.03	(0.64 - 1.64)	0.891	1.02	(0.63 - 1.63)	0.930
Unknown	2.49	(1.85 - 3.32)	0.000	1.29	(0.95 - 1.74)	0.092
Healthcare	**1.00**			**(Ref)**		
Custody	2.64	(2.49 - 2.78)	0.000	1.60	(1.44 - 1.76)	0.000
Operations	1.38	(1.28 - 1.46)	0.000	1.68	(1.48 - 1.88)	0.000
Education	0.96	(0.82 - 1.12)	0.605	1.28	(1.07 - 1.52)	0.005
Contractor	0.35	(0.31 - 0.38)	0.000	0.59	(0.51 - 0.67)	0.000
Unknown	0.47	(0.43 - 0.51)	0.000	1.08	(0.91 - 1.26)	0.364
Position w/o contact w/ residents	**1.00**			**(Ref)**		
Provides direct care	2.17	(2.06 - 2.27)	0.000	1.13	(1.03 - 1.23)	0.006
Graduate degree required for job	**1.00**			**(Ref)**		
Less than a college degree equivalent	2.71	(2.50 - 2.92)	0.000	1.57	(1.40 - 1.76)	0.000
College degree or equivalent	0.87	(0.79 - 0.95)	0.002	1.41	(1.26 - 1.56)	0.000
Unknown	0.59	(0.52 - 0.64)	0.000	-	-	-
Works at 1 institution	**1.00**			**(Ref)**		
Works at 2nd institution	3.57	(3.32 - 3.82)	0.000	0.90	(0.80 - 0.99)	0.043
Works at 3rd institution	4.48	(4.05 - 4.95)	0.000	1.01	(0.88 - 1.14)	0.933
Works at 4th institution	4.31	(3.08 - 6.01)	0.000	1.00	(0.69 - 1.42)	0.982
Works at 5th institution	2.76	(0.58 - 13.00)	0.200	0.72	(0.14 - 3.58)	0.685

Note: Unadjusted and adjusted odds ratio with robust standard errors clustered at institution level estimated with logistic regression. Adjusted odds ratio includes institution fixed effects and all covariates shown in that column. (Ref) refers to reference group. Additionally, adjusted odds ratios in column 2 include staff race/ethnicity with a category for unknown race.

Supplement Table S5.3. Table 5.5 extended to include the 17% of non-missing staff-reported race/ethnicity data. (Content not shown in Table 5.5 shaded in blue.)

	Full Cohort (N = 69,144)								
	(1) Unadjusted Estimates			(2) Adjusted Estimates (without Ever Positive and Race / Ethnicity covariates)			(3) Adjusted Estimates (with Ever Positive and without Race / Ethnicity covariates)		
	Unadj. Odds Ratio	*95% CI*	*p-value*	Adj. Odds Ratio	*95% CI*	*p-value*	Adj. Odds Ratio	*95% CI*	*p-value*
60 or older	**1.00**			**(Ref)**			**(Ref)**		
Younger than 30	2.85	(2.65 - 3.06)	0.000	2.59	(2.38 - 2.81)	0.000	2.53	(2.32 - 2.74)	0.000
30 to 39	1.73	(1.63 - 1.83)	0.000	1.68	(1.57 - 1.80)	0.000	1.65	(1.53 - 1.76)	0.000
40 to 49	1.13	(1.06 - 1.20)	0.000	1.05	(0.97 - 1.11)	0.210	1.03	(0.95 - 1.09)	0.459
50 to 59	1.03	(0.96 - 1.08)	0.422	0.96	(0.89 - 1.03)	0.253	0.95	(0.88 - 1.02)	0.185
Unknown	2.27	(2.10 - 2.45)	0.000	0.85	(0.76 - 0.94)	0.003	0.88	(0.78 - 0.97)	0.019
Women	**1.00**			**(Ref)**			**(Ref)**		
Men	1.01	(0.97 - 1.03)	0.697	0.78	(0.74 - 0.81)	0.000	0.78	(0.74 - 0.81)	0.000
Filipino	**1.00**			**(Ref)**			**(Ref)**		
White	1.77	(1.42 - 2.19)	0.000	2.00	(1.59 - 2.52)	0.000	1.97	(1.56 - 2.48)	0.000
Asian	1.32	(0.99 - 1.74)	0.053	1.23	(0.91 - 1.66)	0.176	1.23	(0.90 - 1.65)	0.180
Pacific Islander	1.82	(0.99 - 3.35)	0.053	1.80	(0.94 - 3.44)	0.074	1.84	(0.96 - 3.52)	0.065
Black/African American	1.99	(1.54 - 2.56)	0.000	1.94	(1.47 - 2.54)	0.000	1.93	(1.46 - 2.53)	0.000
Hispanic/Latino(a)	1.80	(1.44 - 2.24)	0.000	1.86	(1.47 - 2.35)	0.000	1.81	(1.43 - 2.29)	0.000
American Indian/Alaskan Native	2.96	(1.60 - 5.45)	0.001	4.04	(2.15 - 7.54)	0.000	3.93	(2.10 - 7.35)	0.000
Other	2.19	(1.49 - 3.21)	0.000	2.00	(1.33 - 2.99)	0.001	2.00	(1.33 - 2.99)	0.001
Unknown	0.31	(0.25 - 0.37)	0.000	0.16	(0.12 - 0.19)	0.000	0.16	(0.12 - 0.19)	0.000
Healthcare	**1.00**			**(Ref)**			**(Ref)**		
Custody	2.80	(2.67 - 2.92)	0.000	2.84	(2.58 - 3.11)	0.000	2.76	(2.51 - 3.02)	0.000
Operations	1.87	(1.76 - 1.96)	0.000	0.90	(0.81 - 1.00)	0.067	0.88	(0.78 - 0.97)	0.015
Education	1.08	(0.95 - 1.22)	0.222	0.50	(0.42 - 0.58)	0.000	0.49	(0.42 - 0.57)	0.000
Contractor	4.15	(3.89 - 4.42)	0.000	4.17	(3.80 - 4.56)	0.000	4.23	(3.86 - 4.64)	0.000
Unknown	5.42	(5.10 - 5.74)	0.000	6.18	(5.46 - 6.98)	0.000	6.11	(5.40 - 6.90)	0.000
Position w/o contact w/ residents	**1.00**			**(Ref)**			**(Ref)**		
Provides direct care	0.72	(0.69 - 0.74)	0.000	1.84	(1.68 - 1.99)	0.000	1.83	(1.67 - 1.98)	0.000
Graduate degree required for job	**1.00**			**(Ref)**			**(Ref)**		
Less than a college degree equivalent	3.17	(2.97 - 3.36)	0.000	1.62	(1.45 - 1.79)	0.000	1.58	(1.42 - 1.75)	0.000
College degree or equivalent	3.05	(2.85 - 3.26)	0.000	1.42	(1.29 - 1.55)	0.000	1.40	(1.27 - 1.53)	0.000
Unknown	7.05	(6.55 - 7.58)	0.000	-	-	-	-	-	-
Works at 1 institution	**1.00**			**(Ref)**			**(Ref)**		
Works at 2nd institution	0.30	(0.28 - 0.31)	0.000	0.46	(0.42 - 0.50)	0.000	0.46	(0.42 - 0.50)	0.000
Works at 3rd institution	0.23	(0.21 - 0.25)	0.000	0.36	(0.31 - 0.39)	0.000	0.35	(0.31 - 0.39)	0.000
Works at 4th institution	0.25	(0.18 - 0.33)	0.000	0.39	(0.27 - 0.54)	0.000	0.38	(0.27 - 0.53)	0.000
Works at 5th institution	0.22	(0.06 - 0.77)	0.019	0.43	(0.10 - 1.79)	0.246	0.44	(0.10 - 1.78)	0.250
Never positive	**1.00**			**-**			**(Ref)**		
Ever positive	1.40	(1.34 - 1.44)	0.000	-	-	-	1.48	(1.41 - 1.54)	0.000

Note: Unadjusted and adjusted odds ratio with robust standard errors clustered at institution level estimated with logistic regression.
Adjusted odds ratio includes institution fixed effects and all covariates shown in that column. (Ref) refers to reference group.
Additionally, adjusted odds ratios in columns 2 and 3 include staff race/ethnicity with a category for unknown race. Column 2 does not include ever having been positive.

Section 7.3 Supplement

Supplemental Text S7.3.1 Ventilation intervention calculators and other options

A. Portable air cleaner calculator

"This tool is intended to simplify decision-making around portable air cleaners in schools for airborne transmission control (it can also be applied to residential or office air cleaning, noting differences in ventilation practices and occupancy). It is provided to support efforts to supplement outside air ventilation with air cleaning using well established particle filtration strategies. Airborne transmission is not the only mode of transmission, therefore additional risk reduction strategies are required."

B. Maximum CO2 Concentration Calculator

"This tool was developed to support the use of real-time carbon dioxide (CO2) sensors indoors as a way to help evaluate ventilation rates in classrooms. Users input their target air changes per hour through ventilation and information about the classroom, and the calculator returns the estimated CO2concentration. IMPORTANT: sufficient clean air delivery can be achieved through any combination of outdoor air ventilation and filtration, but this tool is only for assessing outdoor air ventilation. It is possible to exceed these target CO2 concentrations and still be meeting targets for clean air through filtration."

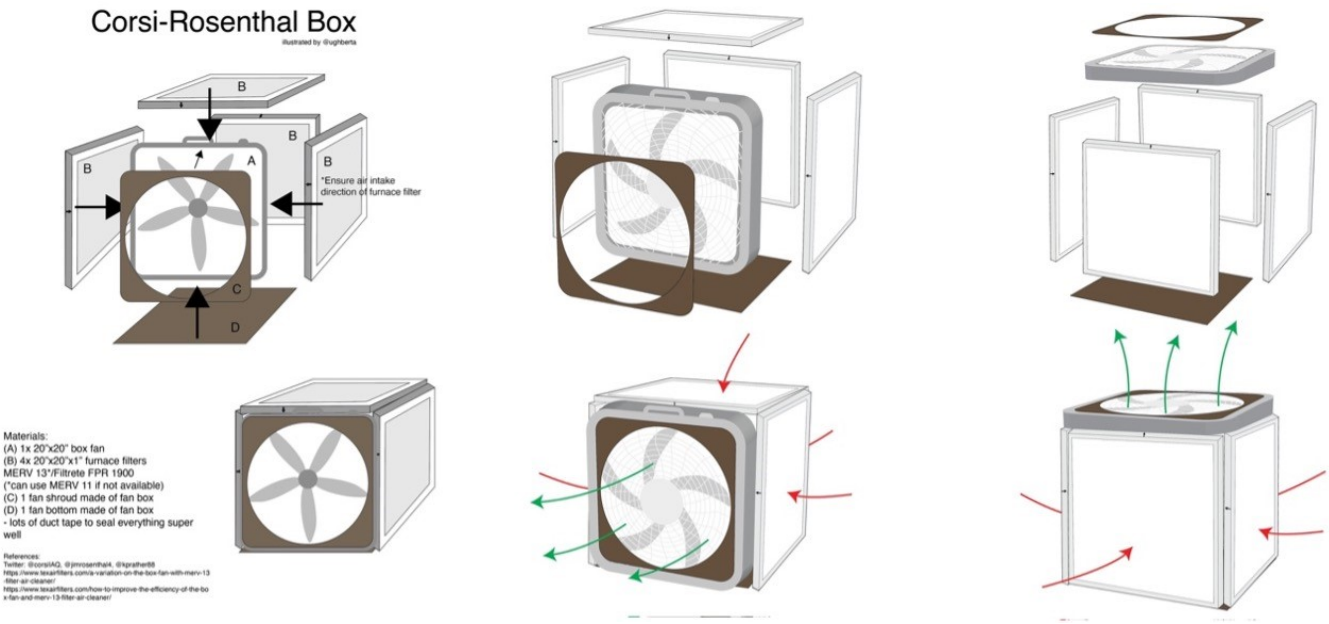
C. Supplemental air cleaning options include:

a. Johnson Controls the Envirco IsoClean filtration system which was originally designed for healthcare use. These machines are durable for use in hospital settings and are therefore more expensive compared to portable air cleaners that are for home and office use. These machines may be energy efficient compared to the consumer models that are ENERGYSTAR (a minimum of 2.9 CADR per watt). Still, there are some advantages to these high-flow filtration units including their ease of installation, simplicity to operate, and the fact that they provide filtered air where people are.

b. High-volume air filtration units with activated carbon to help with odor if changed very regularly. If these units are run continuously 24/7, filters need to be changed a few times a year. Examples of these types of machines include the Carrier Opticlean Air Scrubber, The Enviroco IsoClean CM Hepa Filtration System, and the Daikin CLIP5 and CLIP19 Air Treatment Systems.

c. The Corsi Rosenthal Box is a design for a DIY air purifier that can be built relatively inexpensively. The design consisted of four MERV13 filters which form the sides of a cube. A 20-inch box fan is placed on top and joined to the filters using duct tape. The duct tape seals the system so that air is drawn through the filters and out of the box.

Supplemental Figure S7.3.1. Corsi-Rosenthal Box Build Instructions



Supplemental Text S7.3.2. Germicidal Ultraviolet Irradiation

S7.3.2.1 Introduction and Background

S7.3.2.1a Overview of GUV for air hygiene

The germicidal effect of ultraviolet-c (UVC; 200-280 nm wavelength) has helped reduce the spread of airborne respiratory pathogens for decades (Reed 2010; Nardell 2021). The use of germicidal ultraviolet irradiation (GUV), also referred to as ultraviolet germicidal irradiation (UVGI), was associated with the control of spread of measles — a highly infectious airborne pathogen — in grade schools, and to control tuberculosis. Experiments using viruses in laboratories, controlled indoor settings, and risk models using computational fluid dynamics indicate effective air disinfection by GUV for a variety of viruses. The efficacy and safety of GUV use in buildings for infection control is well accepted and has been summarized elsewhere (P. Jacob Bueno de Mesquita et al. 2021). GUV is recommended by the US Centers for Disease Control and Prevention as a supplemental treatment, beyond ventilation and filtration, to inactivate SARS-CoV-2 in schools, and especially if options for increasing ventilation and filtration are limited (US CDC 2020).

Germicidal lights typically emit a peak wavelength at 254 nm, which readily inactivates respiratory pathogens. Upper-room GUV fixtures are installed to shine light throughout the upper portion of a room and air in the space is mixed so that contaminated air in the occupied zone flows up to the irradiated zone, where it is sanitized and then brought back down into the occupied space (Figure S7.3.2a; Beggs and Avital 2020). Additional pictures of upper-room GUV in practice are shown in Figure S7.3.2b.

Figure S7.3.2a. GUV schematic (from Beggs and Avital, 2020). Upper-room GUV fixtures are typically installed to shine light throughout the upper portion of a room. Air in the space is mixed so that contaminated air in the occupied zone flows up to the zone irradiated with UV-C, sanitized, and then brought down into the occupied space.

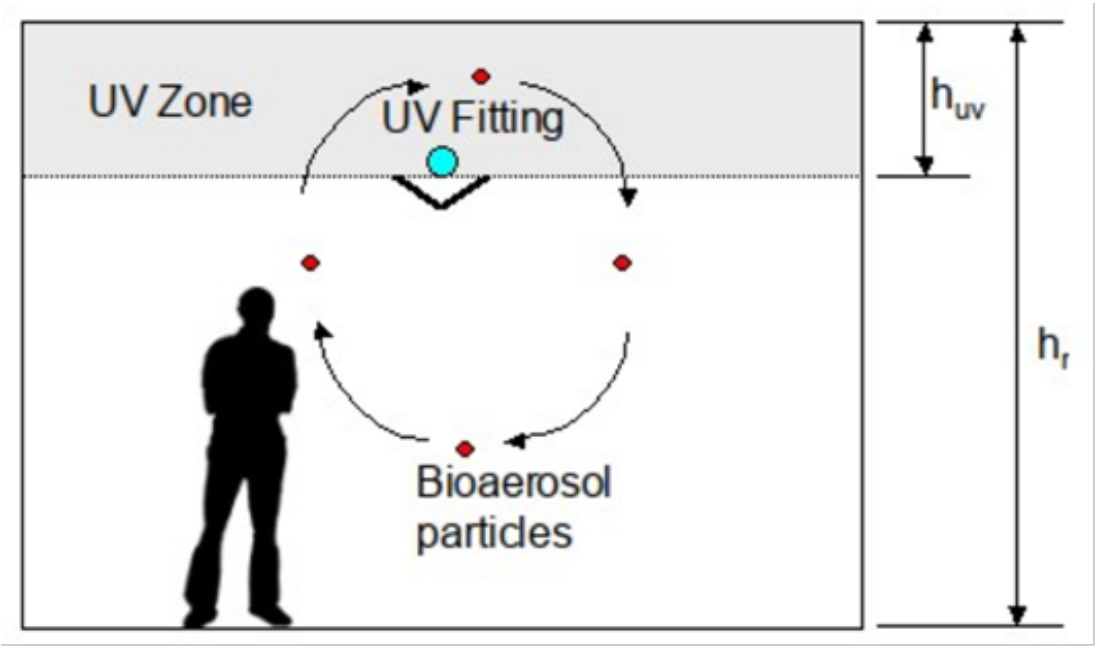


Figure S7.3.2b. Upper-room germicidal fixtures in church (top), school (bottom left), and an airport (bottom right), from Harvard Center for Global Health Delivery (https://ghdcenter.hms.harvard.edu/guv-lighting).

S7.3.2.1b Practical considerations for implementation

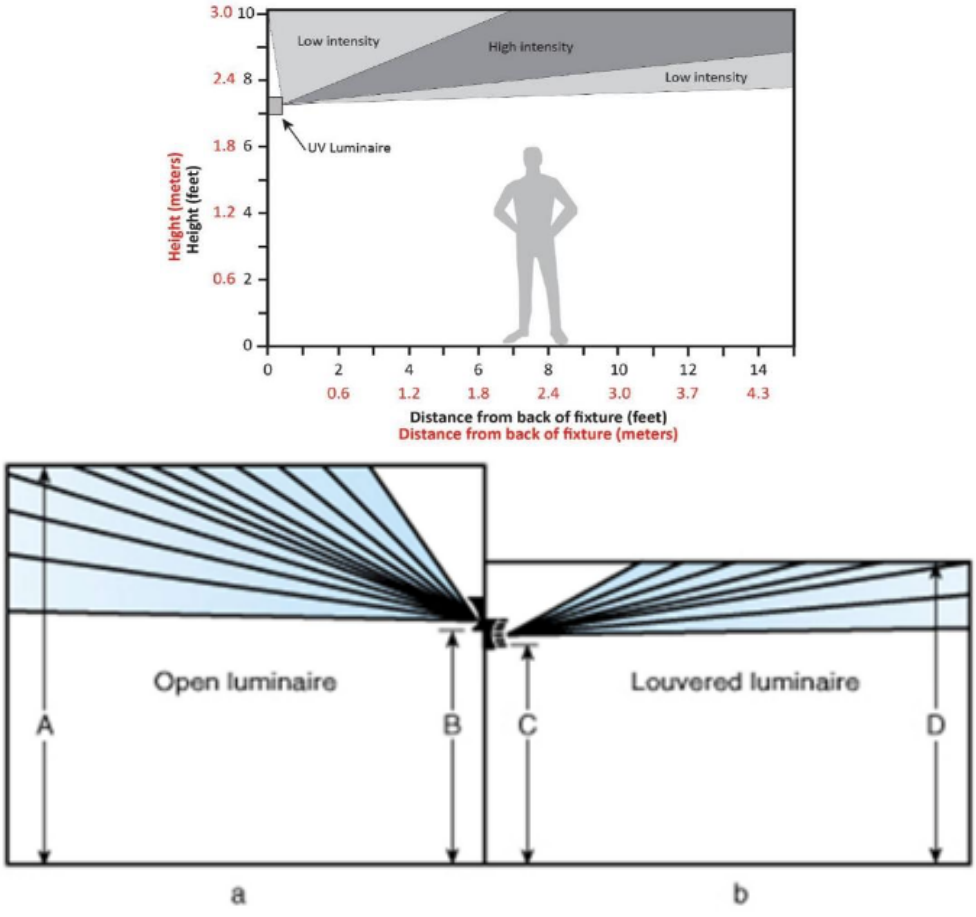
To reduce ocular exposure — which can otherwise cause an irritation — upper-room GUV fixtures designed for use during occupancy are always positioned in the upper portion of the room above the heads of people, at 2.1 m (7 ft) or higher (**Figure S7.3.2c**). Fixtures often use louvers that reduce the penetration of light downward into the occupied space and upward light toward the ceiling that could be reflected down into the occupied space. When the ceiling is approximately 2.7 m (8.9 ft) or higher, the fixtures can be installed without louvers blocking upward light as long as safety measurements are conducted (Nardell et al. 2008), thus allowing for higher levels of sanitizing light to reach a greater volume of air (shining upwards, at an angle, as in **Figure S7.3.2c**, lower panel, B) to reduce eye exposure.

Compared with upper-room fixtures, open fixtures (**Figure S7.3.2c**, lower panel, A) can achieve a greater volume of air sanitation given constant airflow. Open fixtures are typically considered when there is greater ceiling height, reducing the strength of reflected light off the ceiling which could increase exposure in the occupied zone below. Strategies based on research, modeling, and experience can help estimate the placement and orientation of GUV fixtures to achieve desired sanitizing performance (Mphaphlele et al. 2015; Nardell 2021). Properly trained GUV installation services can assist with designing the placement of units to

achieve effective air hygiene, considering occupancy patterns, ceiling height and room geometry, reflective potential, and the extent of air mixing.

Proper installation of fixtures includes measurement of fluence rate around the lamp unit to assure sufficient light for desired germicidal effect while maintaining human exposure below acceptable levels. A photometer (such as International Light Model IL1400A SEL240 or Gigahertz-Optik UV-3725) can be used to measure the light output and determine the time it would take to achieve inactivation of aerosolized virus based on the susceptibility of the particular airborne pathogen. Fixtures should be those specified for 254 nm wavelength and should report their output wattage, which may range from 0.3 - 10 W or more. The effective irradiance from the lamps in practice should be measured to evaluate potential sanitizing effect. A reasonable value for a new bulb could be 200-400 or more μW/cm^2, but depends on the use scenario and should be evaluated by someone with appropriate training. Lamps should be cleaned with an alcohol solution and a cloth once every 3 months and has been described by others (Bürgi and Vincent 2020).

Figure S7.3.2c. Placement of GUV fixtures. Images from Illuminating Engineering Society IES Committee Report CR-2-20-V1a.



S7.3.2.1c Mix the air to increase disinfection efficiency

Upper-room GUV disinfects the air in the upper portion of the room space, and the quantity of disinfected air delivered to occupants depends on the extent of air mixing between the disinfection zone above and the breathing zone below. Air movement in indoor environments includes the rise of warm air from around humans, and other airflow currents from windows, doors, infiltration from outdoors, mechanical systems, and fans. The addition of one or more ceiling fans can increase air mixing and subsequently the effectiveness of ultraviolet air sanitation (Ko, First, and Burge 2002; Pichurov et al. 2015). A chamber experiment at 60% relative humidity showed the addition of a fan led to 87 eACH (equivalent air changes per hour) versus 16 eACH without one (McDevitt et al. 2008), and an even greater effect at lower humidity. A numerical modelling study examining the role of vertical mixing rate on estimated GUV effectiveness showed that the greatest increase in GUV effectiveness would occur at 0.05 m/s vertical airspeed (Jensen 2021). This is consistent with the observations of others who also suggest that the direction of a ceiling fan for air mixing does not influence effectiveness (Nardell 2021; Mphaphlele et al. 2015). As ACH from ventilation and filtration increases, higher fan speeds are needed to draw air into the disinfection zone before it is otherwise moved out of the space or filtered. Standalone air cleaners with HEPA filtration (e.g., Envirco, Carrier, Daikin) or high-MERV filtration (e.g., Corsi-Rosenthal Box) can promote mixing to increase eACH by GUV, in addition to their own filtration-based delivery of clean air.

S7.3.2.1d Effectiveness

Knowledge of the susceptibility of coronaviruses in aerosols, estimated at ~0.4 m^2/J (Walker and Ko 2007), and irradiation flux from GUV units, inform computational fluid dynamics models (Zhu et al. 2012; Pichurov et al. 2015) to estimate eACH. Studies of GUV effectiveness have shown eACH ranging from ten to hundreds (Mphaphlele et al. 2015; Escombe et al. 2009; McDevitt et al. 2008), underscoring the potential to mitigate infection risk. Building ventilation and filtration generally achieve much less than 10 ACH, which may not reduce airborne transmission risk to the extent needed to protect exposed individuals from an infectious dose or to quell an epidemic across public spaces. Respiratory protective equipment can also be used, but requires population-scale access to respirators and adherence to use, which pose logistical and behavioral challenges. N95s may not be commonly used when a epidemic is beginning and perceived risk is low.

S7.3.2.1e Costs and benefits

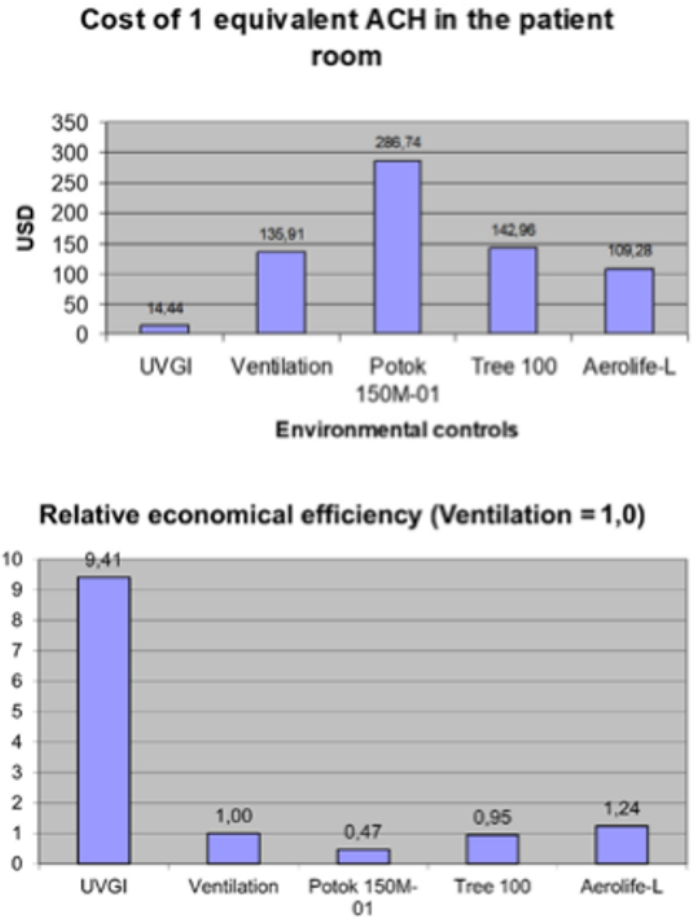
Nardell reported on a study where bacterial spores were released in a TB hospital patient room in Russia that was disinfected by GUV, ventilation, and three models of air cleaners (Nardell 2021). The costs of one eACH in the room was much lower for GUV compared with all other methods, and 9.41 times cheaper than ventilation (**Figure S7.3.2d**). This data along with the already well-recognized high efficiency air disinfection provided by GUV supports GUV as a cost-effective way of increasing infection control beyond what can be conferred by ventilation and filtration alone.

S7.3.2.1f Safety

UVC does not readily penetrate the skin to the level where it affects live cells. The effects of exposure on the skin are medically negligible, and much lower than a similar duration of exposure to UVA and UVB rays from the sun outdoors (Bergman et al. 2021; Sliney 2013; Maverakis et al. 2010; Nardell et al. 2008). The threshold limit value (TLV) 6.0 mJ/cm^2 provided by the American Conference of Governmental Industrial Hygienists (ACGIH) refers to the dose at which workers can expect no adverse effects (eye or skin) given exposure for 8 hours a day for 40 hours a week for a lifetime. This TLV is equivalent to 0.2 μW/cm^2 for an eight-hour exposure or 0.4μW/cm^2 for a four-hour exposure. The time that people spend in different locations and whether they typically sit or stand in a particular space, and to what extent these factors vary, informs the acceptable levels of UVC irradiance in that area. Photobiology research has shown that a level of 0.4 μW/cm^2 provides safe exposure given the normal movement of individuals in medical or educational settings and the biology of the human eyelid which blocks some exposure to UV light from above (First et al. 2005; Nardell et al. 2008; Coker et al. 1999). This allows increased germicidal effect. Since those in the prison settings may not likely exceed 4 hours of exposure to 0.4 μW/cm^2 due to physical movement in and out of spaces and the positioning of GUV light fixtures, it could be reasonable to accept a maximum level of between 0.2 and 0.4 μW/cm^2 at eye level.

UVC cannot penetrate through non-quartz glass, and thus, fixtures could be placed safely where they are shining light toward indoor windows (e.g., windows that range between multiple stories in a building and are inoperable). An LED version of the UVC lamp has been developed and it is likely that in the near future they will provide similar levels of air disinfection compared with conventional 254 nm mercury lamps. 222 nm wavelength UVC appear to be another emerging option where exposure direct eye or skin exposure is negligible due to the low penetrance of 222 nm, allowing the direct irradiation of occupied spaces. (M. Buonanno et al. 2020).

Figure S7.3.2d. Bacterial spores released in a tuberculosis hospital patient room in Russia were disinfected by GUV, ventilation, and three models of air cleaners and the costs of 1 eACH in the room was much lower for GUV compared with all other methods, and 9.41 times more economical than ventilation.



S7.3.2.2 Proposed sketch of GUV implementation in two prison environments

Consultation with GUV researchers and practitioners, as well as available peer reviewed literature indicated that 20 eACH could be reasonably achieved for the 270 and CMF spaces (McDevitt et al. 2008; Mphaphlele et al. 2015; P. Jacob Bueno de Mesquita et al. 2021). San Quentin spaces were also reviewed; however, a site visit would be required to make a better-informed assessment due to building layout and air flow complexities with respect to GUV disinfection. For this reason, the 270 and CMF Dorm were the focus of GUV implementation planning and risk reduction modeling. As described earlier in more detail, considerations for effective and safe implementation of GUV fixtures include, placement, UV fluence rate (strength of light), fixture orientation, presence of reflecting surfaces, occupancy location by frequency and duration, and air mixing and airflow patterns.

In the absence of site visits, we received preliminary GUV installation design suggestions and cost estimates from two vendors, and an independent consultant with years of experience working on GUV implementation at the Center for Disease Control and Prevention. A site visit is typically essential to design and plan for GUV

implementation, so input was taken as suggestions and was generally consistent. The vendors had extensive experience installing GUV and other building controls in commercial spaces including schools, places of worship, airports, and correctional facilities. **Figures S7.3.2e and S7.3.2f** show some draft GUV fixture placement designs, including ceiling fan placement for the 270 and CFM spaces, respectively. The light emitted from a fixture is depicted by a triangle with light waves expanding horizontally to some extent from the source. These plans are not drawn to scale, but give a sketch for how facilities might be outfitted. To improve infection control, it is recommended for both spaces that mechanical air systems remain running continuously to promote air mixing. Prisons may also consider additional precautions to prevent potential access to or tampering with fixtures and ceiling fans.

In the 270, greater infection control benefit will come from net airflow moving into cells where air is exhausted. This way sanitized air from the dayroom can move into the cells, preventing a constant inflow of contaminated air from the cells of potentially infectious inmates. In the 270, three fixture designs are proposed. Draft design 1: If exposure above the cells on the second floor is deemed to be of low concern, it is possible to place fixtures above cell doors facing out over the landing, toward the day room. Draft design 2: Fixtures may be placed directly above the day room area, given space for mounting. Draft design 3: Fixtures may be directed away from the guard tower if exposure is a concern.

In the CMF dorm, it may be more feasible to add GUV to the central dining area in the middle of the building (**Figure S7.3.2f** CMF draft design 1). Upon reviewing the space in greater detail, the installers can determine if fixtures could be installed so that they spread along the length of the building to increase effectiveness (**Figures S7.3.2f** CMF draft design 2).

Figure S7.3.2e. Draft design options for the implementation in the 270.

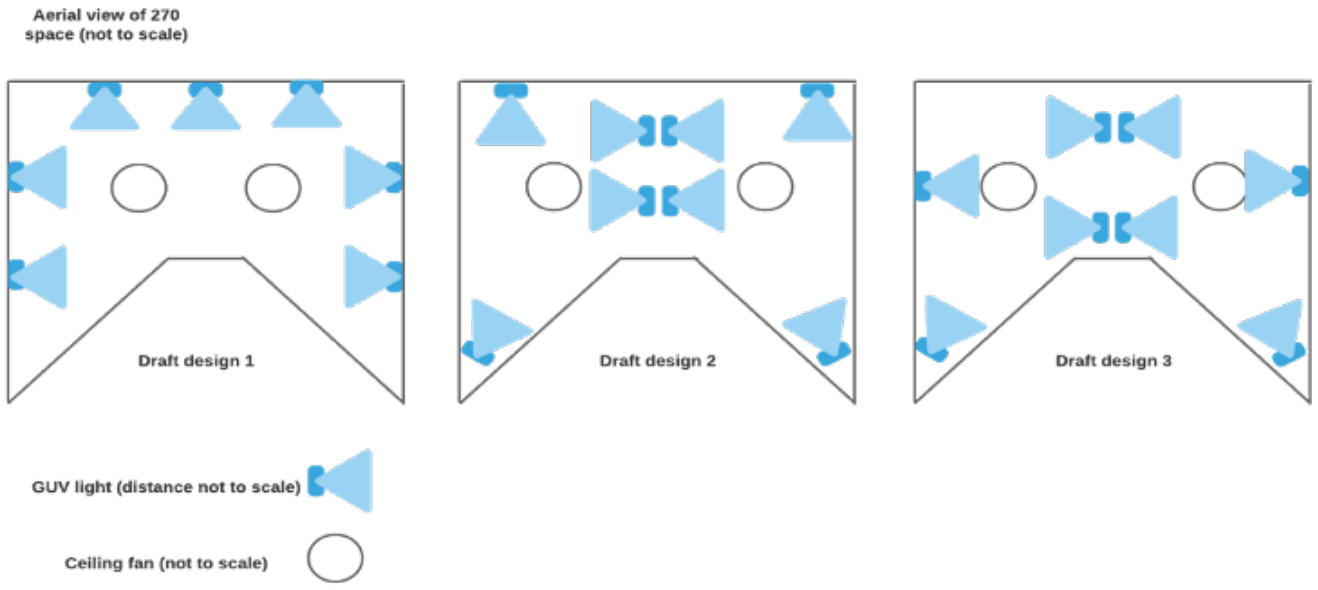
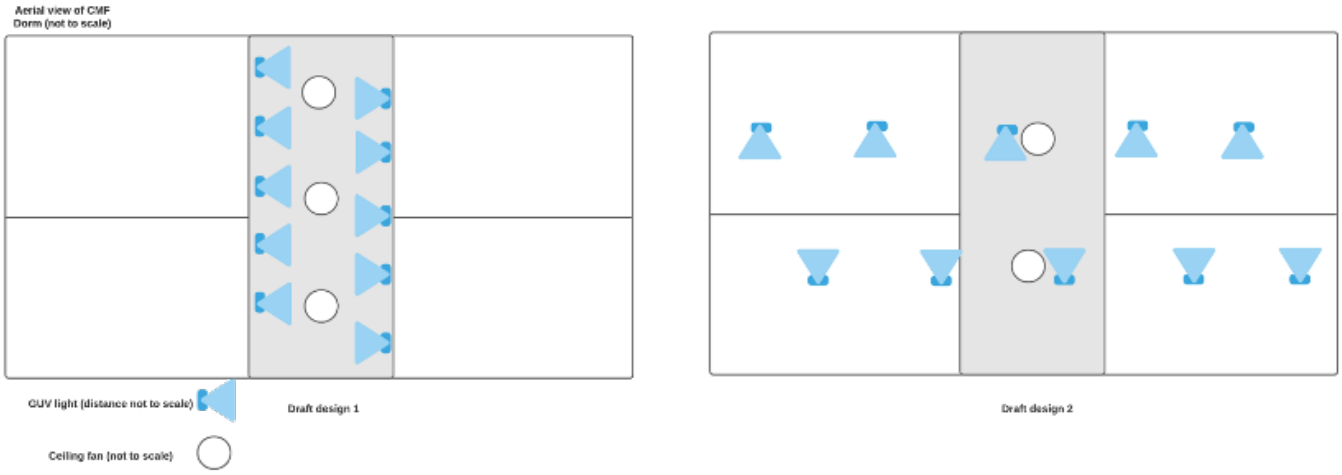


Figure S7.3.2f. Draft design options for the implementation in the CMF dorm space. It may be more feasible to add GUV to the central dining area in the middle of the building (left), however, if possible, fixtures could also be installed so that they spread along the length of the building (right).



S7.3.2.3 Cost to implement GUV air hygiene

Installation costs include material costs of the fixtures, and labor costs to install and verify efficacy and safety. Operation costs include those for energy, cleaning, and replacement. **Table S7.3.2.1** and **Table S7.3.2.2** and 2 show approximations of initial installment costs and ongoing operation and maintenance costs, based on the experience of vendors and the consultant.

Table S7.3.2.1 Cost approximations of GUV in 270 space (approximately 8,900 ft^2)

Cost item	Cost per unit	Number units	Total cost to implement	Cost per year (post implementation)
GUV fixtures	$1,250 – $1,600	6-8	$10,000 - $12,800	- Fixtures will last for many years
Lamps	$30 - $150	6 - 24	$180 - $3,600	$180 - $3,600
Site visit (1x/year) (evaluate, install, test units for effectiveness/safety)	$5,000	-	$5,000	$1,000
Ceiling fan(s)*	$2,000	2	$4,000	(periodic maintenance could be done by staff in-house)
Electrical work (fixtures & fans)	-	-	$5,000 – 15,000	-
Electrical costs ($0.20/kWhr)**	-	-	-	50 W fans (2) + 40 W fixtures (8) = $736
Total			$19,180 - $40,400 ($2.10 - $4.5/sq ft)	$1,026 - $5,336 ($0.12 - $0.60/sq ft)

* Cost estimates do not include installation of ceiling fans.

** Electric costs from: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=table_5_06_a (data from November 2021 and taken as within range of commercial and residential consumer types; accessed January 13, 2022)

Table S7.3.2.1 Cost approximations of CMF dorm (approximately 13,500 ft^2)

Cost item	Cost per unit	Number units	Total cost to implement	Cost per year post implementation
GUV fixtures	$8,000 - $16,000	10	$10,000 - $12,800	-
Lamps	$30 - $200	6 - 24	$180 - $3,600	$180 - $3,600
Site visit (1x/year) (evaluate, install, test units for effectiveness/safety)	$5,000	-	$5,000	$1,000
Ceiling fan(s)*	$2,000	3	$6,000	-
Electrical work (fixtures & fans)	-	-	$5,000 – 15,000	(Periodic maintenance could be done by staff in-house)
Electrical costs ($0.20/kWhr)**	-	-	-	50 W fans (3) + 40 W fixtures (10) = $964
Total			$21,180 - $41,600 ($1.58 - $3.08/sq ft)	$2,189 - $ 5,564 ($0.02 - $0.41/sq ft)

* Cost estimates do not include installation of ceiling fans.

** Electric costs from: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=table_5_06_a (data from November 2021 and taken as within range of commercial and residential consumer types; accessed January 13, 2022)

S7.3.2.4 Summary of GUV implementation considerations

a. GUV can deliver greater air disinfection than is achievable through ventilation and filtration and can mitigate outbreaks of highly infectious pathogens.
b. GUV is often more cost effective than ventilation and filtration. The benefit-to-cost ratio increases with time, following the larger initial investments in installation.
c. Air disinfection to prevent respiratory infection is especially important in crowded indoor spaces, and spaces where masks or respirators are not always used (including when the threat of infection is low and an outbreak is beginning).
d. Exposure safety should be carefully considered before and after fixture installation, validated with photometer measurements. GUV output should be measured to estimate effectiveness and appropriate spacing between units (if multiple units are used within a single space) to achieve a desired level of expected air disinfection.
e. Ceiling fans are advisable to promote air mixing. Other methods of air mixing can also be used, including standalone air cleaners that push air upwards, and HVAC diffusers and inlets, or exhaust vents.

f. Professionals advise facilities on designing placement of GUV for safety and effectiveness, do initial installation and period testing and bulb replacement, and train users on cleaning and maintenance. They can help establish safety and maintenance plans, which should be in place to assure long-term benefit.

S7.3.2.5 Estimating aerosol transmission risk for SARS-CoV-2 and influenza in prisons

We constructed a simple model of potential airborne infection risk reduction as a result of implementing GUV in CA correctional facility settings that have been identified as potential spaces for effective implementation. We focused on risk reduction for SARS-CoV-2, and separately, for influenza transmission. We considered the effect of masking, immunization, increase in clean air delivery from filtration and/or outdoor air, and from the addition of GUV. We used a Wells-Riley model (Riley, Murphy, and Riley 1978; Dai and Zhao 2020; Rudnick and Milton 2003) to estimate risk under these scenarios for: a) a 270-type dayroom, and b) an open dorm building environment (CMF dorm). Model inputs and code are available at: https://gitlab.com/jacobbueno/prison_transmission_guv.

S7.3.2.5a Assumptions about the prison environments

We considered that exposure from a single primary case will occur for three days for SARS-CoV-2 and two days for influenza (staff or inmate, although the very first case is more likely to be a staff member who then infects an inmate and sets off a chain of infection). These exposure periods refer to the time during which an infectious person is shedding substantial, infectious virus, and no quarantine/isolation measures have been implemented.

For the 270, we considered an exposure time of six hour per day outside of the cell, two of which were for meals or some heavier breathing activity/speaking without mask. We considered that the entire 270 population receives exposure outside of the cell at the same time. While not all inmates may be exposed to each other at once in the day room, this assumption is reasonable given exposure uncertainties and given that there were observed air connections between day rooms and cell (both directions). For the CMF dorm space, we considered continuous exposure, with two hr per day for meals or some heavier breathing/speaking without mask. Because air is shared throughout the dorm at all times, the relevant exposure period is longer than that of the 270. A lower breathing rate is considered during the sedentary period in the CMF, during sleep and other times apart from two hr/day where eating and other activities with heavier breathing may be done.

S7.3.2.5b Estimated control measure effectiveness in the prison environments

- No mask versus mask (cloth or surgical mask) except during eating. No vaccination in population versus 50% versus 90% vaccination rate.

    - Masking and vaccination rates are representative of the range of vaccination in CA among staff and inmates during the COVID-19 pandemic through October, 2021 (Harris and Hayes 2021).
- Vaccine effectiveness is taken as 70% for mRNA vaccines for SARS-CoV-2 (P. Tang et al. 2021) and the same was taken for influenza as a best-case scenario.
- 2 air changes per hour (ACH) with clean air from existing ventilation and filtration
- 6 ACH with clean air from increase in filtration (and/or ventilation)
    - Possible to achieve 4 ACH by adding 2 commercial air cleaners (e.g., Environ, Carrier, or Daikin) to the 270 or the CMF space with 1,500 cfm clean air delivery rate.
- 2 ACH with clean air from existing ventilation and filtration plus 20 eACH from GUV = 22 eACH total
- 6 ACH from filtration and/or ventilation plus 20 eACH from GUV = 26 eACH total

The 20 eACH is considered to be a reasonable estimate given studies of GUV effectiveness, including a study of human transmission to guinea pigs in South Africa (Mphaphlele et al. 2015), which measured 24 eACH, as well as in experiments in an environmental chamber (McDevitt et al. 2008), which found potential of up to hundreds of eACH. Rooms that are properly outfitted with GUV are likely to be able to achieve 20 eACH and potentially more.

S7.3.2.5c Estimated breathing rates and viral infectious periods

- Inmates and staff will probably be breathing air at a little above sedentary when interacting while awake. This corresponds to 10 L/min of air inhaled and exhaled.
- For SARS-CoV-2: We considered three days of infectious shedding for cases with mild to moderate symptoms, derived from the exhaled breath viral shedding data from Adenaiye and colleagues (2021).
- For influenza: We considered two days of infectious shedding, based on published shedding rates from symptomatic young adults.
- Symptomatic and asymptomatic or pre-symptomatic individuals are expected to shed infectious SARS-CoV-2 or influenza virus into exhaled breath (Qiu et al. 2021; Paul Jacob Bueno de Mesquita et al. 2020).

S7.3.2.5d Mitigating airborne exposure is important for disease control

Given limited epidemiological data, the available evidence of increased airborne transmissibility during SARS-CoV-2 viral evolution supports efforts to estimate and mitigate airborne transmission risk (Adenaiye et al. 2021; Torjesen 2021). SARS-CoV-2 delta variant is estimated to be 40-60% more transmissible than alpha (Scientific Pandemic Influenza Group on Modelling, Operational sub-group (SPI-M-O) 2021). As of October, 2021, it was thought that the "delta-plus" SARS-CoV-2 variant may be about 10% more transmissible than delta variant, and the recent emergence of omicron variant with potential for further infectiousness underscores the realism of highly transmissible scenarios in risk modeling and the utility of preparing for highly infectious airborne pathogens (Doucleff 2021). The trend in increasing transmissibility with SARS-CoV-2

viral evolution, shown in the small sample size of alpha versus wildtype SARS-CoV-2 virus by Adenaiye and colleagues, is consistent with evolving transmission advantage.

We considered fine viral aerosol ≤5 μm emitted in the exhaled breath of an infectious person. These viral particles can accumulate and persist in the air for minutes to hours if not otherwise removed or disinfected and are within the size range most likely to be important for transmission for respiratory viruses (J. W. Tang, Tellier, and Li 2022). Future modeling work may explore the contributions of coarser aerosols; however, the current model provides a reasonable estimate to inform public health interventions. Designing control strategies to mitigate exposure where airborne infection risk is relatively high — such as from emerging pathogens like SARS-CoV-2, and including where there is little to no population immunity — would be especially important in crowded settings such as live-in correctional facilities (Furuse et al. 2020).

S7.3.2.5e Estimated SARS-Cov-2 and influenza virus quanta emission rate

The quanta emission distributions over a theoretical population of infectious SARS-CoV-2 or influenza infected individuals are shown by **Figure S7.3.2g**. Estimated SARS-CoV-2 delta-plus variant shedding for someone with mild symptoms is just over 1,000 RNA copies/hr without a face mask and approximately 500 RNA copies/hr while wearing a face mask (~50% reduction with mask reported in studies of viral exhaled breath aerosols) (Milton et al. 2013; Yan et al. 2018; Adenaiye et al. 2021). This assumes approximately 70% increase in RNA shed in delta-plus vs alpha variant cases (Scientific Pandemic Influenza Group on Modelling, Operational sub-group (SPI-M-O) 2021; Doucleff 2021). We converted measurements of SARS-CoV-2 RNA contained in exhaled breath into quanta emissions by dividing by a factor of 100. This means that we assumed that every 100 RNA copies were associated with an infectious dose 63% (infectious dose required to infect 63% of susceptible people exposed, or to infect a susceptible person 63% of the time). This conversion factor is largely unknown but is consistent with what has been reported in previous estimations (Bazant and Bush 2021; Popa et al. 2020; Fears et al. 2020).

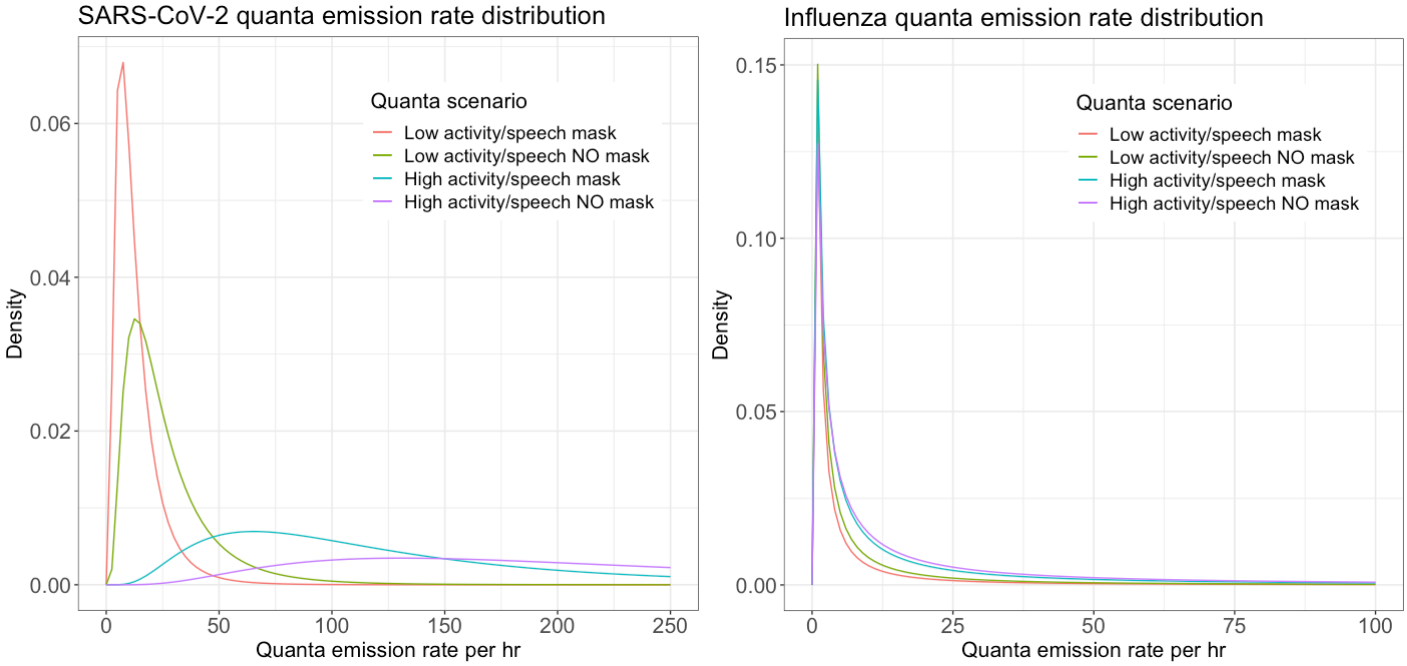
We assumed that when people are speaking loudly, or singing, they can generate an order of magnitude more viral RNA (G. Buonanno, Stabile, and Morawska 2020; Asadi et al. 2019). We then estimate geometric mean quanta emission rates of 21 for low or soft speech without a mask, 11 for low or soft speech with a mask, 211 for loud speech without a mask, and 106 for loud speech with a mask. The loud speech scenario may also approximate activities where heavier breathing is involved. We use geometric standard deviations of 2 for these quanta shedding distributions, based on measured viral shedding into fine exhaled breath SARS-CoV-2 aerosols (Adenaiye et al. 2021).

We considered a scenario where infectious influenza cases may also pose transmission risk. We assumed quanta emission from previously published work (Yan et al. 2018; Paul Jacob Bueno de Mesquita, Noakes, and Milton 2020), and the same 10-fold increase for loud speech/physical activity as was taken for SARS-CoV-2. In the absence of masking, the estimated geometric mean for influenza quanta emission per hour is 5 and 0.5 for low emission and high emission activities, and the geometric standard deviation is 13.

Based on a longitudinal cohort of COVID-19 cases and their contacts, those fully vaccinated for COVID-19 shed peak SARS-CoV-2 RNA loads similar to those with vaccination (Singanayagam et al. 2021). It is unclear if

vaccination reduces infectiousness of emitted virus. Singanayagam and colleagues found that index cases that were fully vaccinated were transmitting to those with and without vaccination at a similar rate (~25% secondary attack rate). We considered a similar assumption for influenza.

Figure S7.3.2g. Quanta emission distributions for SARS-CoV-2 (left) and influenza virus (right).



S7.3.2.6 Transmission risk for a primary infector and subsequent secondary infectors

Transmission risk can be interpreted as the risk of an individual becoming infected given exposure to the airborne virus. On average, this is equivalent to risk of a population becoming infected given exposure. Reproductive ratio is the total number of people infected, on average, by a single infectious person. A reproductive ratio above one indicates a growing epidemic, a reproductive ratio at one means an epidemic that will continue until enough people get infected or immunized and natural immunity increases, and a reproductive ratio below one indicates a declining epidemic.

S7.3.2.6a Estimates of SARS-CoV-2 risk and outbreak predictions

Estimates of risk and reproductive ratio for influenza are plotted alongside those for SARS-CoV-2 in **Figure S7.3.2h**. In the absence of masking and vaccination, risk can reach 20% for a 90th percentile SARS-CoV-2 shedder in a space with 2 ACH. Even at 6 ACH, which is an achievable baseline for ventilation and filtration combined, risk is about 3-8% depending on the shedding strength across the 270 and CMF spaces. This level of risk is associated with transmission to between 4 and 9 individuals during a few days of exposure. Masking and vaccination are unlikely to be used in the early stages of an outbreak. Under such conditions, within a

couple of weeks, the entire inmate and staff population could be infected unless effective rapid testing and isolation could be quickly implemented. Increasing clean air delivery via filtration and/or outdoor air from 2 ACH to 6 ACH could cut reproductive ratio by roughly half, however only the scenarios with GUV, providing 22 or 26 eACH would maintain reproductive ratios below approximately 1-2, even in the event of exposure to a SARS-CoV-2 variant supershedder. The addition of GUV reduces risk to below 5% in almost all cases. Overall, risk is similar between the 270 and CMF sites, although slightly higher for CMF. Even though the exposure period in the CMF is much greater than that of the 270 (due to open air connection between all dorm pods), the higher volume of air to occupant ratio helps reduce infectious aerosol exposure there.

The risk of transmission is higher for the SARS-CoV-2 than influenza, especially for the cases, where masks are not worn, or when no one is immunized, and where 2 or 6 ACH is delivered. This is expected given higher infectious dose generation rates for SARS-CoV-2 compared with influenza. An influenza case in the 270 that is shedding virus at the median level (50th percentile) is unlikely to transmit to more than one individual, given that 3-6 feet distancing and provision of at least 2 ACH clean air delivery with good mixing. However, when a primary influenza case is a supershedder defined as someone shedding virus at the 90th percentile, then the reproductive ratio can reach 6 in the absence of masking and vaccination, unless GUV is used.

Transmission of SARS-CoV-2 (or a pathogen with similar infectious dose generation rate) to 5 others within the 270 or CMF dorm space might realistically, under the scenario of a typical case in the absence of GUV controls, and to many more should the case be more contagious than average (Figure S7.3.2h). If this were to happen and all 5 of those secondary cases were typical shedders (i.e., shedding at the median level of infectiousness), then we could expect over 40 subsequent cases in the absence of masks, vaccination, and GUV, and between 2 and 5 given all controls except GUV (Figure S7.3.2i). If an initial case were to transmit to 10 instead of 5, then we could expect up to 60-70 subsequent cases (Figure S7.3.2j).

Only the combination of GUV, clean air delivery from ventilation and/or filtration, masking, and vaccination at 90% would keep the reproductive ratio below 2-3. Additional air cleaning (from enhanced GUV effectiveness and air filtration/ventilation) could reduce this further, and potentially achieve a reproductive ratio below one. The consistent use of respirators (i.e., N95 filtering facepieces) could also mitigate risk and should be considered as part of an infection control plan.

Figure S7.3.2h. Transmission risk and reproductive ratio in 270 and CMF. Red dashed line indicates reproductive ratio of one.

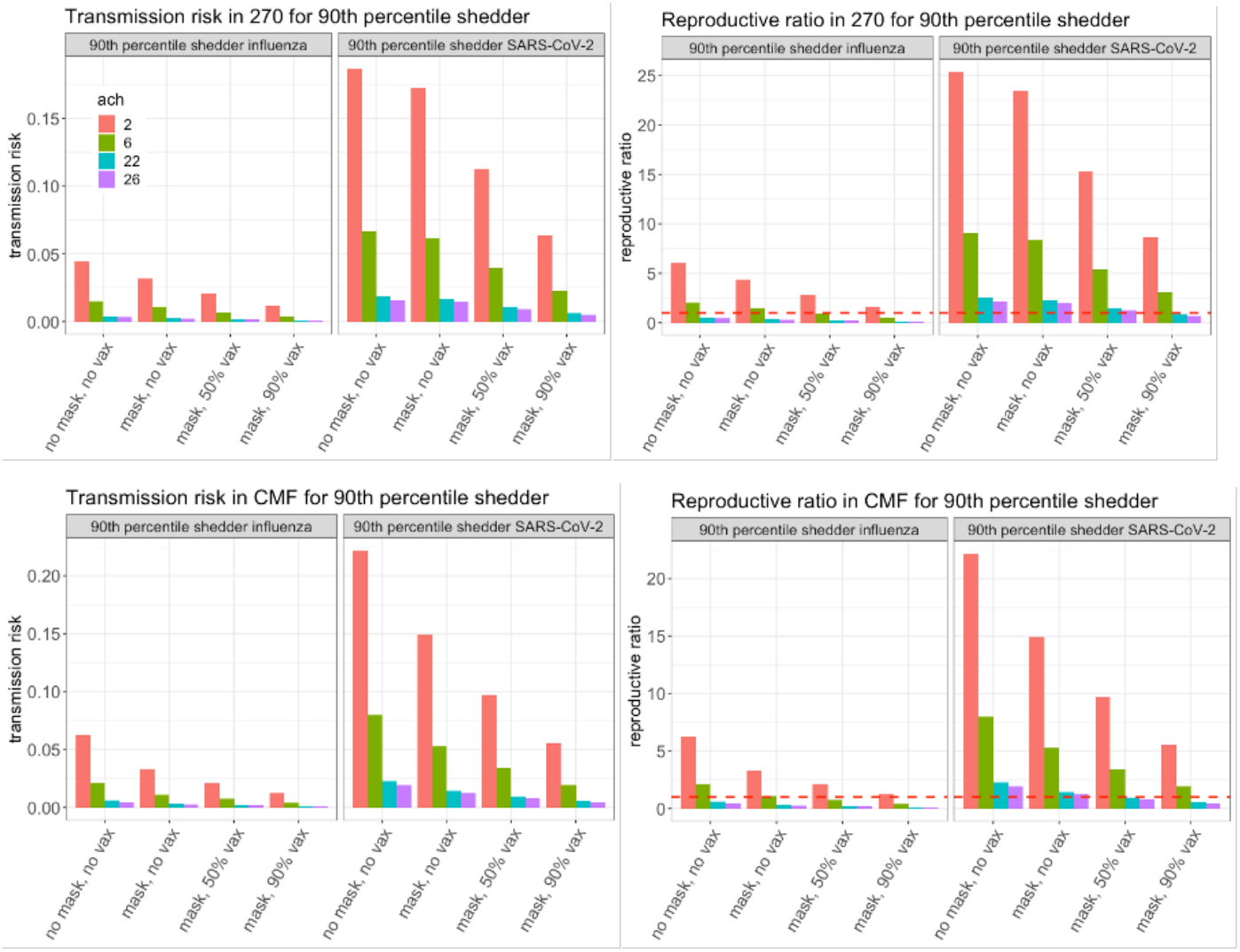


Figure S7.3.2i. Onward SARS-CoV-2 transmission in 270 and CMF given 5 people infected from initial infector. Red dashed line indicates reproductive ratio of one.

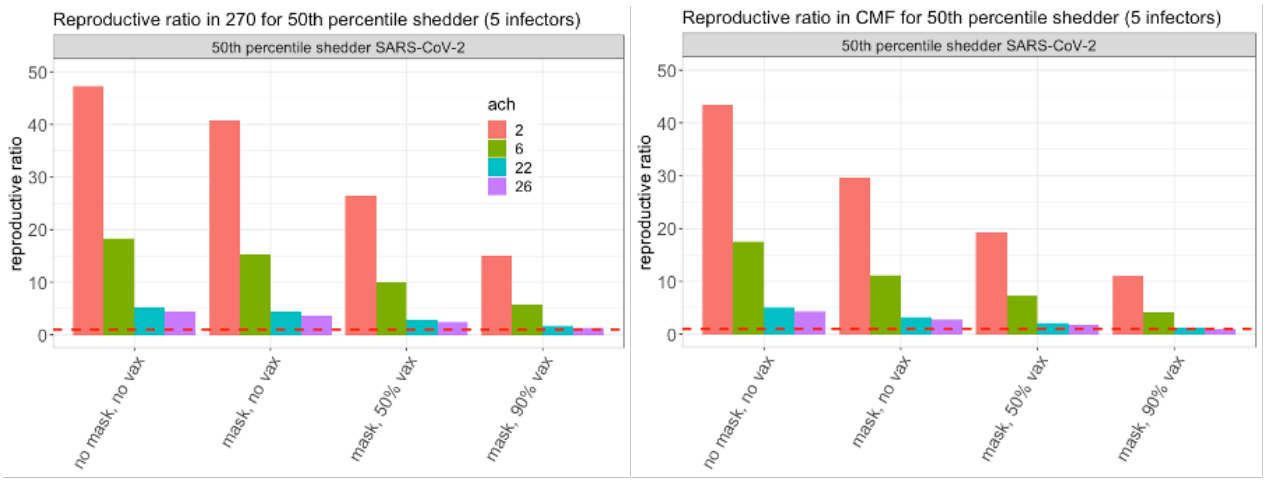
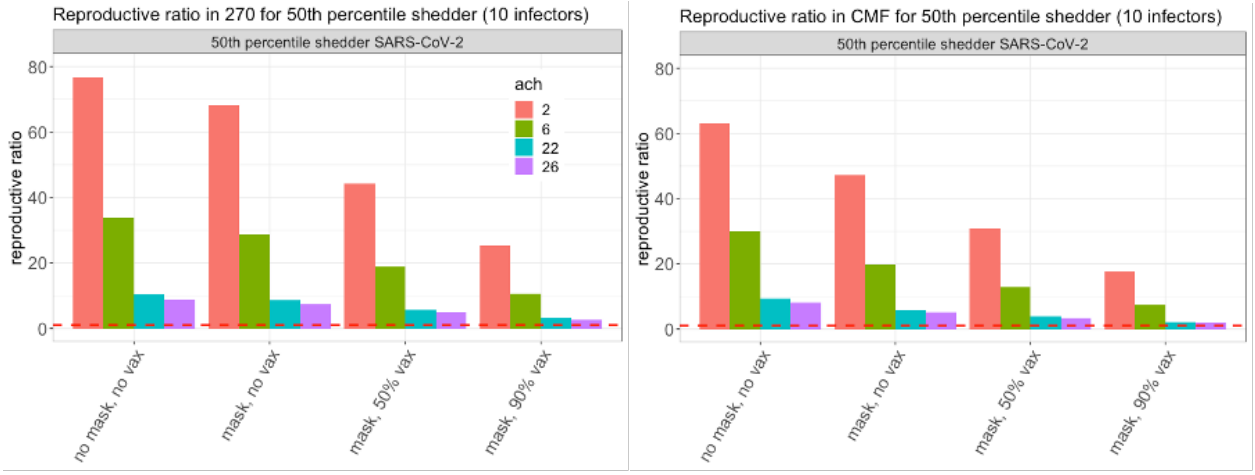


Figure S7.3.2j. Onward SARS-CoV-2 transmission in 270 and CMF given 10 people infected from initial infector. Red dashed line indicates reproductive ratio of one.



S7.3.2.7 Summary

S7.3.2.7a Key summary points

- The level of risk estimated by models for the 270 and CMF sites show that existing conditions are likely to lead to outbreaks given introductions of the virus to a single individual.
- Infection risks were estimated here based on existing epidemiologic and virologic data, mostly current through 2021. However newly emerging pathogens and variants could lead to even higher risk than that predicted here.
- Models underscore the importance of highly effective infection control, which can be achieved with GUV, to prevent the initial spread of the virus throughout the population. Once a primary case transmits to others (>1), the infection spread can quickly outpace control measures, however these control measures such as use of GUV would dramatically reduce potential outbreaks at their beginning thus providing the facility staff with time to quell an epidemic through testing, isolation, and quarantine measures.

S7.3.2.9 References

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Table S7.5.1 Quarantine and Isolation Person-Days in CDCR Institutions 3/1/2020 - 10/9/2021

Institution	Person-days Quarantine	Person-days Isolation	Person-days Total
ASP	101,048	51,356	2,114,203
CAC	136,176	16,236	1,217,544
CAL	126,379	17,803	1,736,962
CCC	139,803	22,689	1,615,130
CCI	156,791	31,344	1,847,141
CCWF	154,011	10,933	1,352,594
CEN	196,637	18,227	1,829,701
CHCF	426,687	19,556	1,487,440
CIM	208,304	20,838	1,452,819
CIW	107,865	14,688	693,394
CMC	116,676	38,588	1,915,257
CMF	131,613	13,446	1,245,292
COR	255,862	20,896	1,883,554
CRC	138,540	31,668	1,488,463
CTF	134,263	37,385	2,688,339
CVSP	79,497	41,084	1,248,839
DVI	111,540	7,693	663,629
FSP	79,736	18,275	1,465,782
HDSP	108,561	26,364	1,956,521
ISP	40,777	26,194	1,641,865
KVSP	41,464	14,484	2,098,327
LAC	153,501	32,939	1,685,652

MCSP	254,155	27,072	2,293,789
NKSP	238,436	20,306	1,704,187
PBSP	164,328	5,043	1,351,720
PVSP	92,399	27,763	1,675,826
RJD	53,587	18,647	2,096,377
SAC	152,481	5,600	1,320,765
SATF	137,099	40,978	2,778,508
SCC	153,276	23,897	1,972,601
SOL	130,584	18,333	2,006,964
SQ	63,594	70,923	1,727,966
SVSP	205,281	18,996	1,713,684
VSP	111,753	24,092	1,694,042
WSP	267,588	26,048	1,758,924

Figure S7.5.1. Average (median) and distribution for the number of days each resident spent in quarantine from March 1, 2020 and October 9, 2021 by institution.

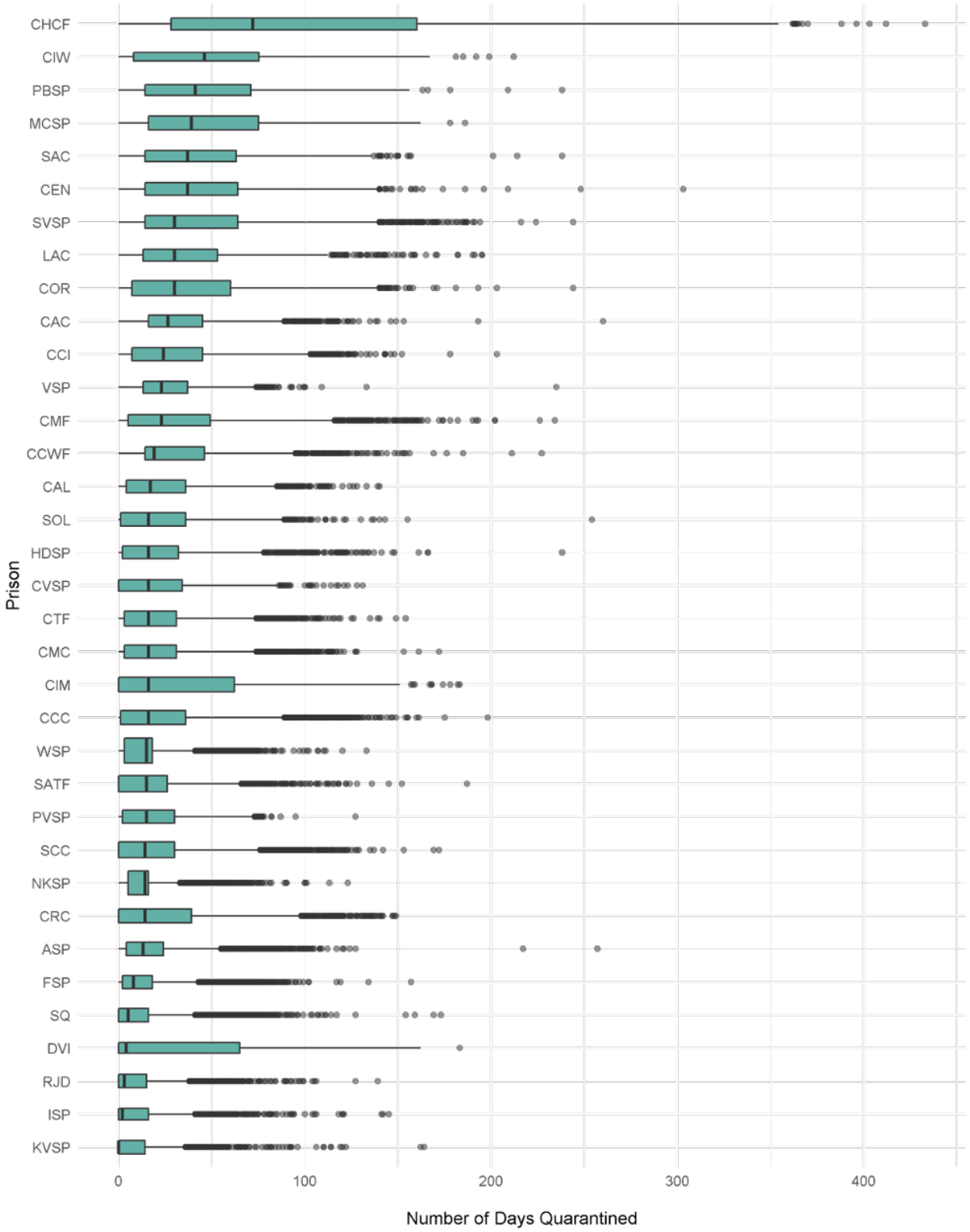


Figure S7.5.2. Number of days residents who were ever isolated spent in isolation from March 1, 2020, and October 9, 2021, by institution.

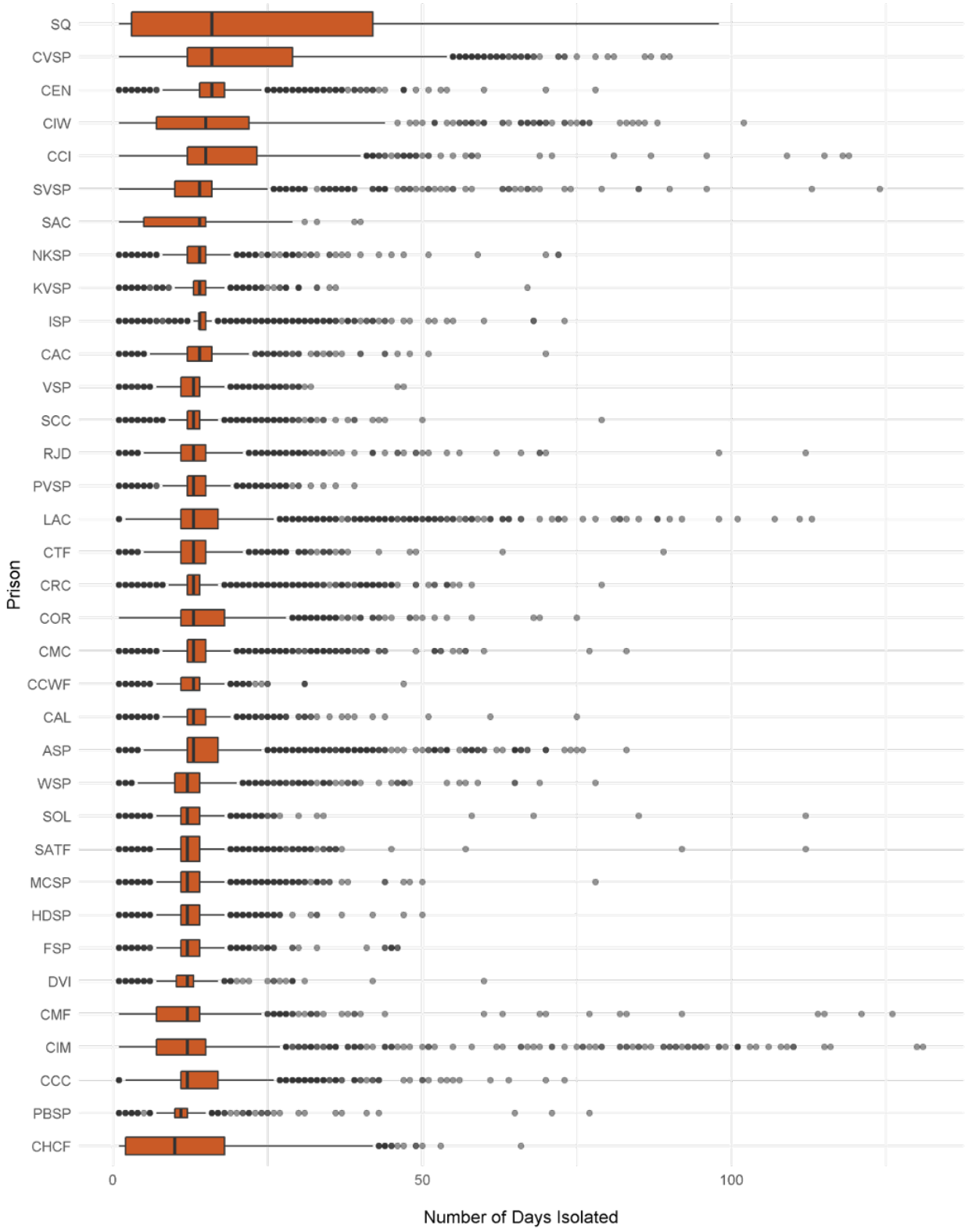


Figure S7.5.3.(A.1-A.35). Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population, for each institution in alphabetical order.

Figure A.1: **Results from ASP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

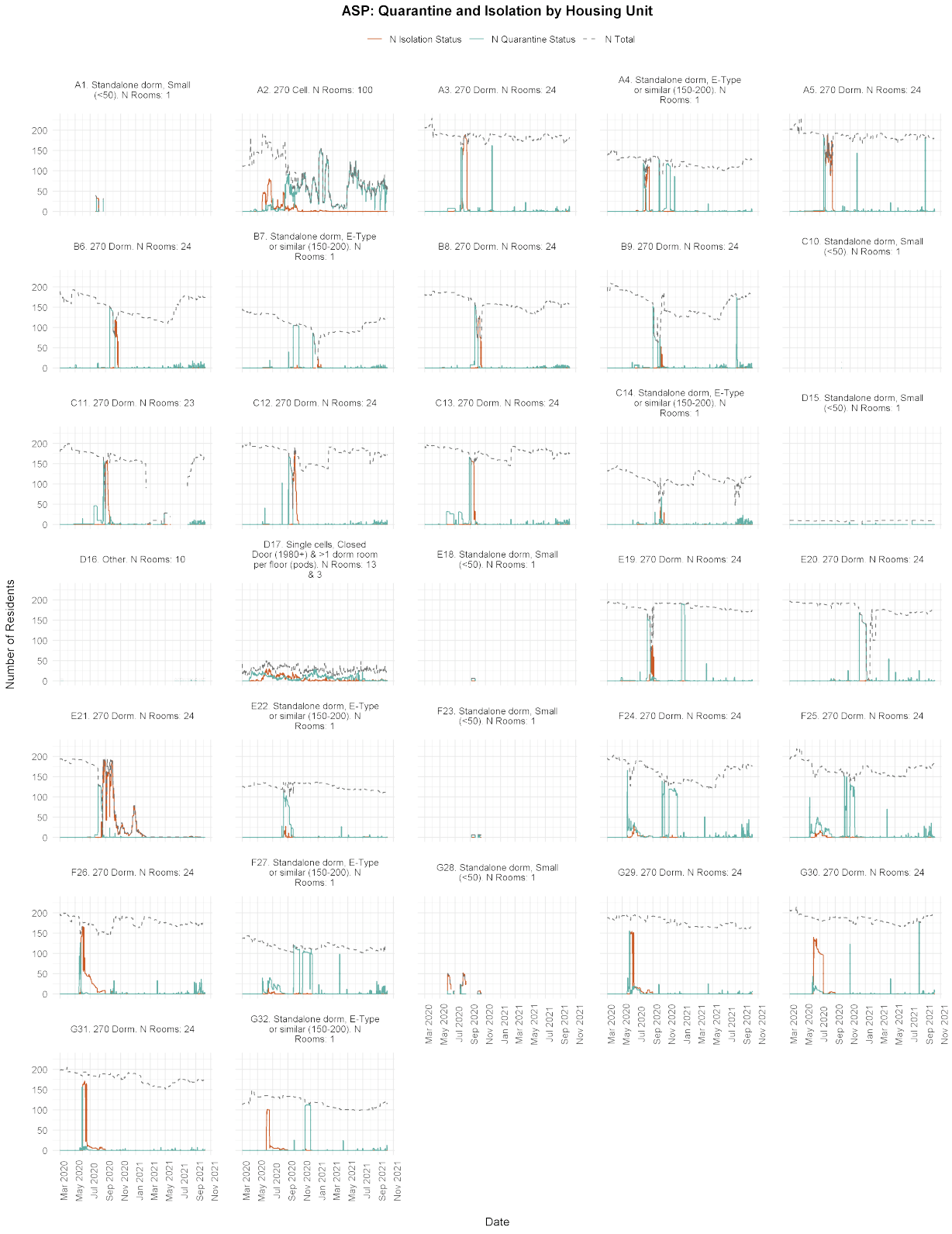


Figure A.2: **Results from CAC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.3: **Results from CAL.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

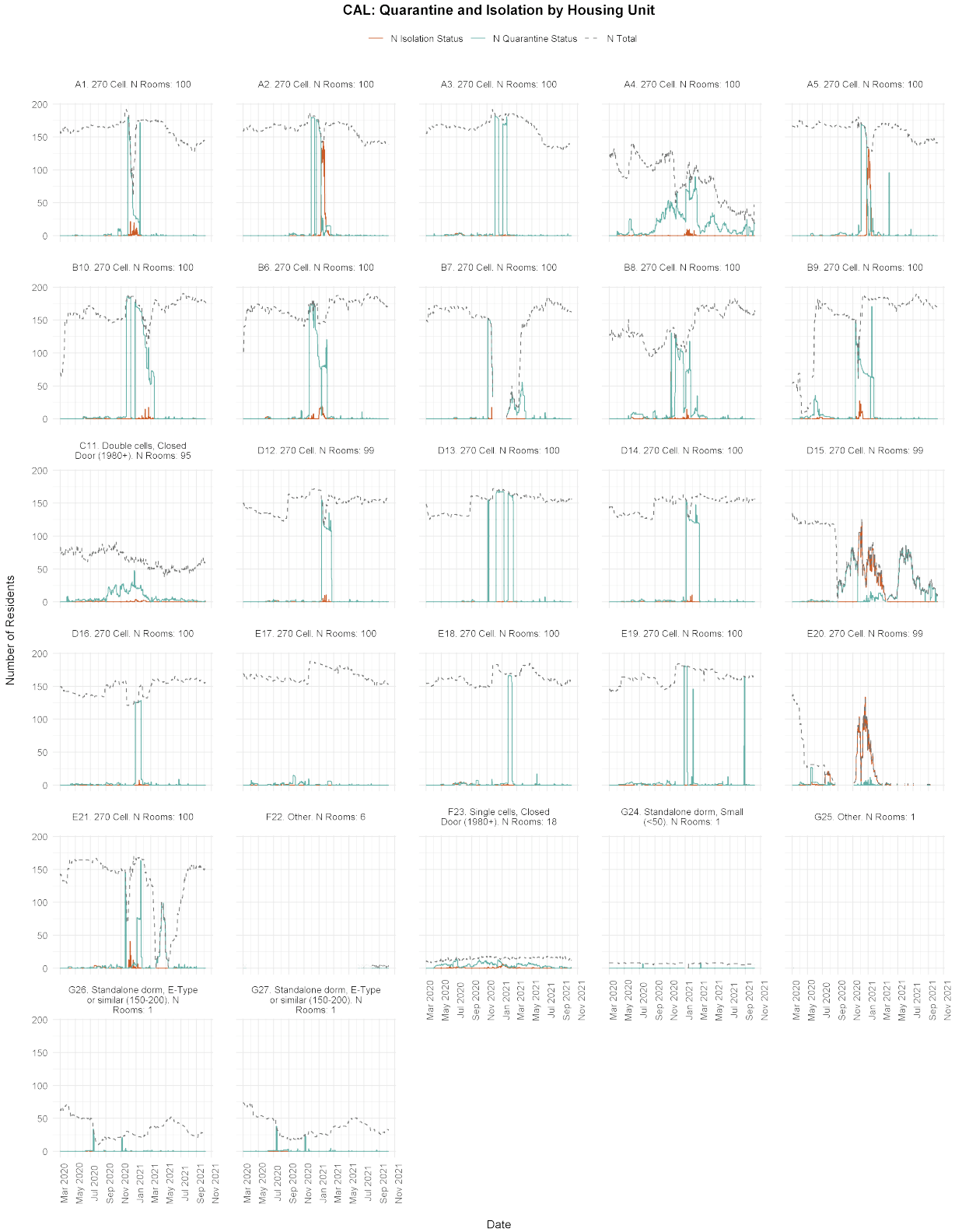


Figure A.4: **Results from CCC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.5: **Results from CCI.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.6: **Results from CCWF.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.7: **Results from CEN.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.8: **Results from CHCF.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

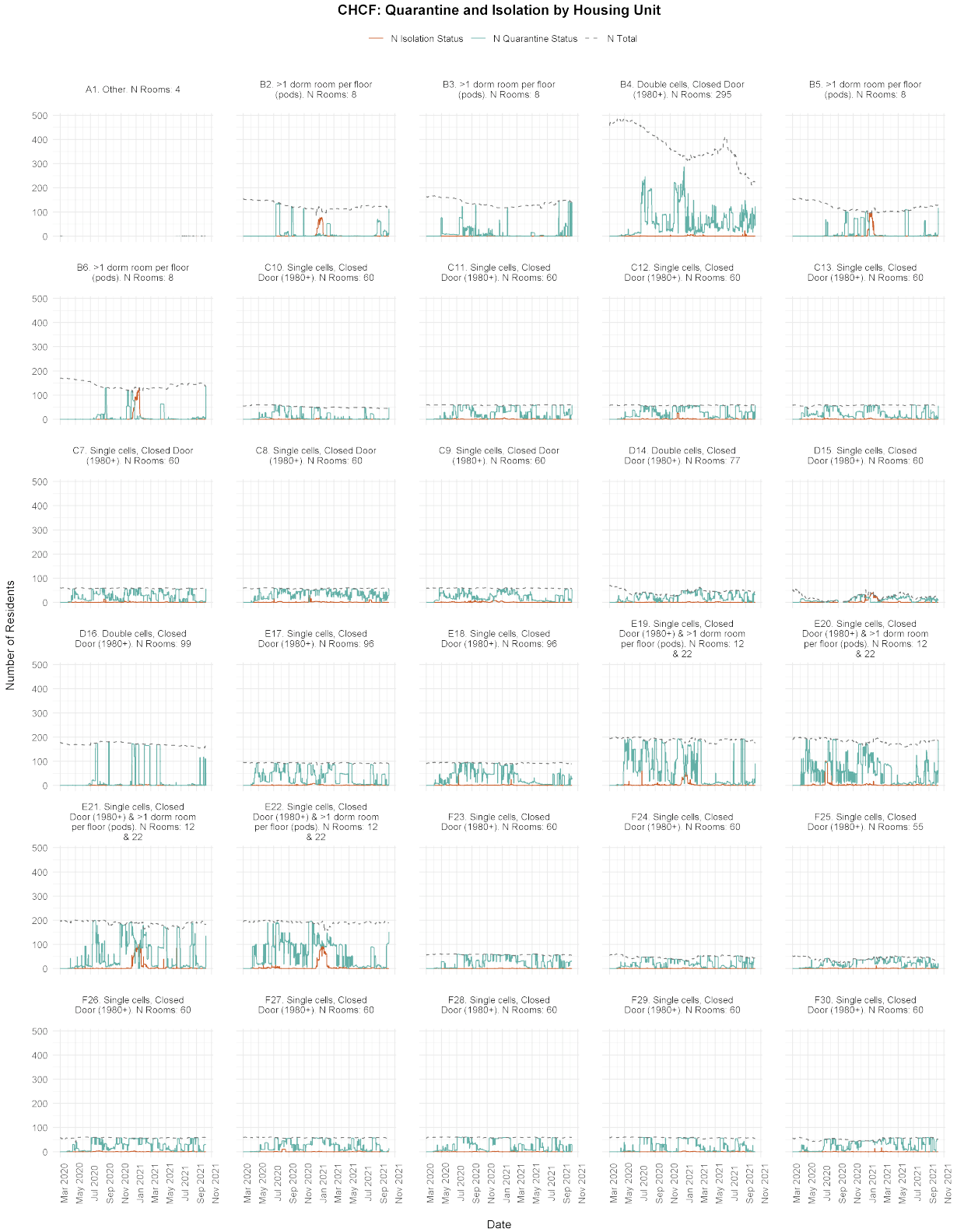


Figure A.9: **Results from CIM.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

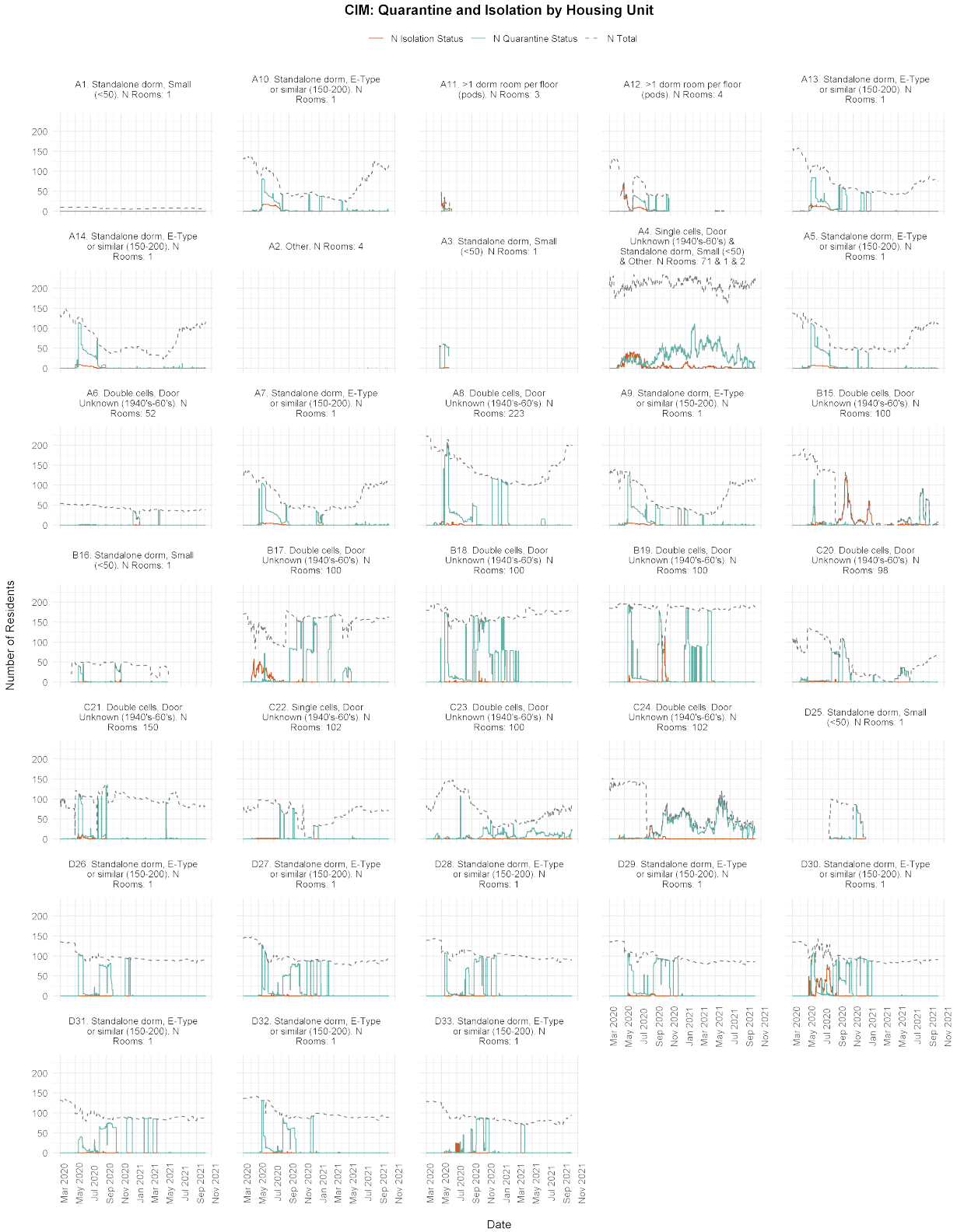


Figure A.10: **Results from CIW.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.11: **Results from CMC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

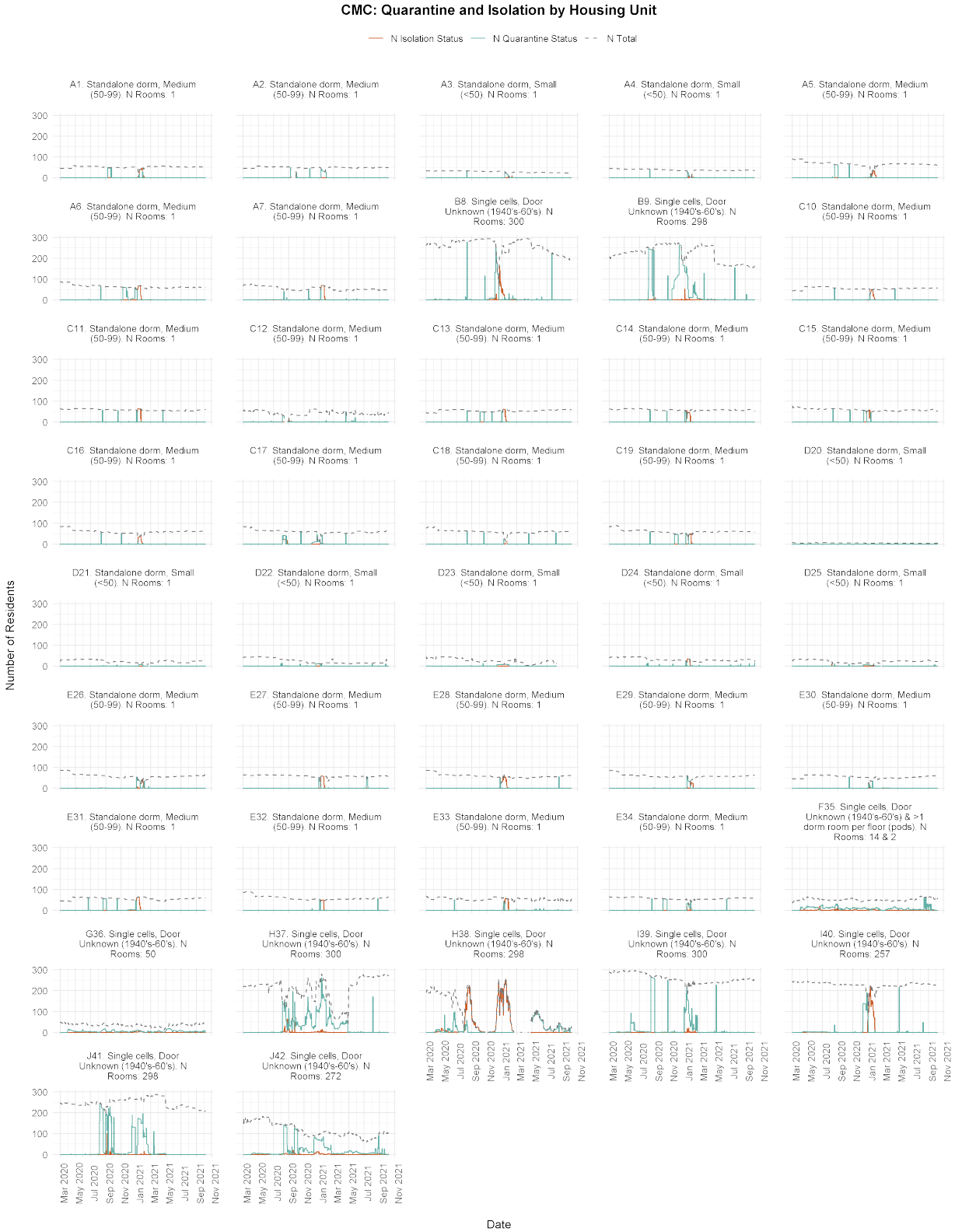


Figure A.12: **Results from CMF.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.13: **Results from COR.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.14: **Results from CRC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

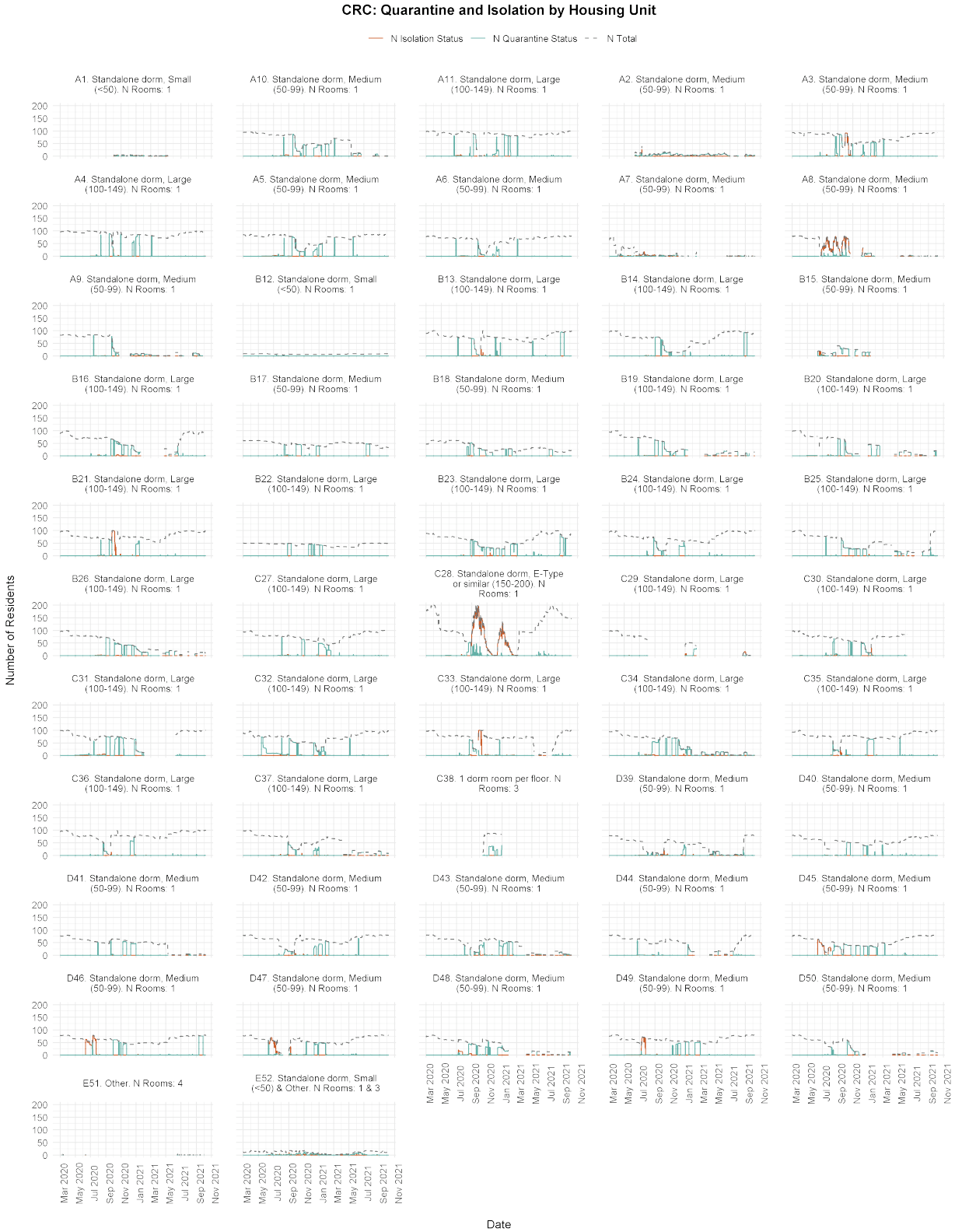


Figure A.15: **Results from CTF.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

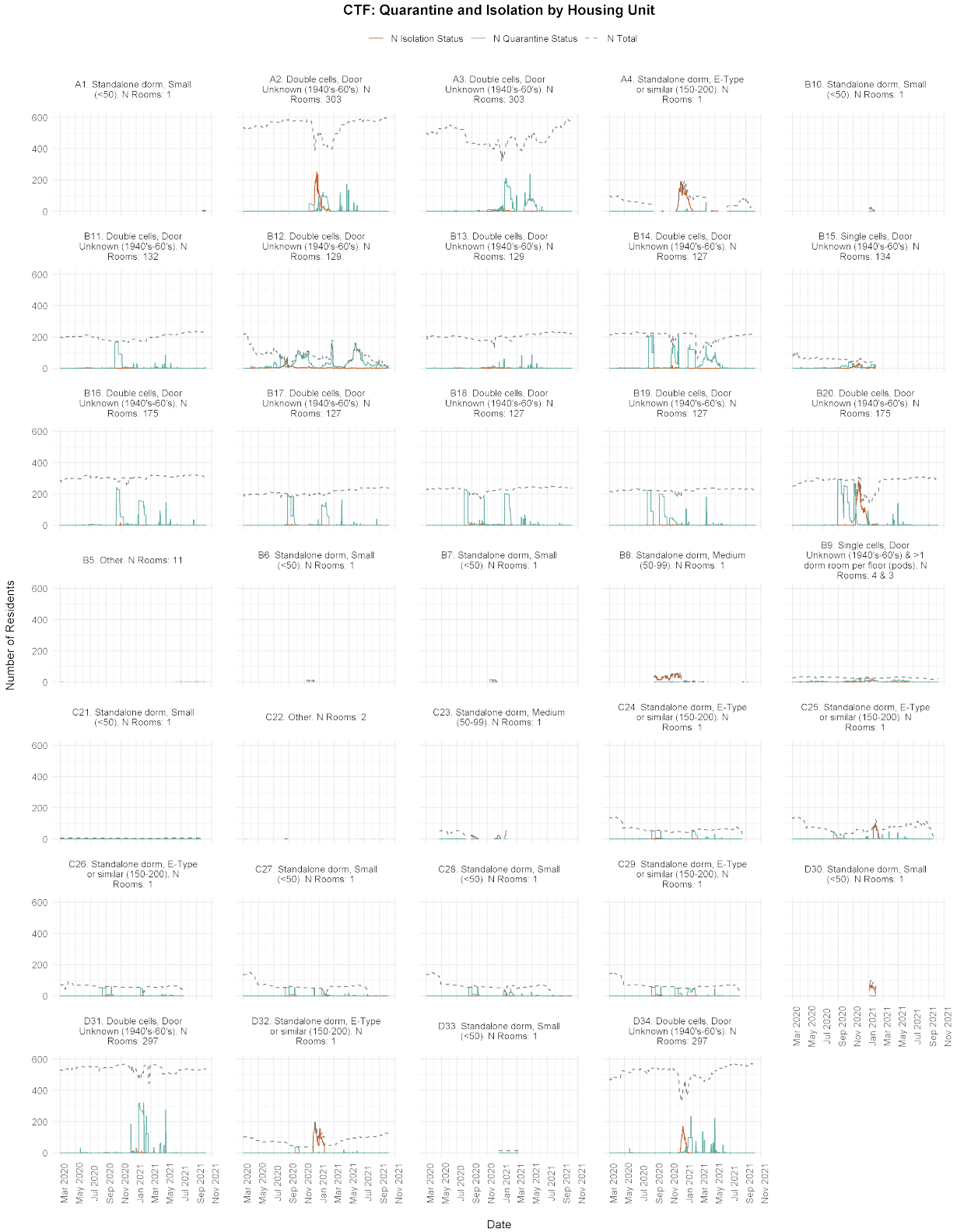


Figure A.16: **Results from CVSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

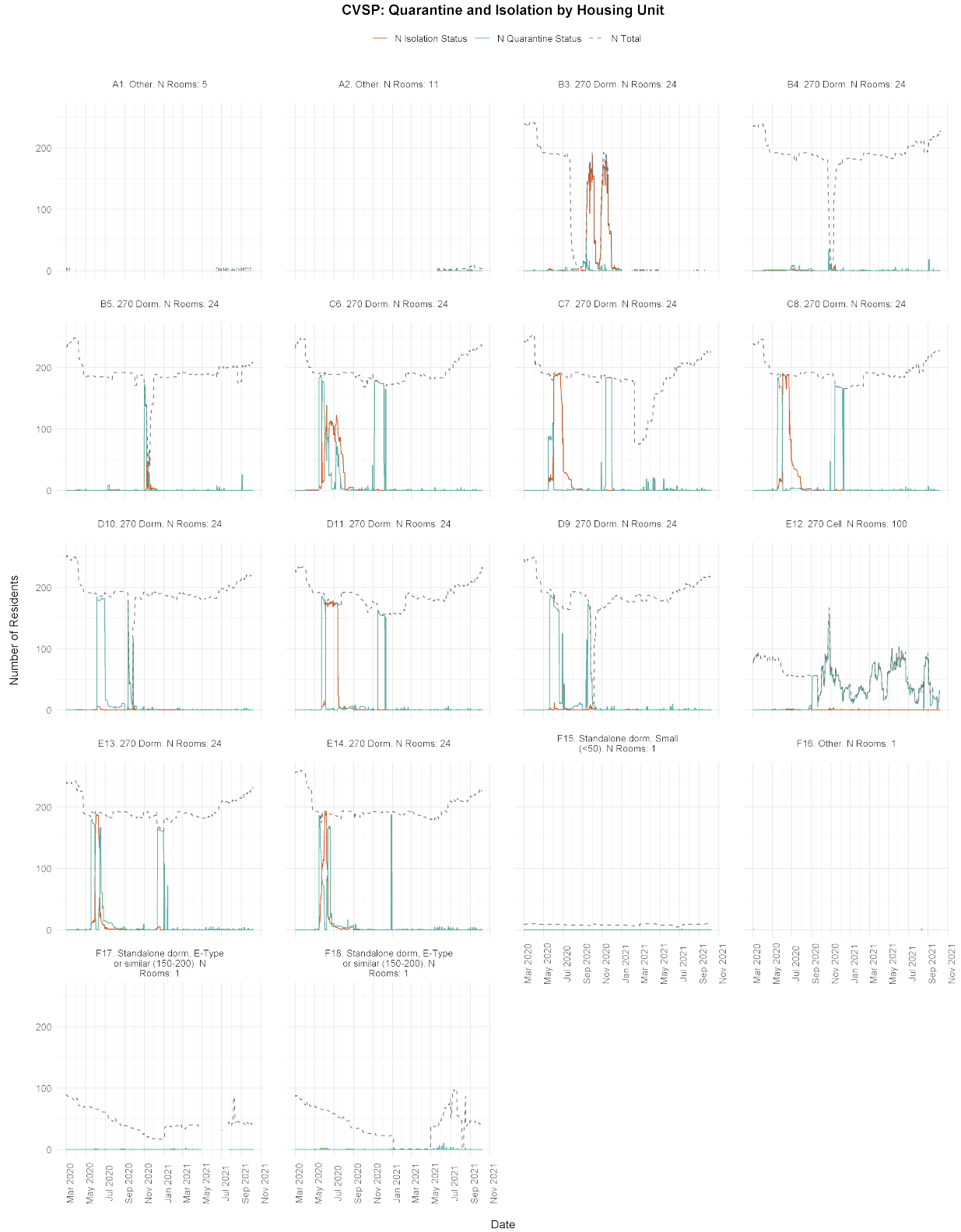


Figure A.17: **Results from DVI.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.18: **Results from FSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.19: **Results from HDSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.20: **Results from ISP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

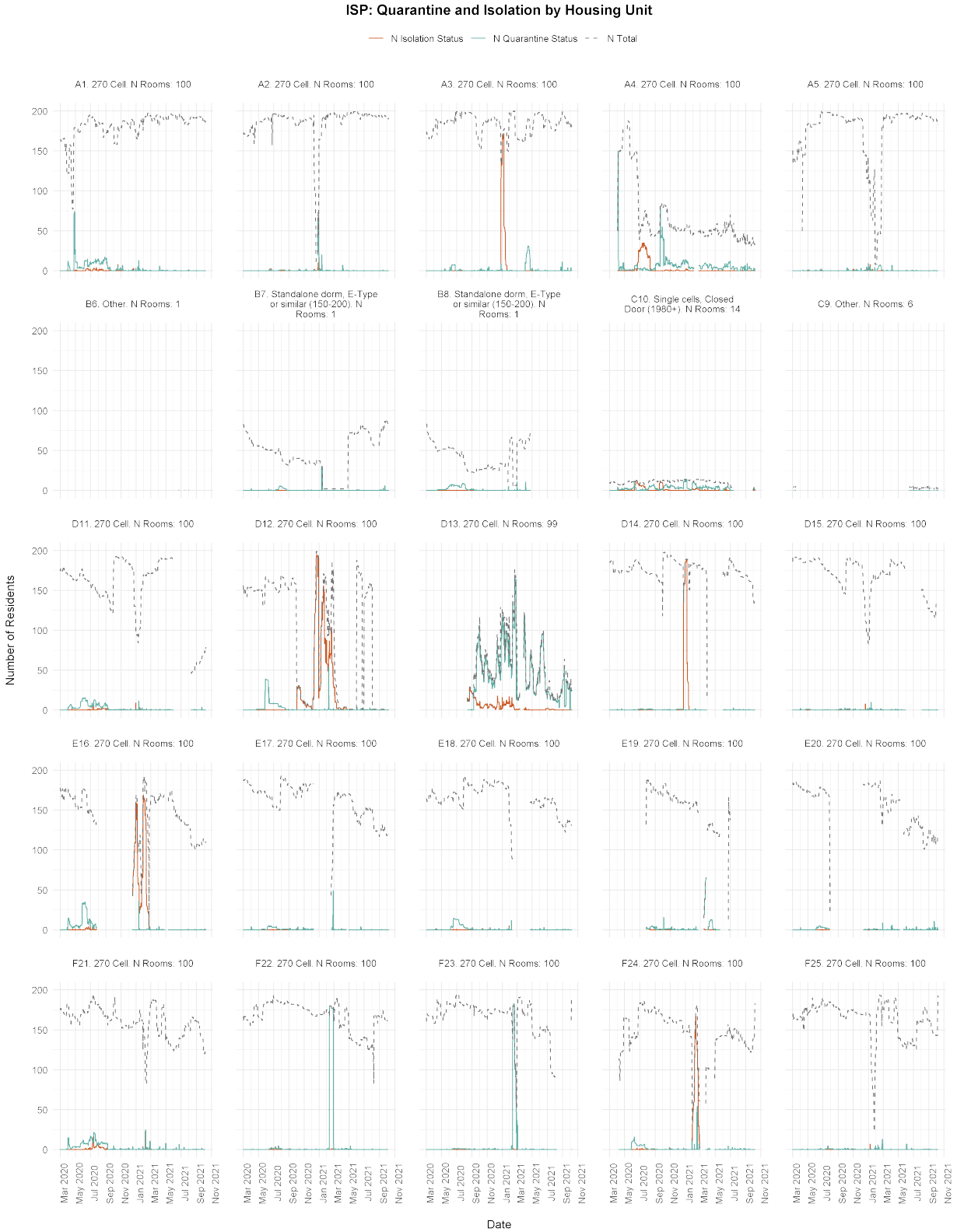


Figure A.21: **Results from KVSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

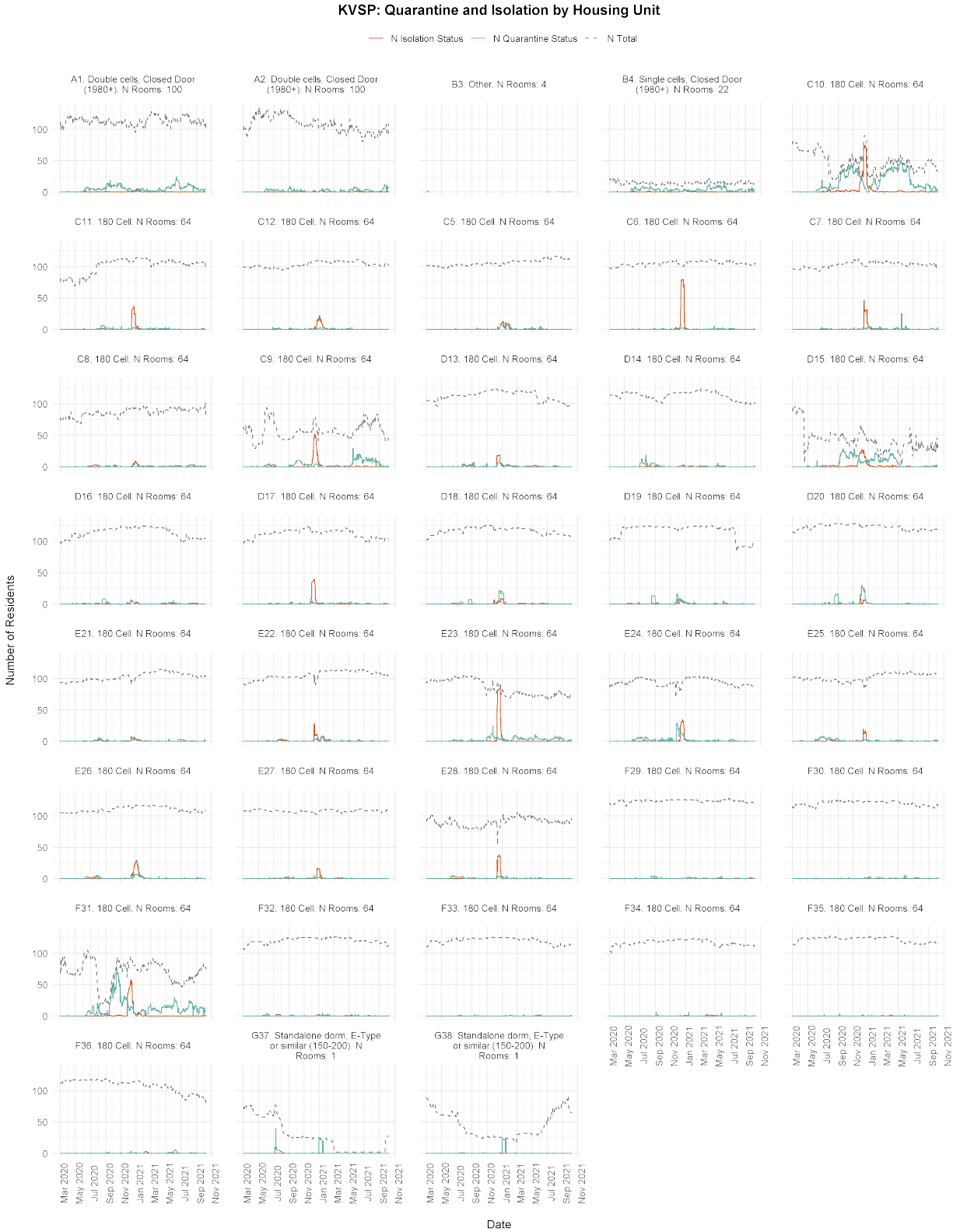


Figure A.22: **Results from LAC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.23: **Results from MCSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.24: **Results from NKSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

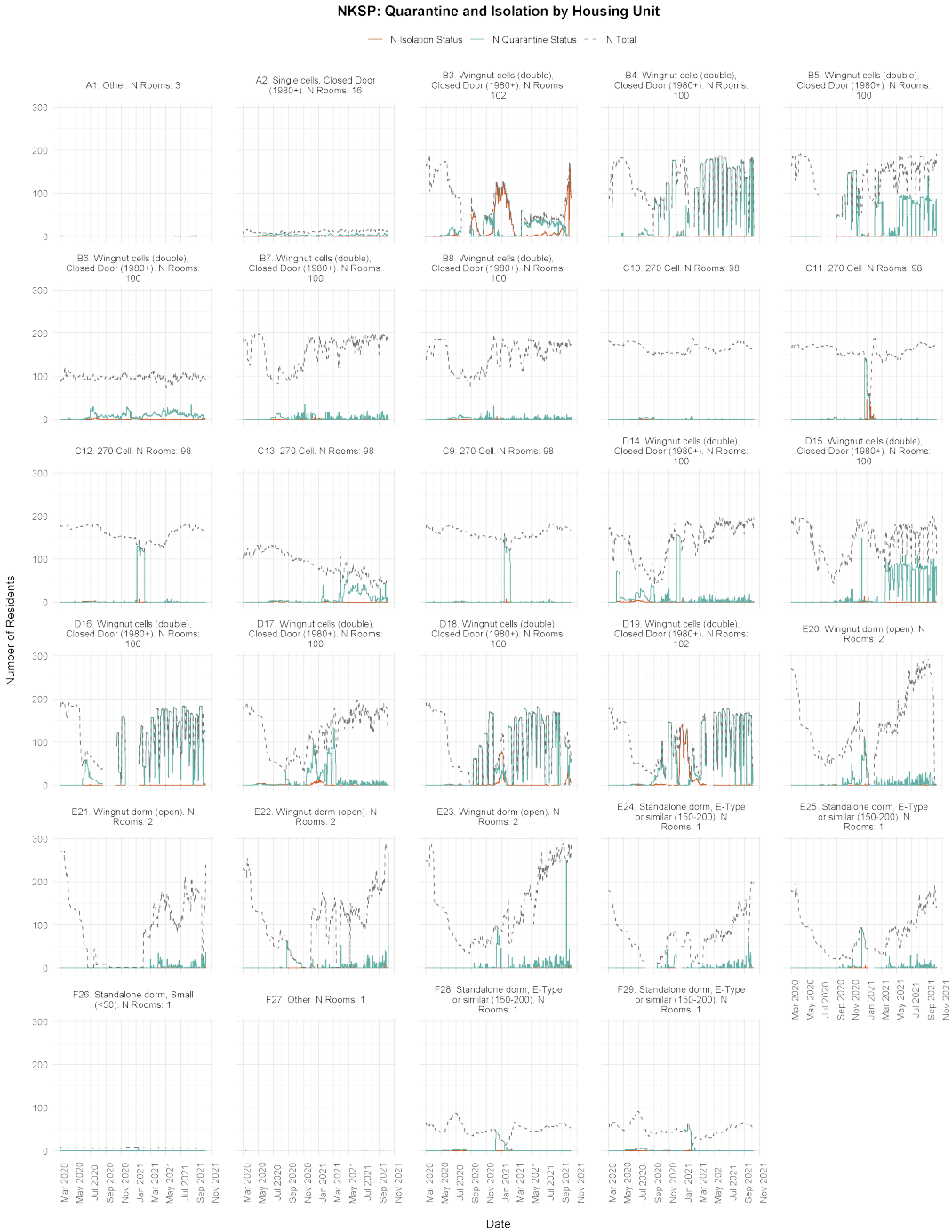


Figure A.25: **Results from PBSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

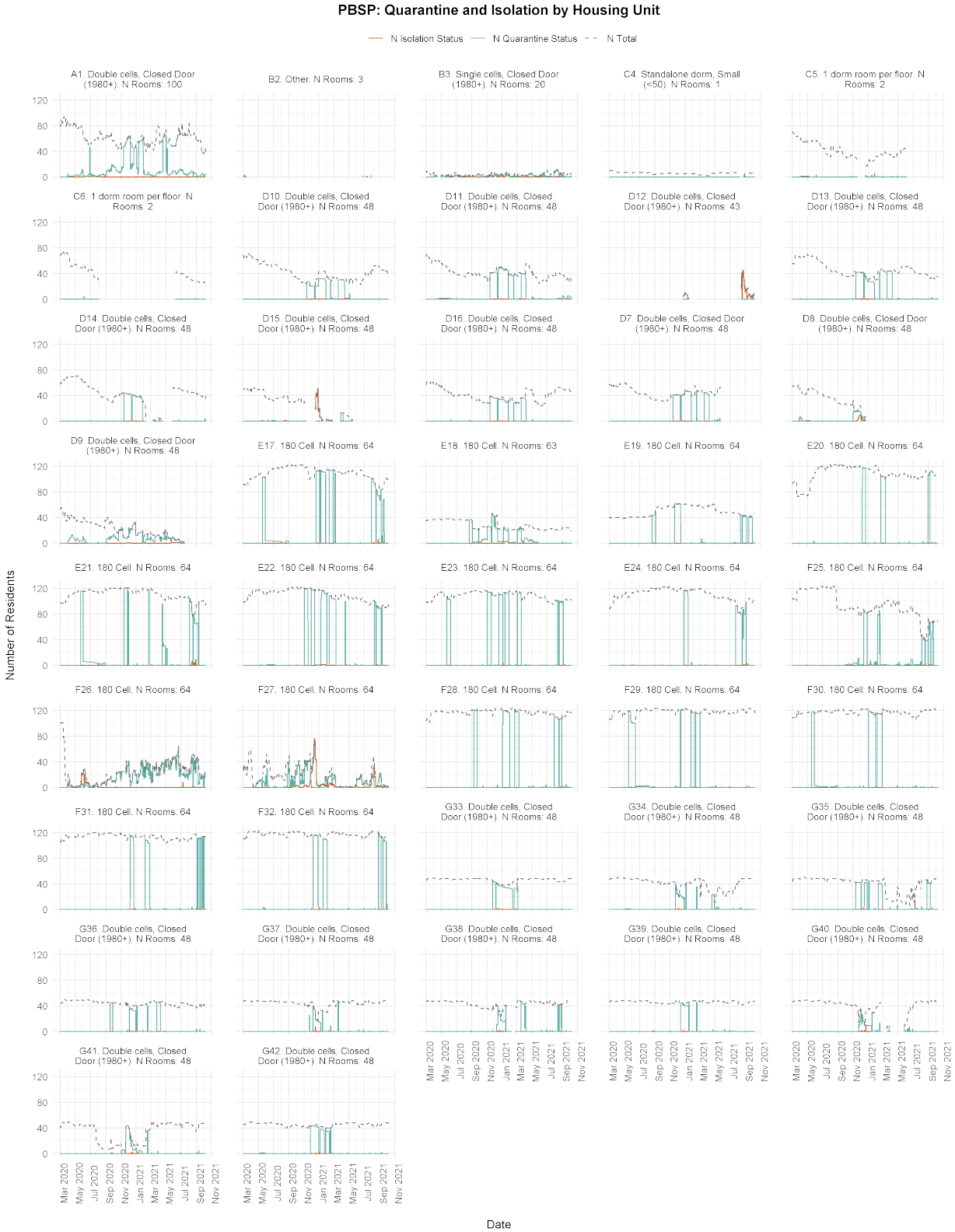


Figure A.26: **Results from PVSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.27: **Results from RJD.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.28: **Results from SAC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.29: **Results from SATF.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.30: **Results from SCC.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

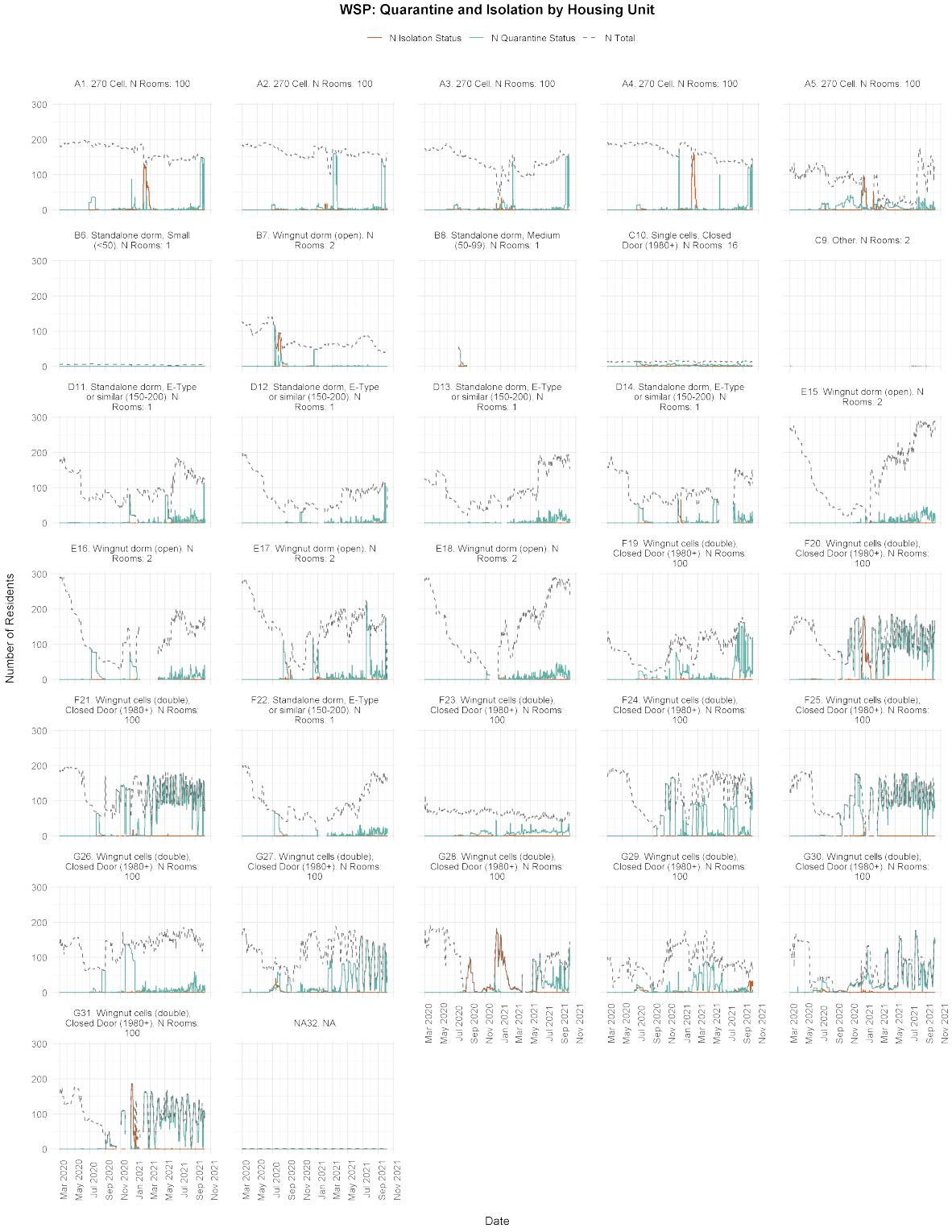
Figure A.31: **Results from SOL.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.32: **Results from SQ.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.33: **Results from SVSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.34: **Results from VSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.

Figure A.35: **Results from WSP.** Number of residents with quarantine status and isolation status by housing unit, compared to total housing unit population.



Section 9 Supplement

- **Supplemental Text S9.1.** Amend FAQ on Providing Acute Care for Seriously Ill Incarcerated Patients, July 8, 2020 update. Accessible here: https://amend.us/wp-content/uploads/2020/07/Caring-for-Seriously-Ill-CDCR-Patients-7.8-LBR.pdf.z

- **Supplemental Text S 9.2.** Amend Resources: Advance Care Planning in Prison or Jail: Resources for Correctional Clinicians and Patients during COVID-19. Accessible here: https://amend.us/wp-content/uploads/2020/05/ACP-for-Correctional-HCW-5.5.2020-1.pdf

- **Supplemental Text S9.3.** Rorvig L, Williams B. Providing Ethical and Humane Care to Hospitalized, Incarcerated Patients With COVID-19. American Journal of Hospice and Palliative Medicine®. 2021 Jun;38(6):731-3. Accessible here: https://journals.sagepub.com/doi/full/10.1177/1049909121994313

- **Supplemental Text S9.4.** Amend Vaccine FAQ, November 21, 2021 updated version in English and Spanish

Section 10 Supplement

Supplement S10.1. Reproduction number and incidence estimates by institution

Estimates of daily true incidence and effective Rt by housing units in the individual institutions (in alphabetical order) are presented in **Figures A.1–A.35**, below.

Each figure includes four plots, summarizing the sequence of SARS-CoV-2 outbreaks at one CDCR institution. First, the overall number of cases detected each day was plotted. This provided a summary of the number, timing, size and duration of outbreaks, and of their rates of growth and decline during their progression. Vertical bars marked the start of each separate outbreak at the institution.

Second, the number of new cases each day was plotted for each housing unit in the institution. Two different estimates of this quantity were presented, as discussed above: (i) the number of cases detected per day was shown by vertical bars, and (ii) the estimated number of cases infected per day was shown by filled curves. The filled curves for cases infected per day were shown at double height relative to the cases detected, for visibility. Both plots were color coded to reflect the type of room occupied by individuals each day, for comparison. Housing units were ordered from bottom to top in order of the first date a case was detected.

Third, the estimated effective reproduction number (Rt) was plotted by day for each housing unit. Because values of Rt greater than one reflect ongoing spread of the disease, red color was used for values greater than one and blue for values less than one. Transparency was used to distinguish Rt values in locations where disease transmission was likely. Housing units were ordered in the same sequence as above.

Fourth, the collection of Rt values estimated over each week was combined into bins of width 0.1 and summarized in a bar plot. Bars were color coded by room type, with bar width indicating the estimated total daily infectiousness of individuals described by Rt values in each bin, in each type of room.

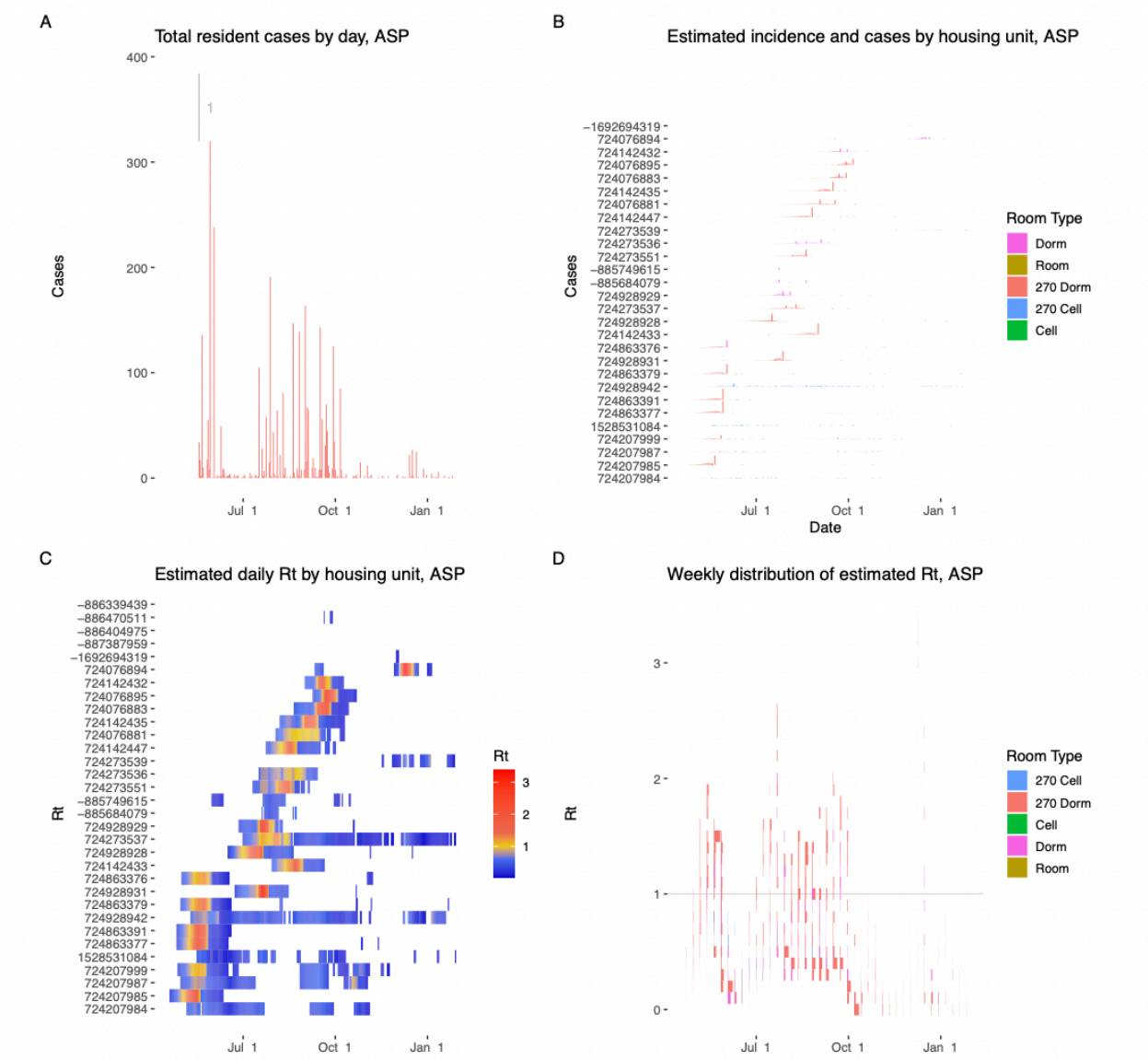


Figure A.1: **Results from ASP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

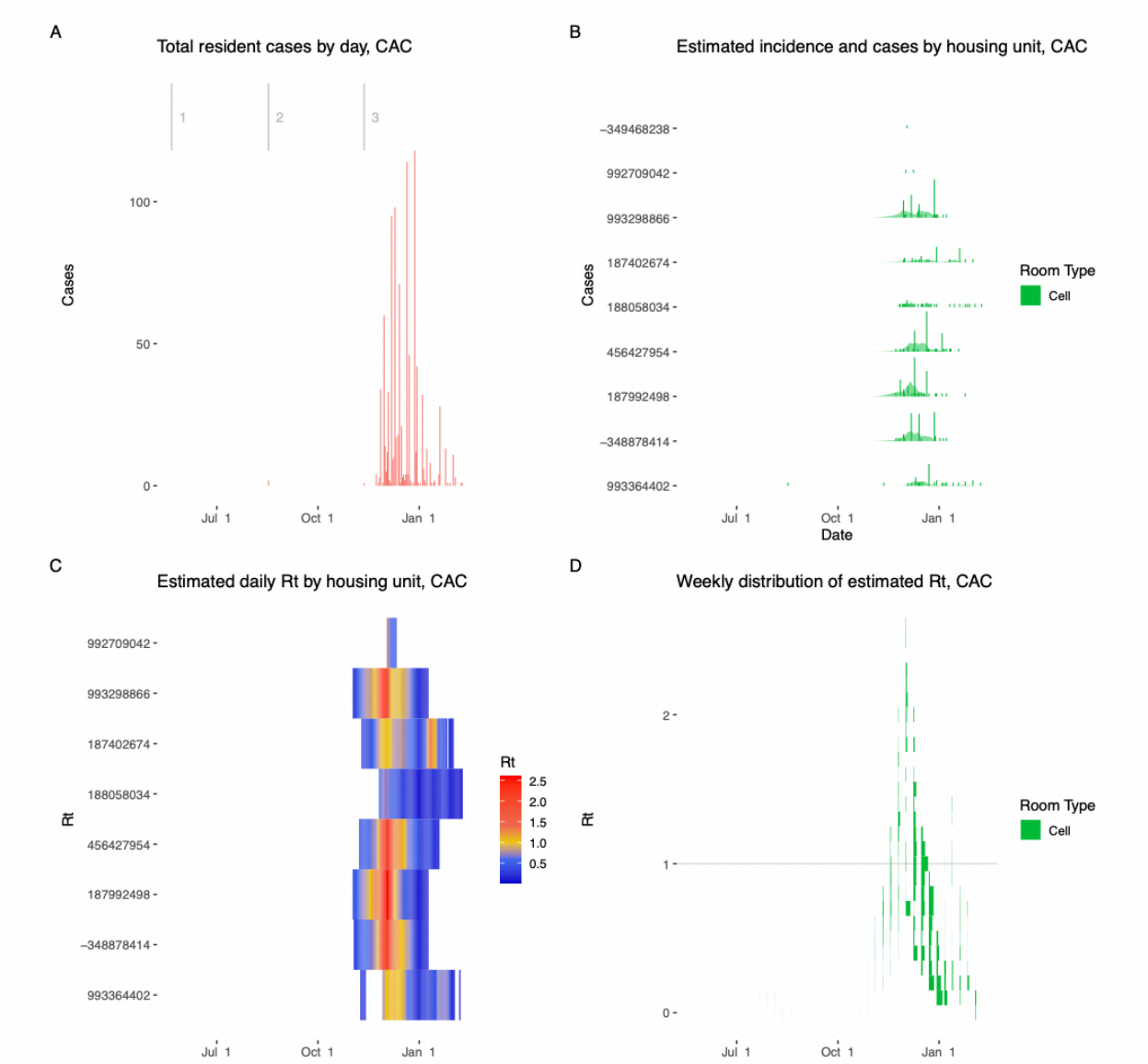


Figure A.2: **Results from CAC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

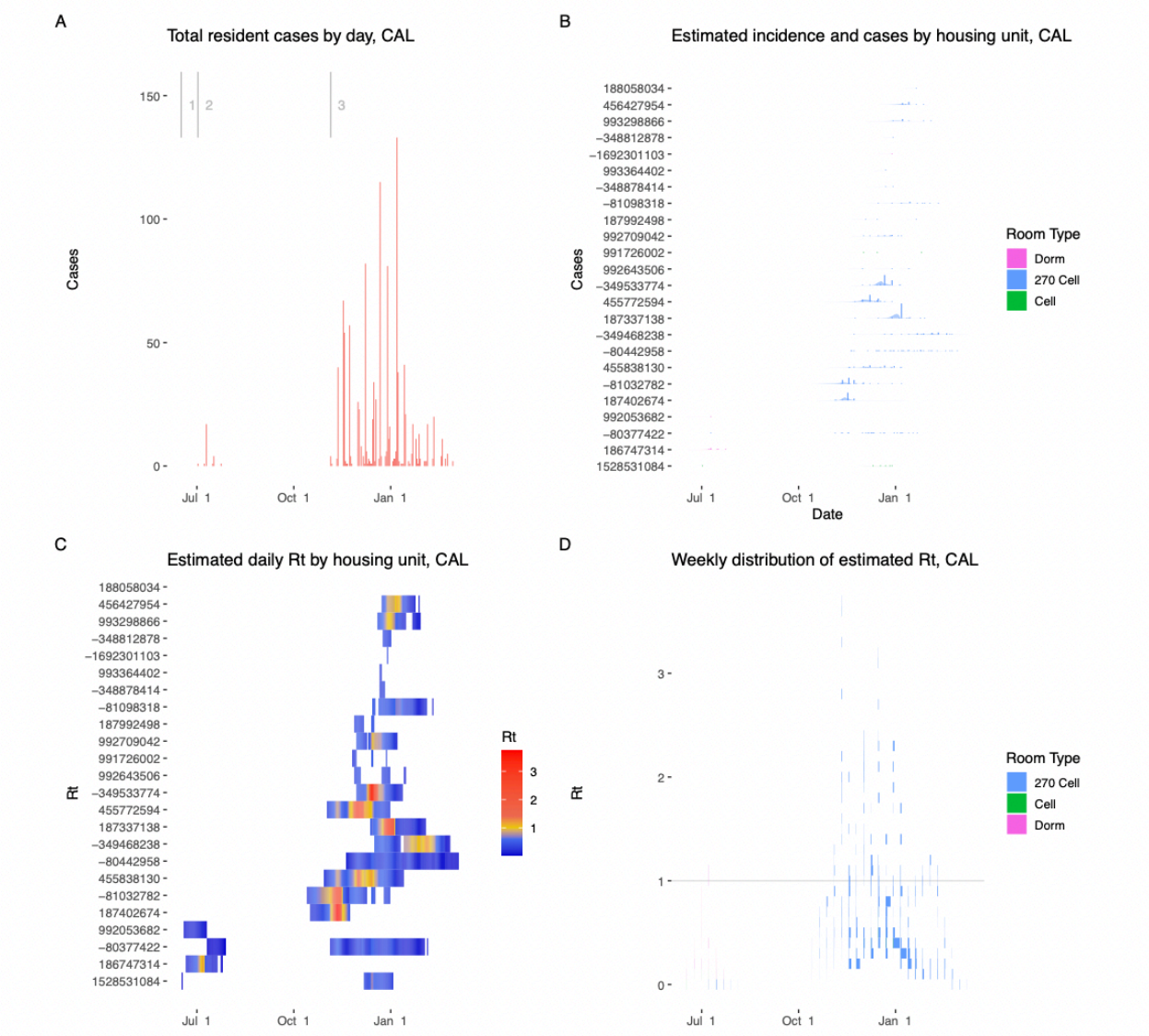


Figure A.3: **Results from CAL. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

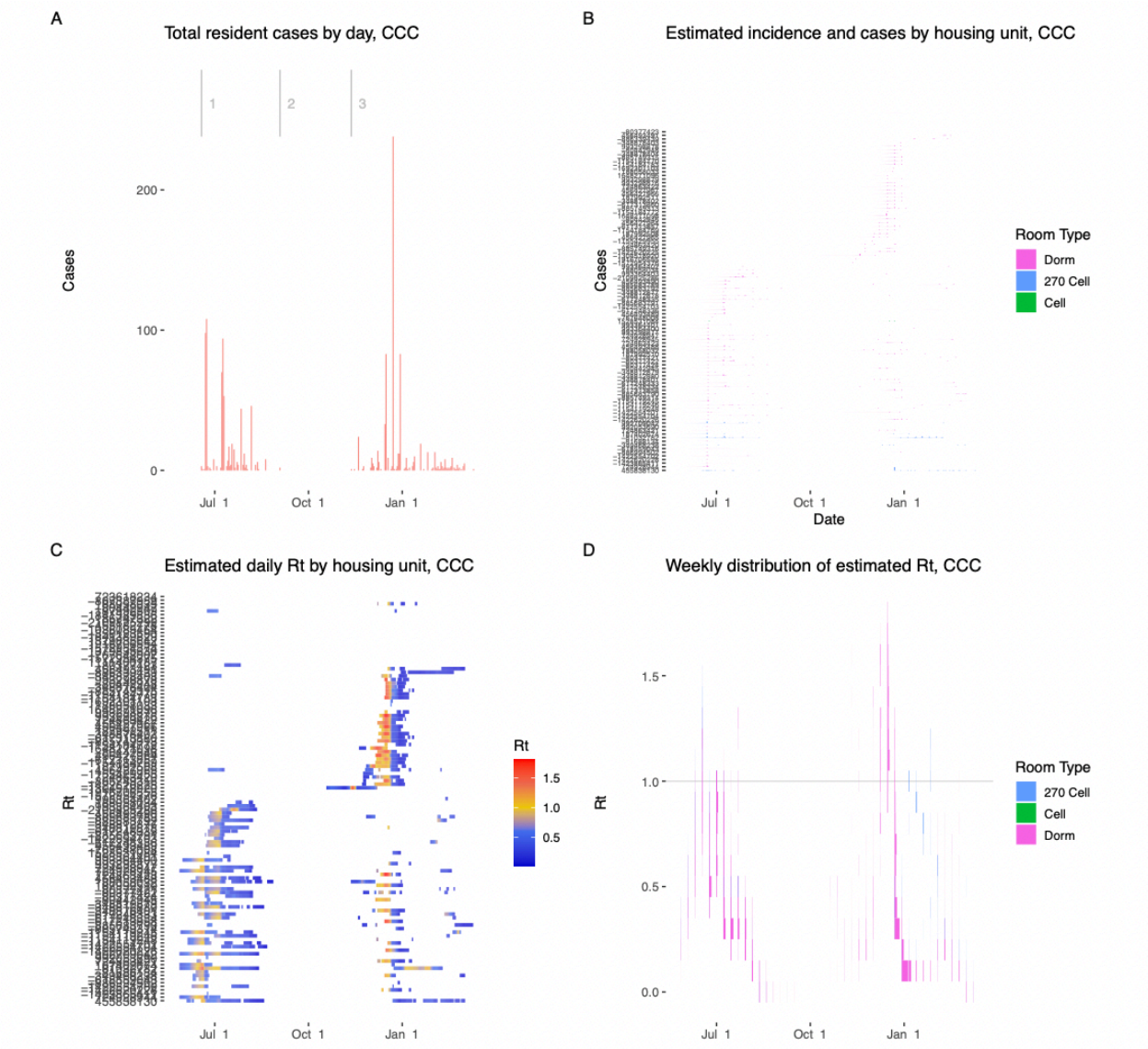


Figure A.4: **Results from CCC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

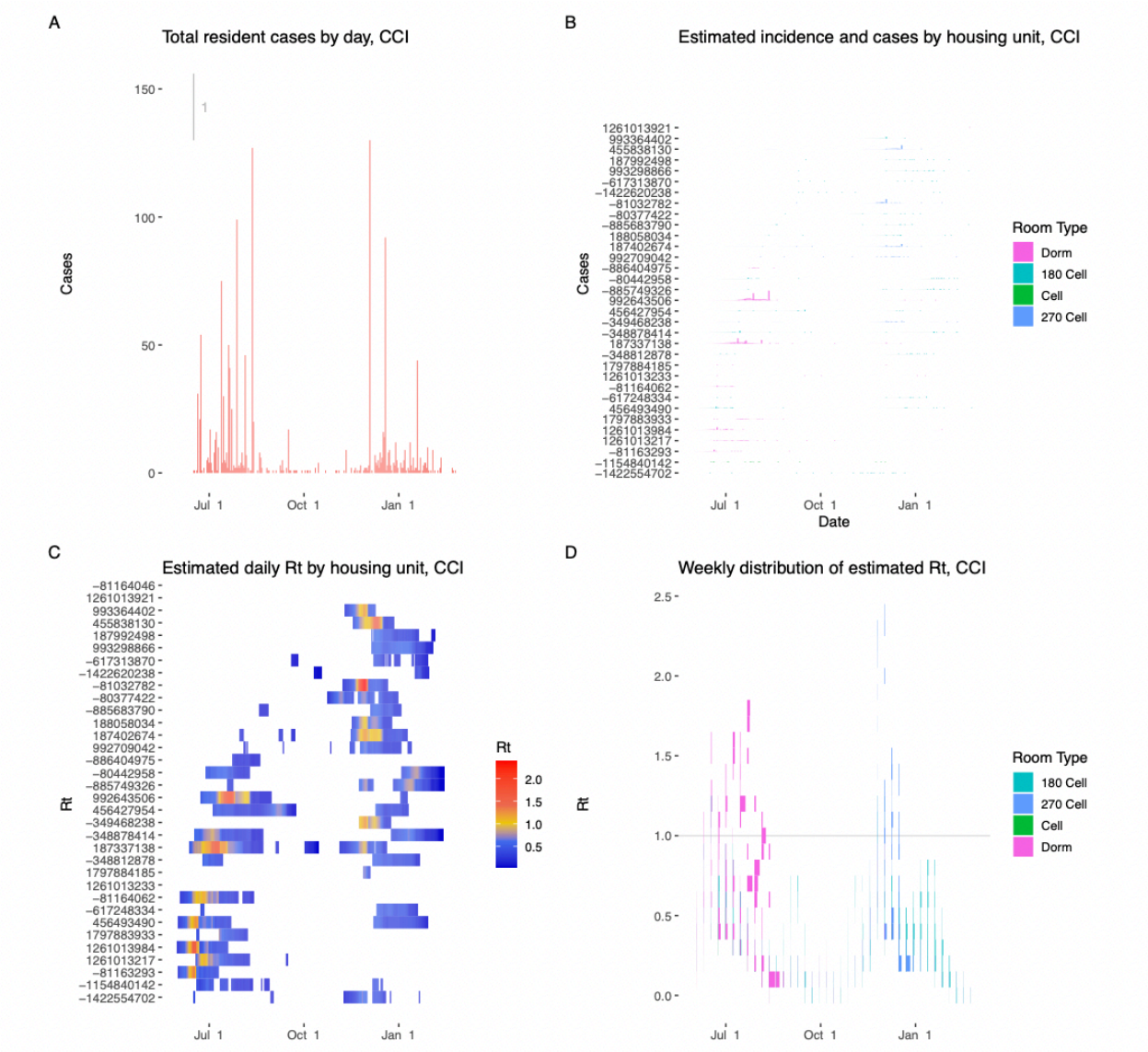


Figure A.5: **Results from CCI. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

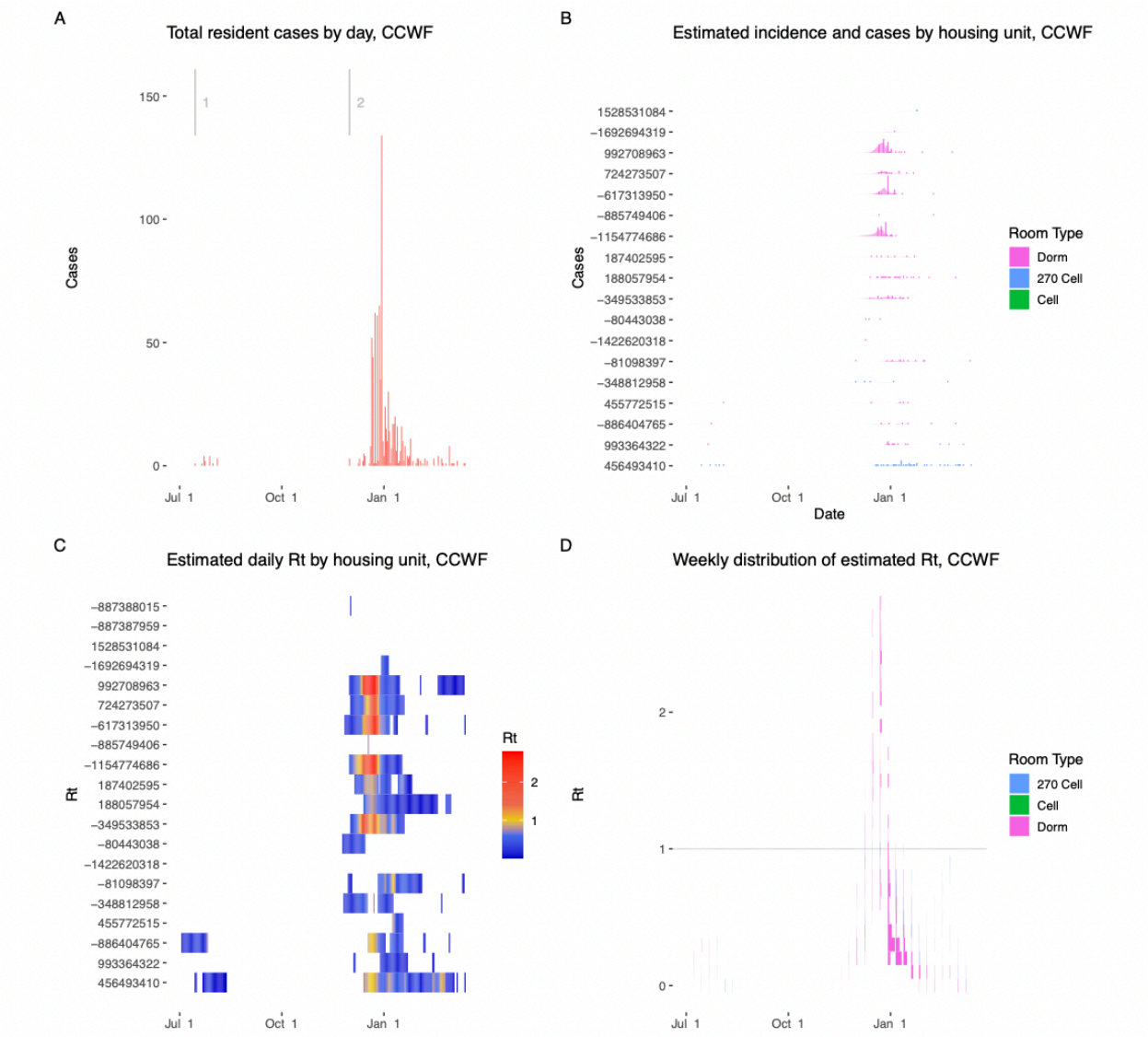


Figure A.6: **Results from CCWF. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

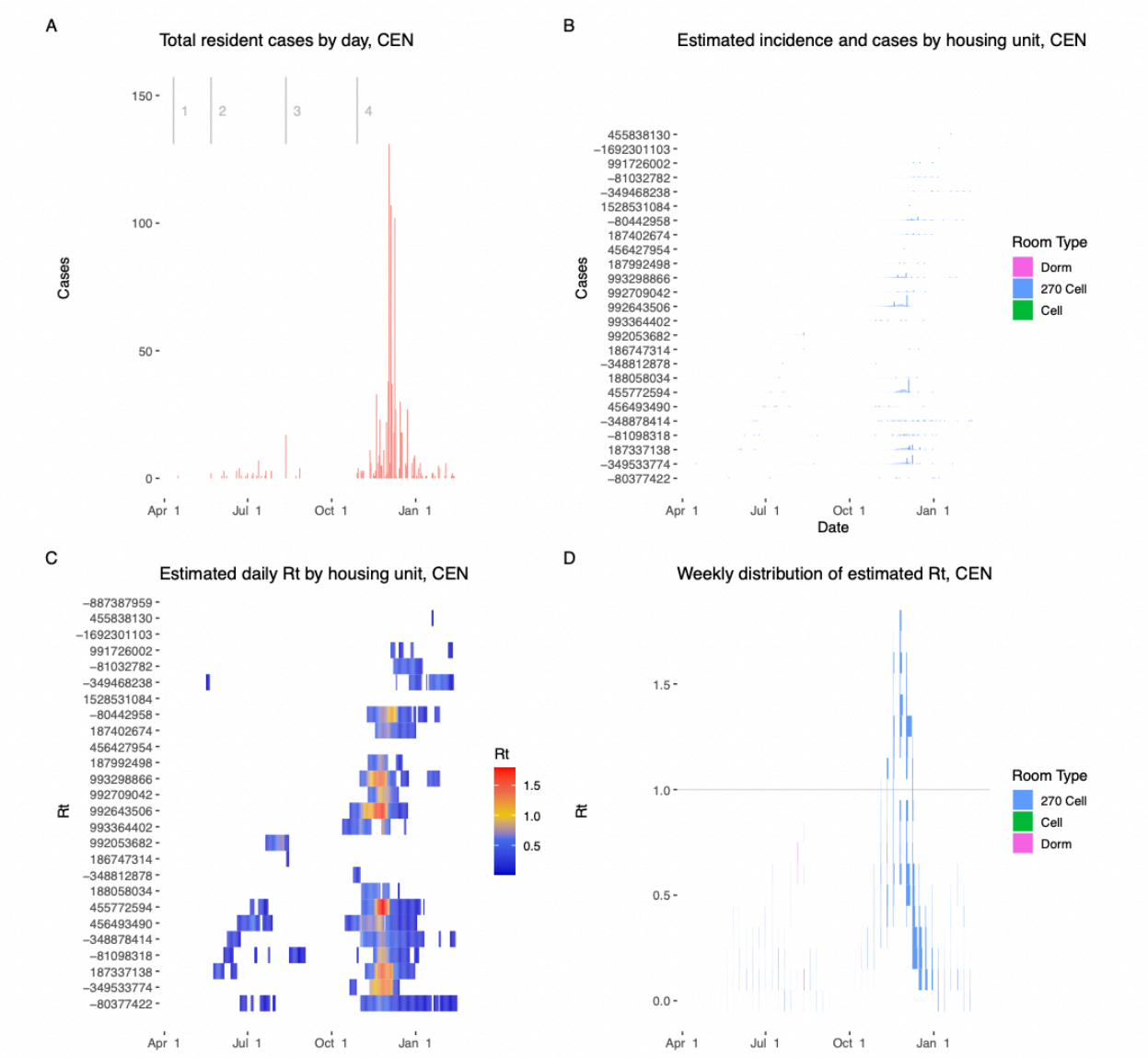


Figure A.7: **Results from CEN. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

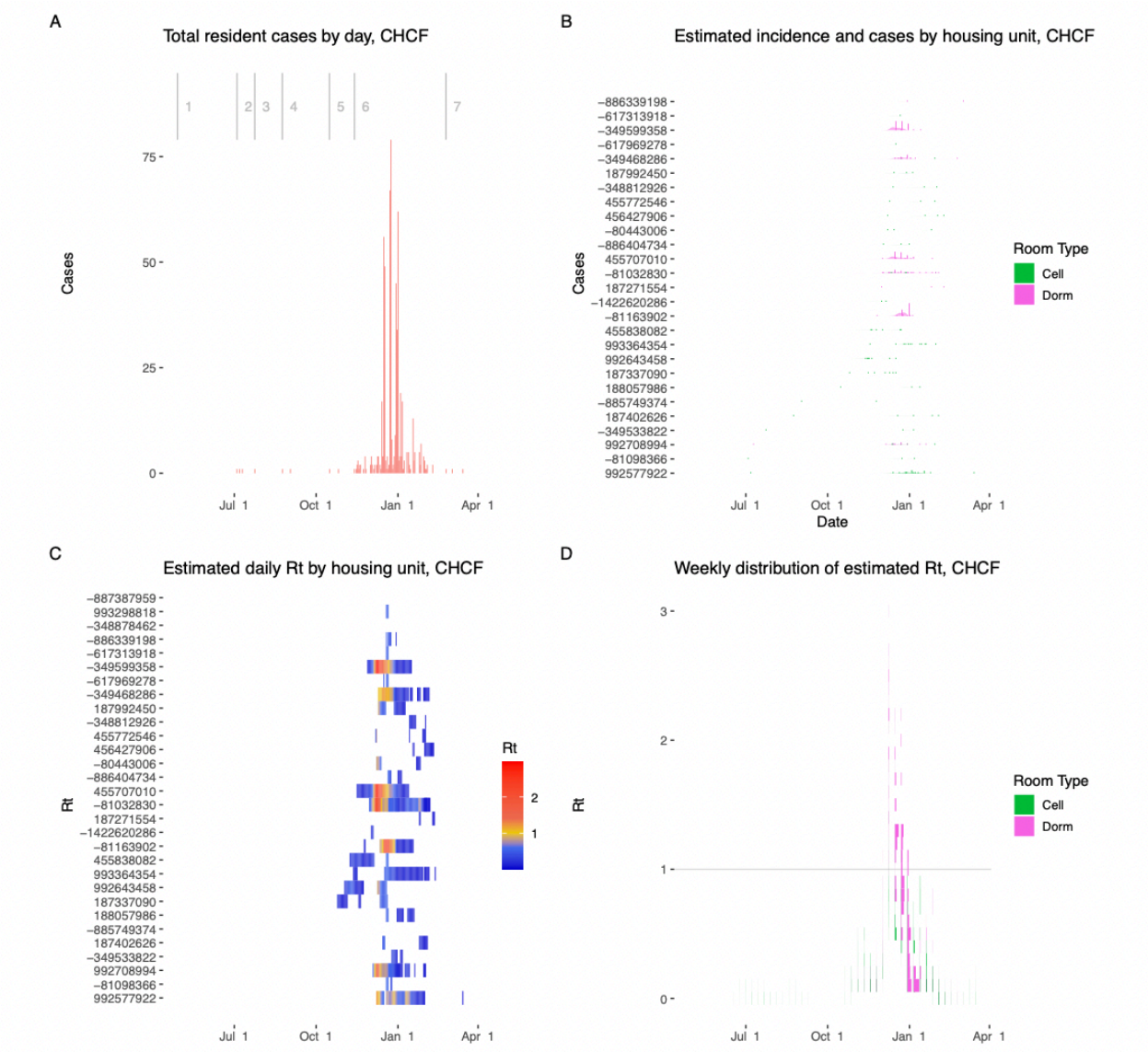


Figure A.8: **Results from CHCF. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

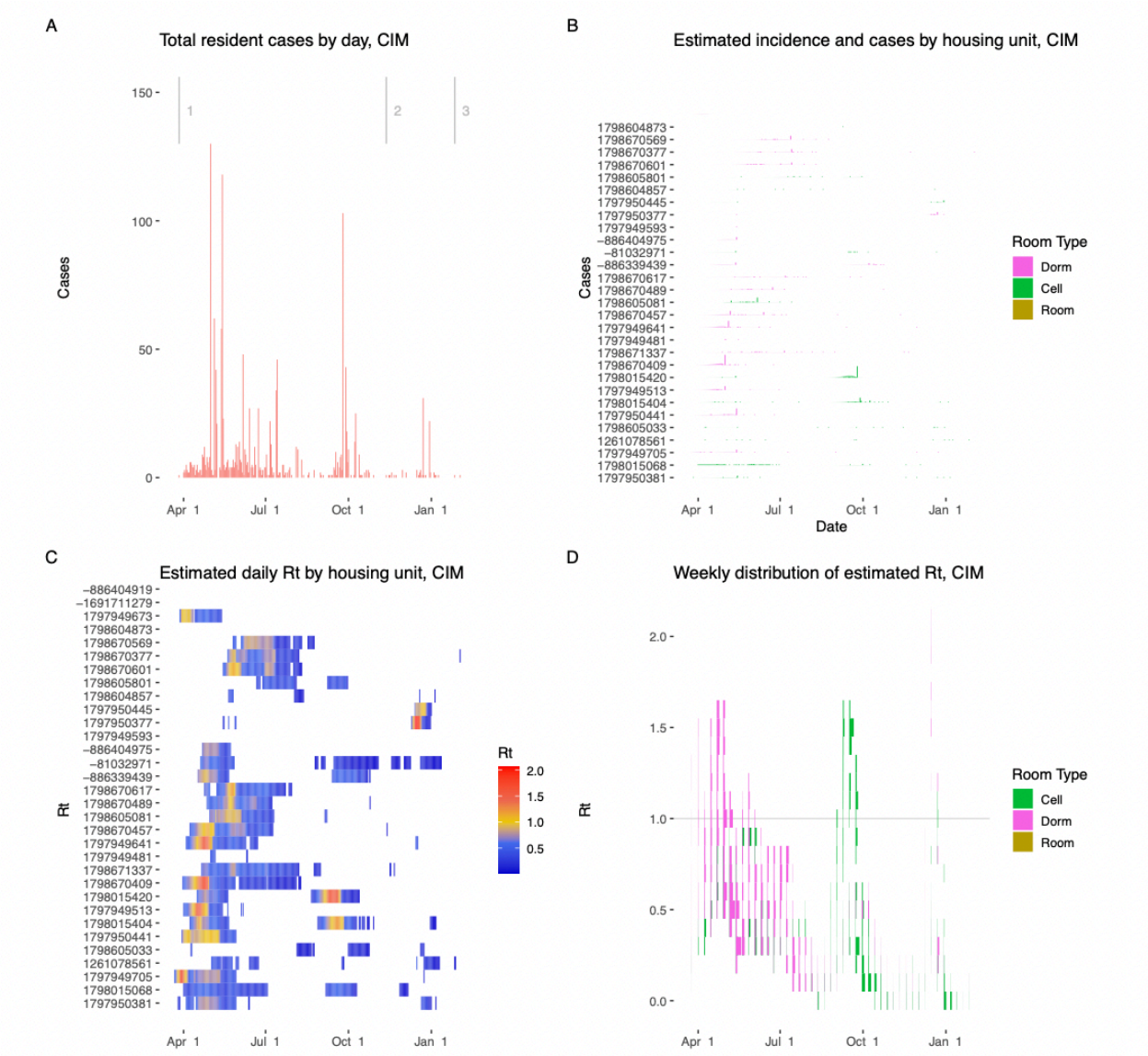


Figure A.9: **Results from CIM. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

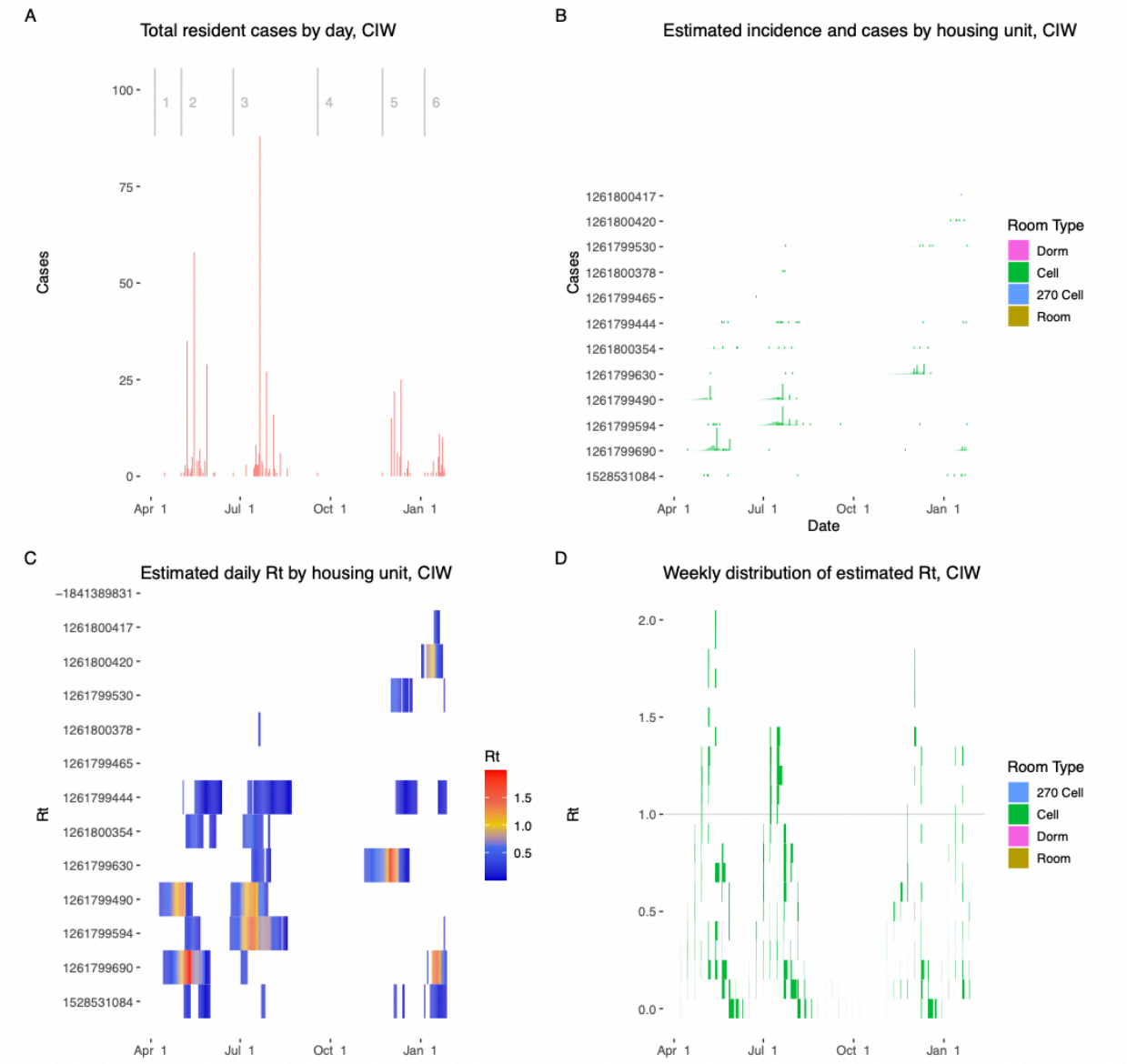


Figure A.10: **Results from CIW. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

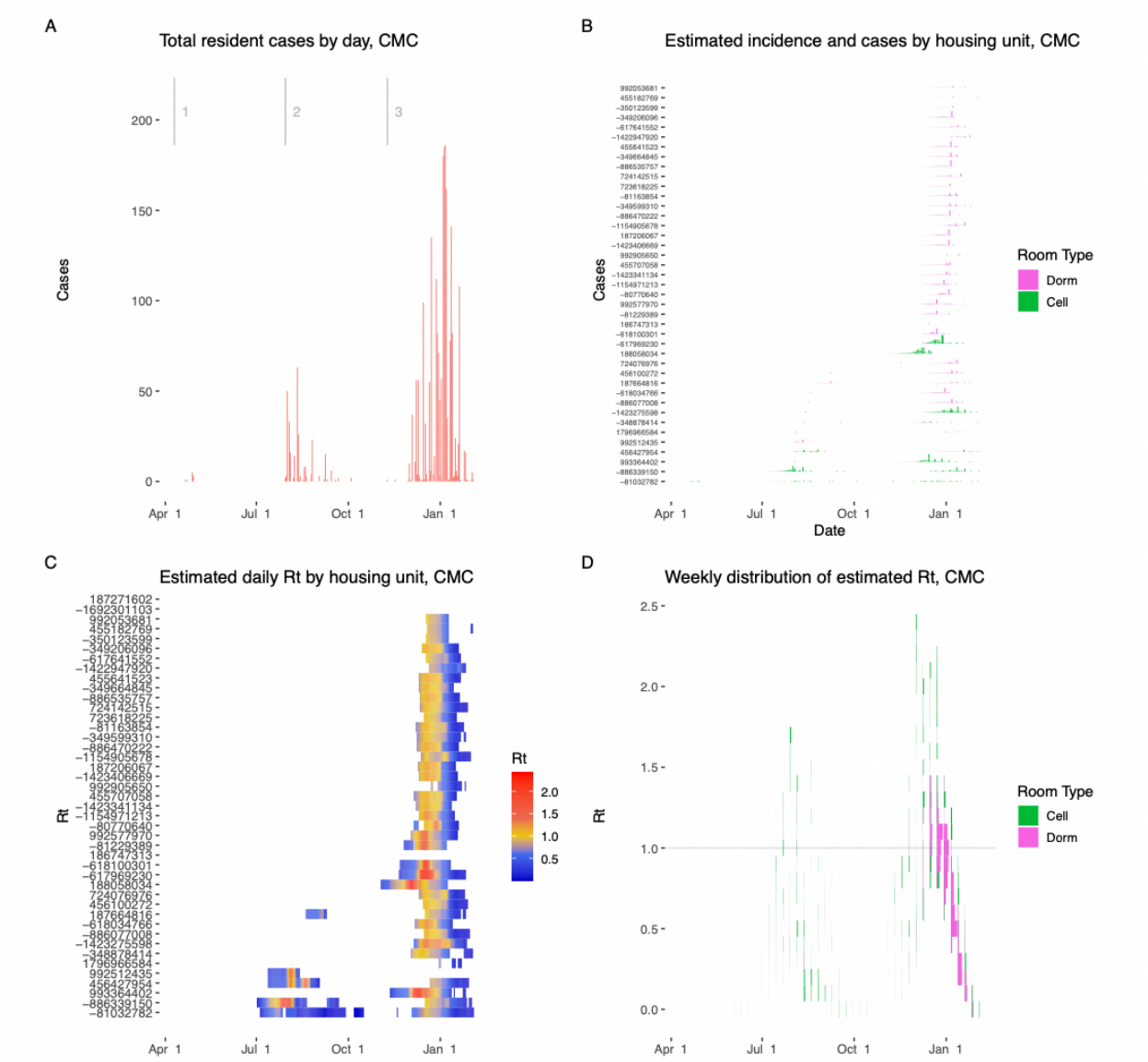


Figure A.11: **Results from CMC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

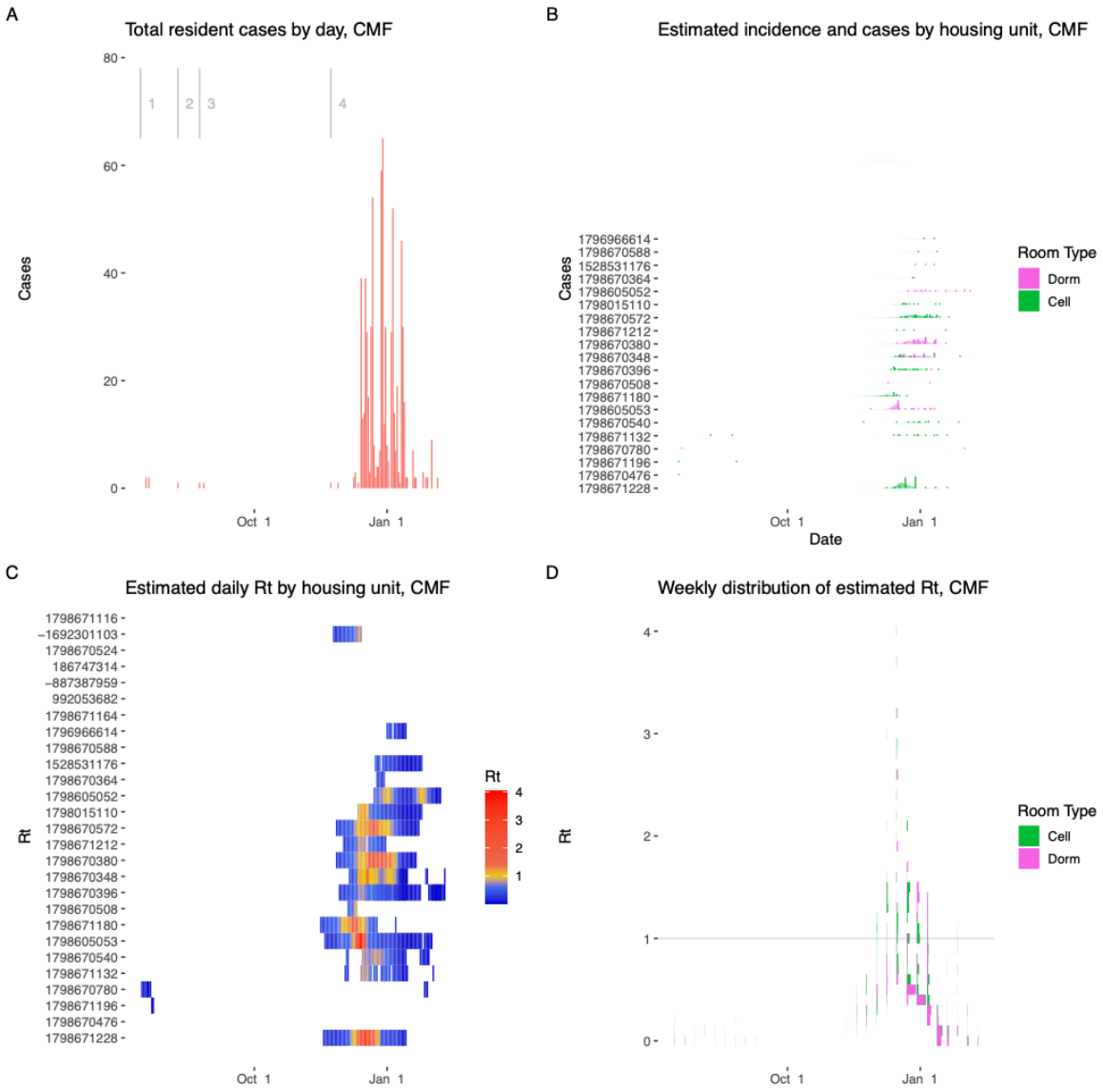


Figure A.12: **Results from CMF. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

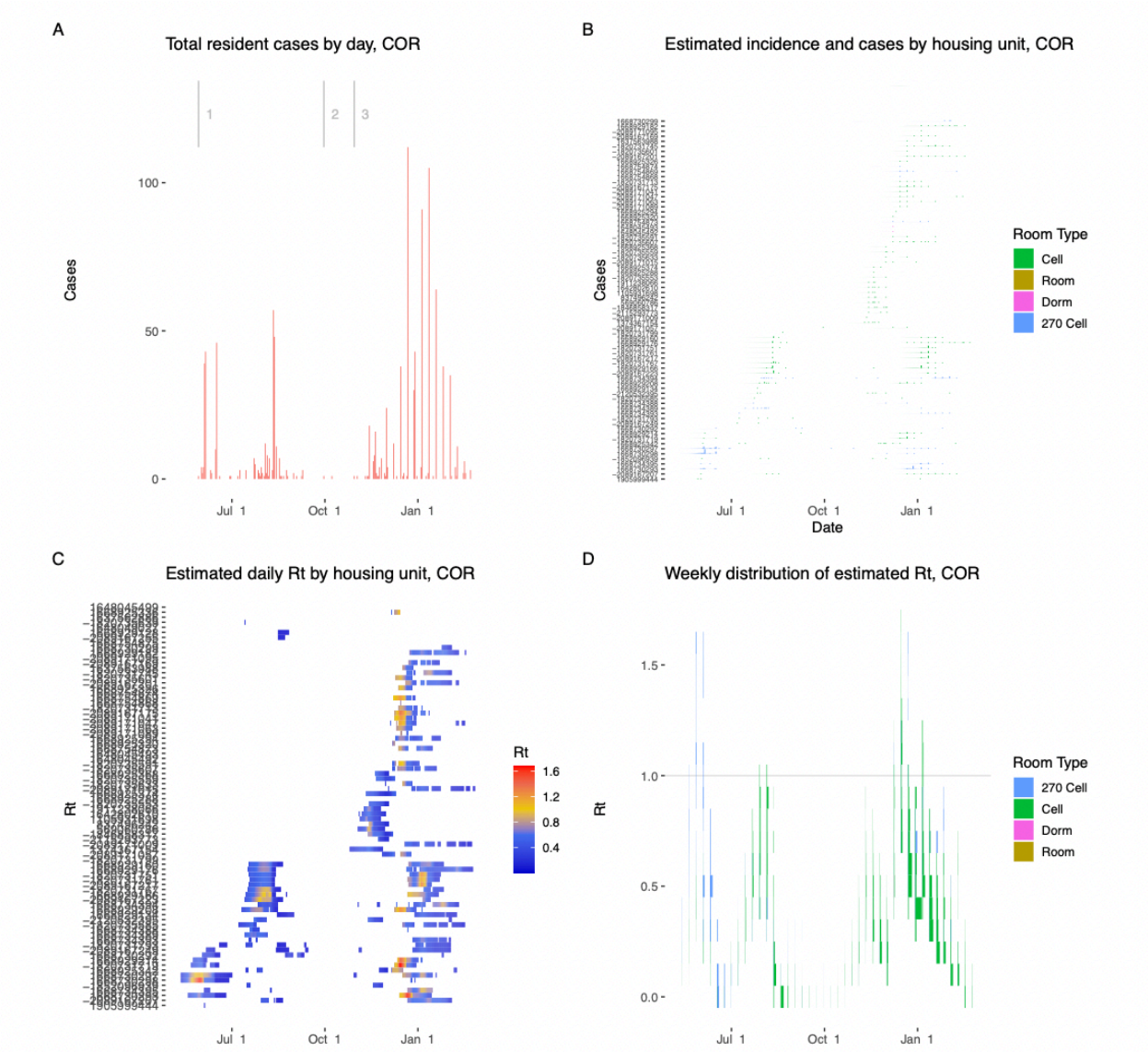


Figure A.13: **Results from COR. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

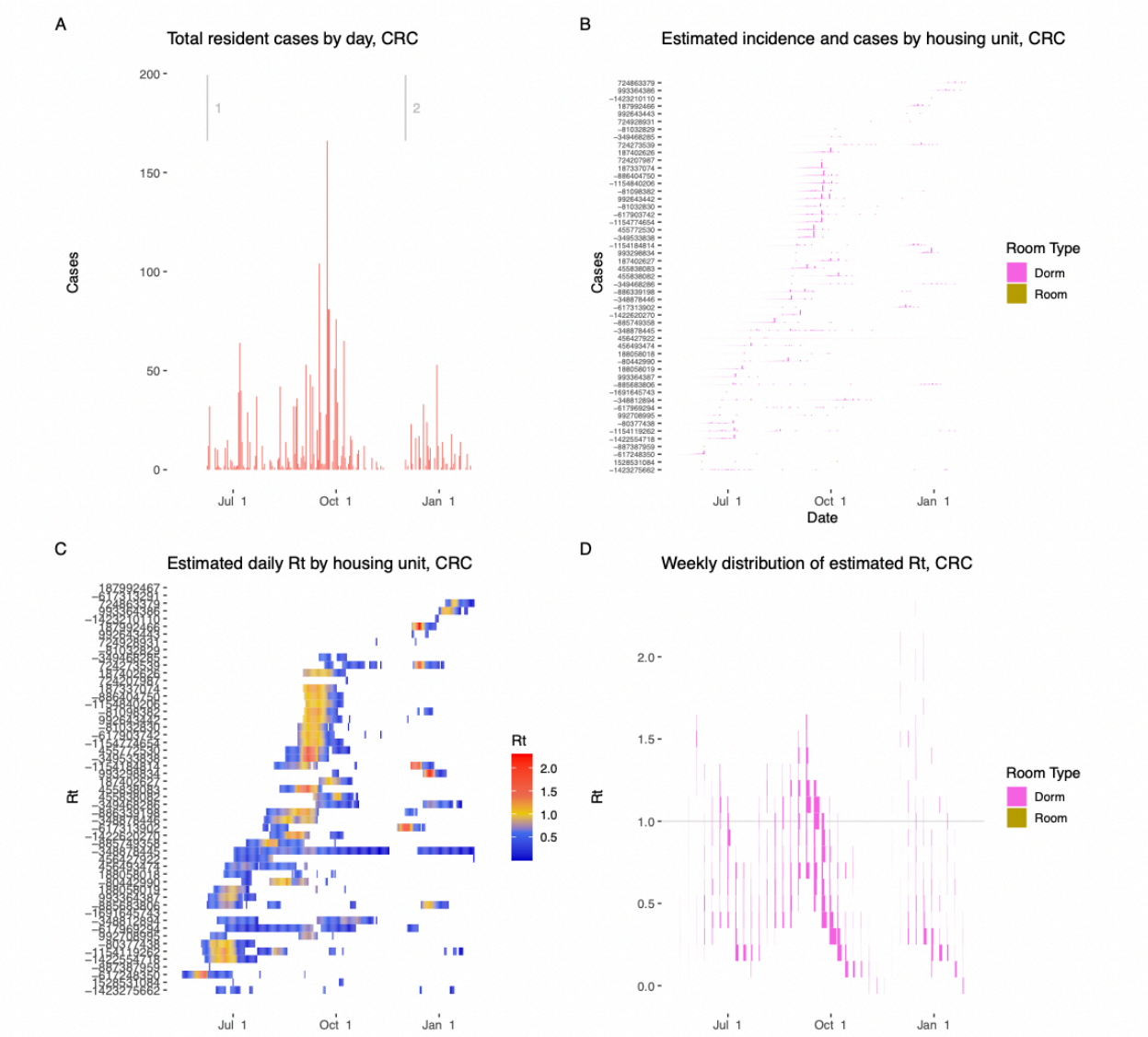


Figure A.14: **Results from CRC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

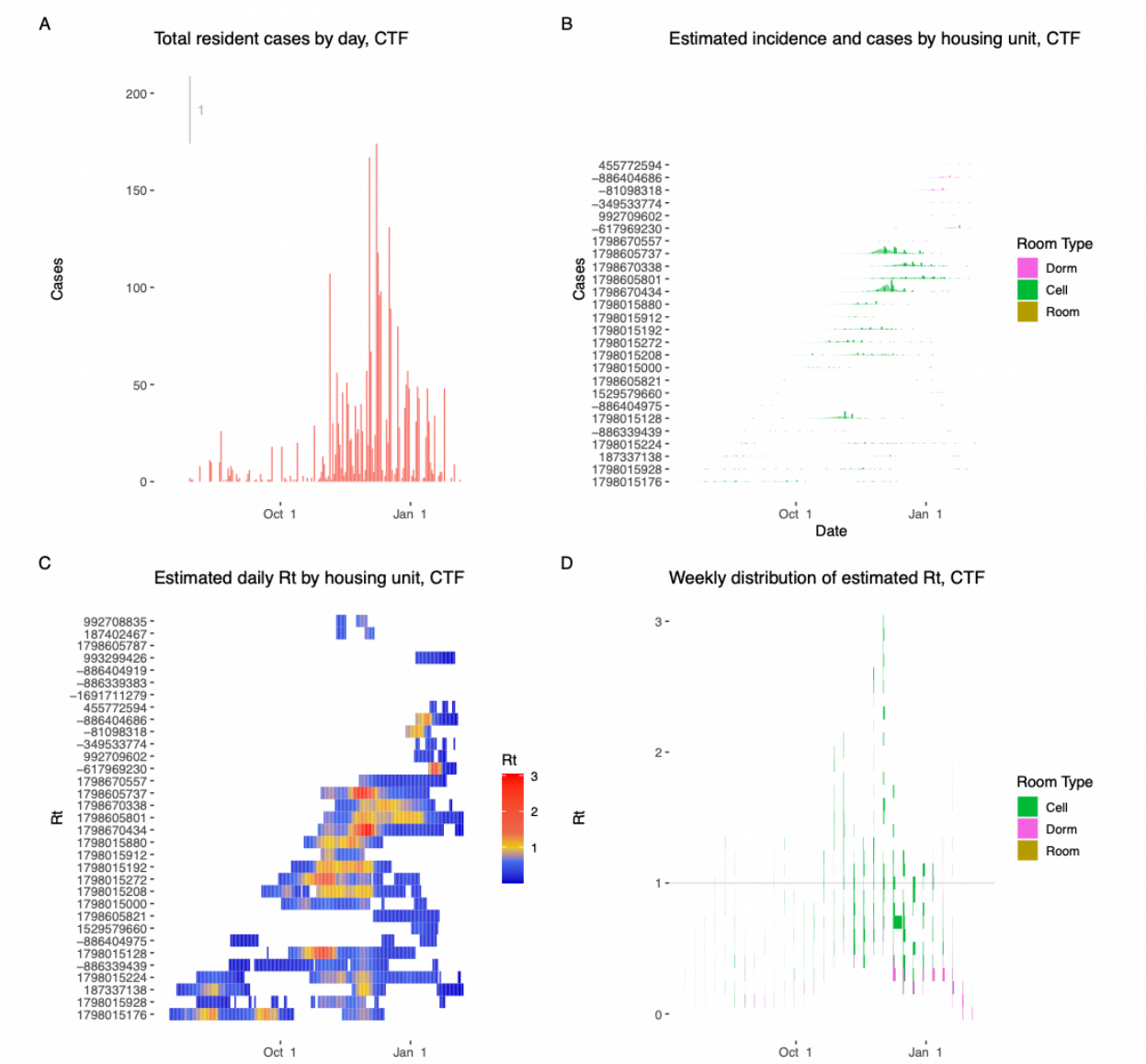


Figure A.15: **Results from CTF. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

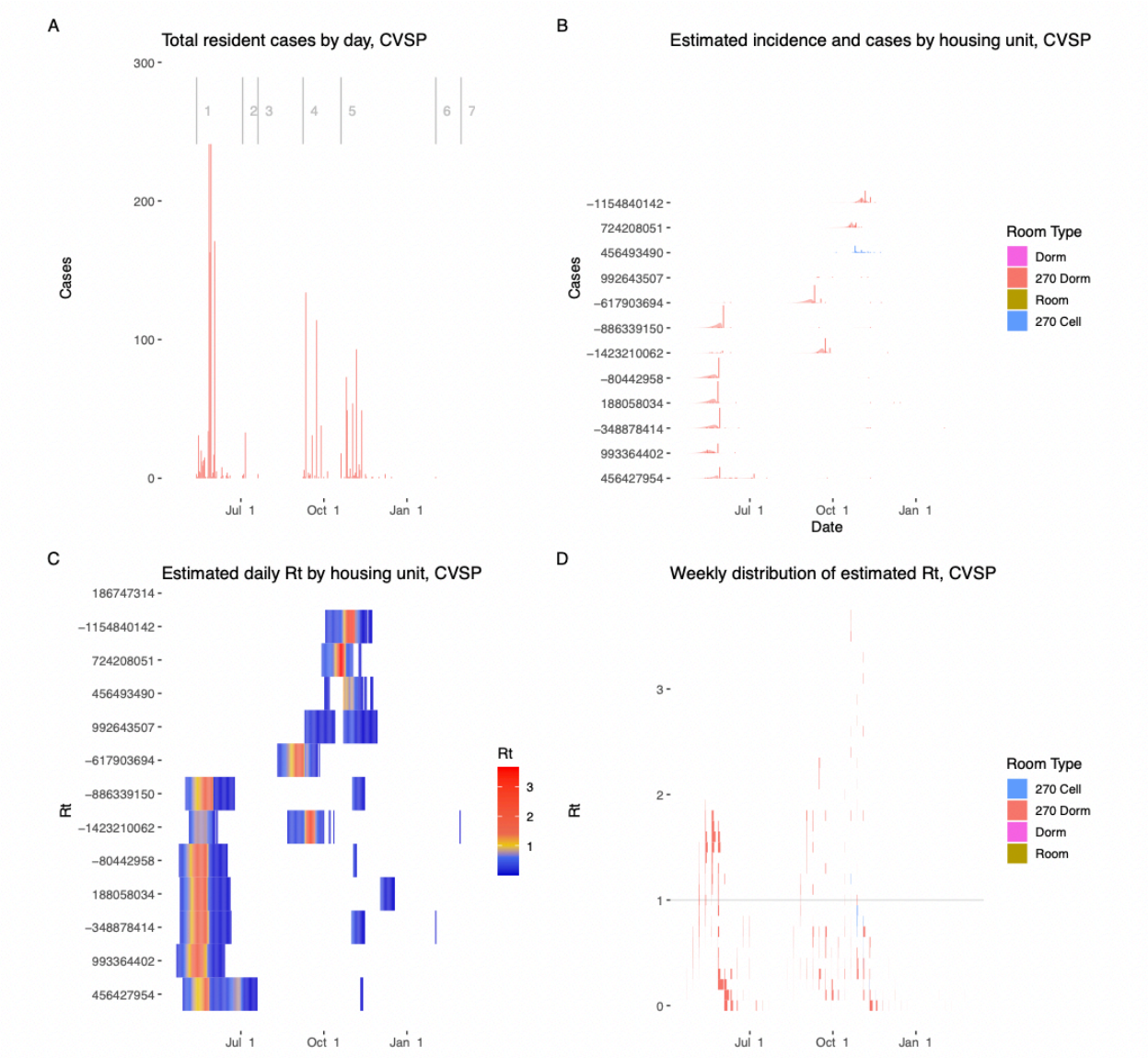


Figure A.16: **Results from CVSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

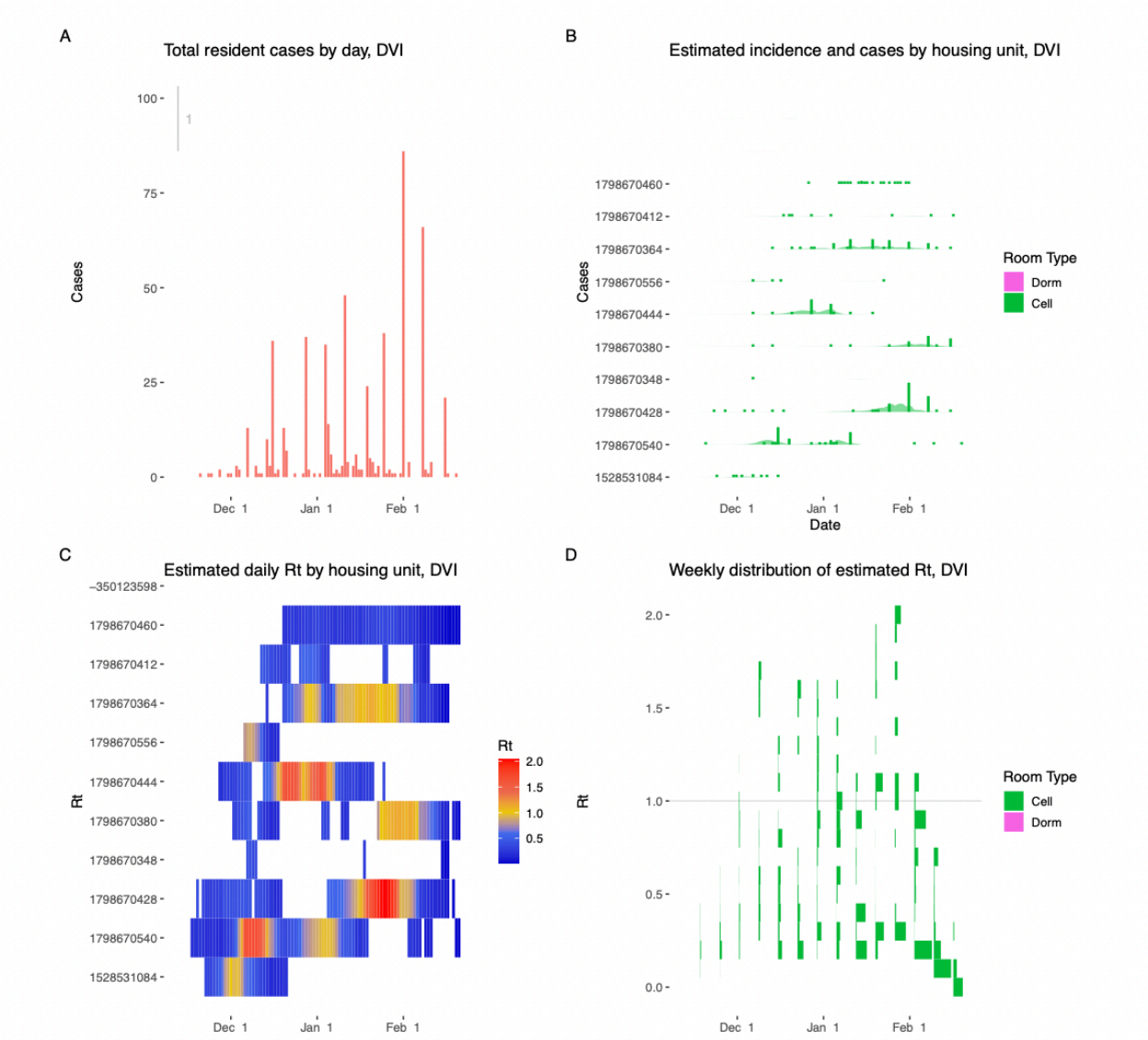


Figure A.17: **Results from DVI. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

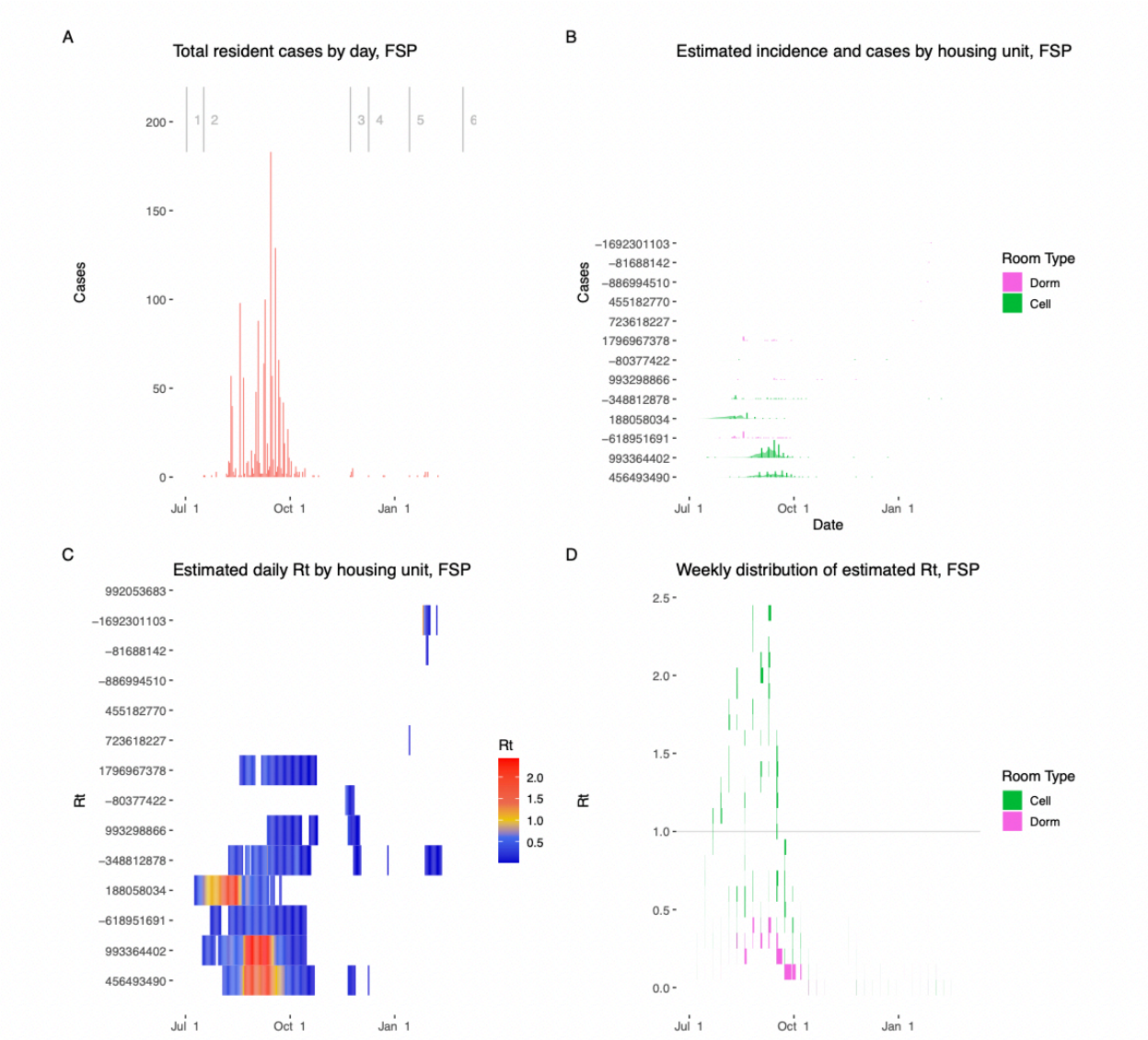


Figure A.18: **Results from FSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

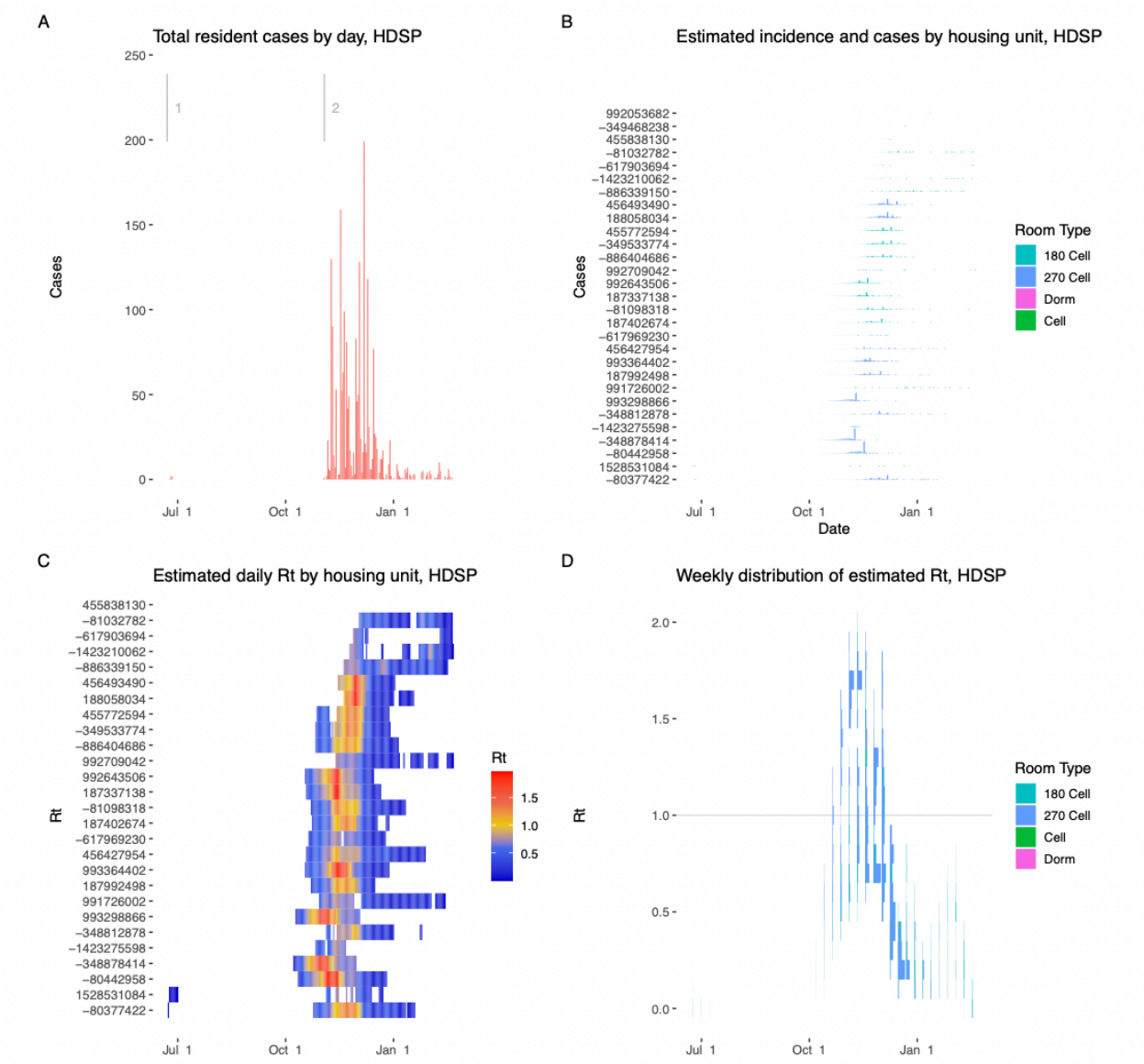


Figure A.19: **Results from HDSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

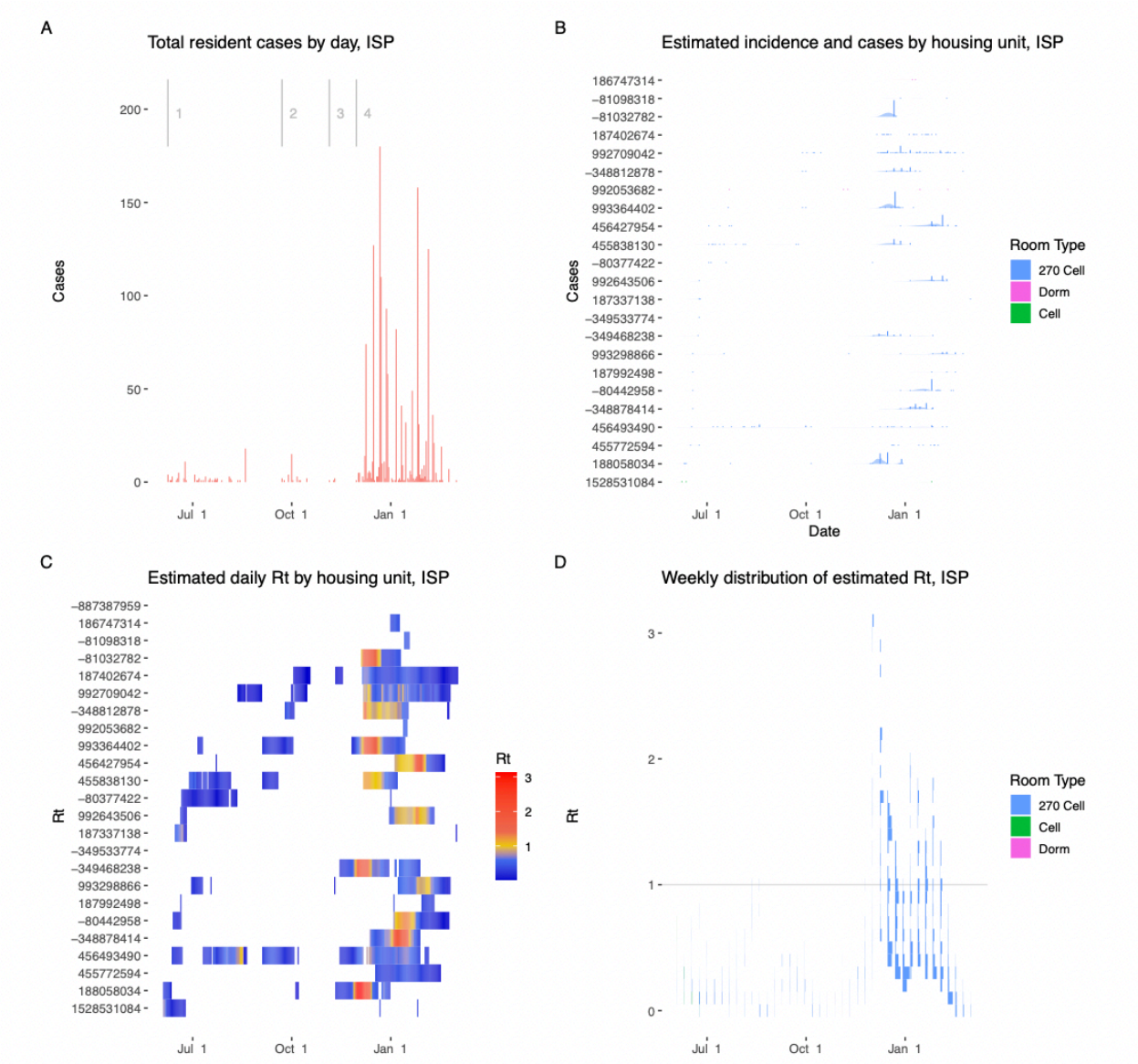


Figure A.20: **Results from ISP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

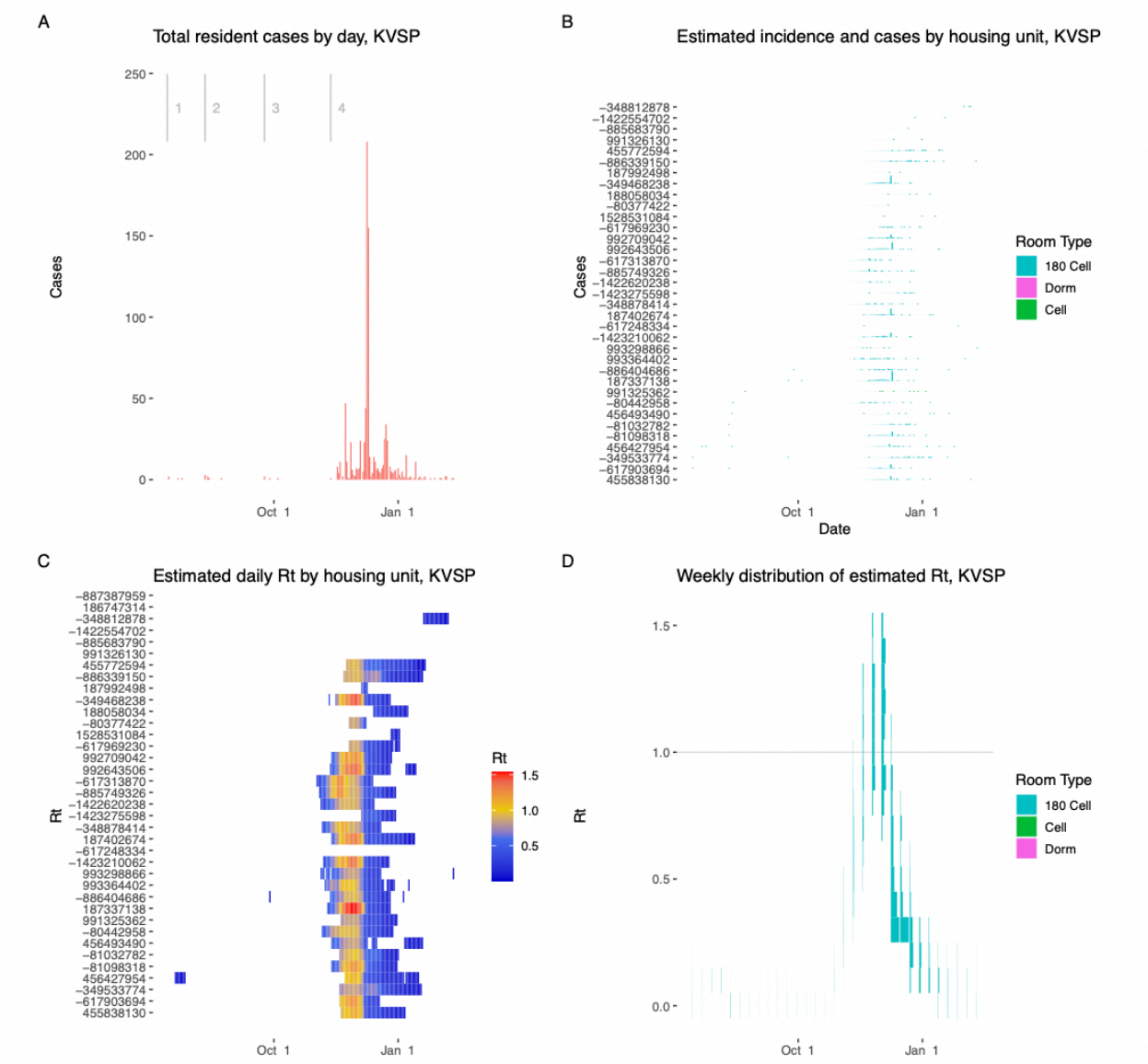


Figure A.21: **Results from KVSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

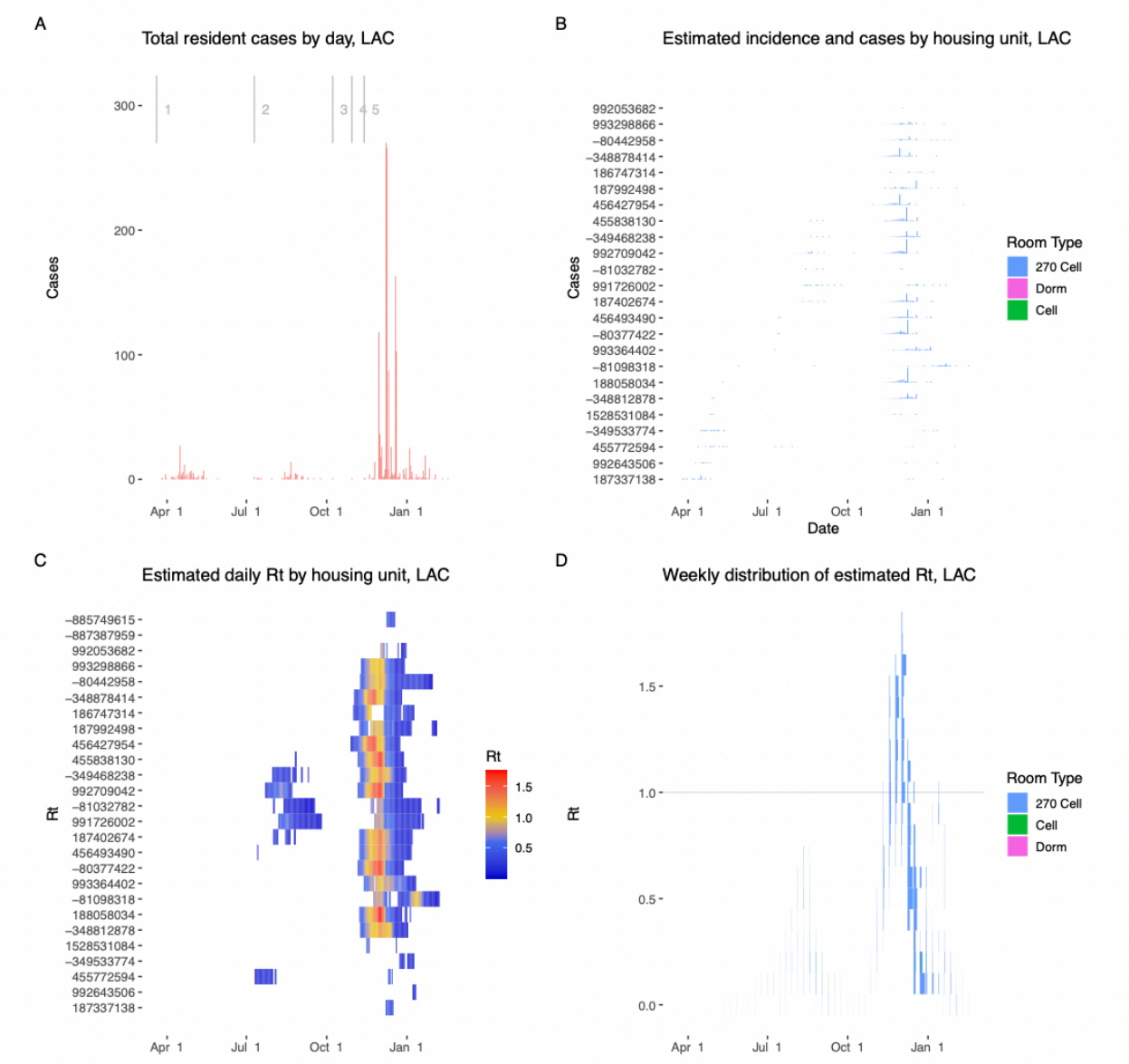


Figure A.22: **Results from LAC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

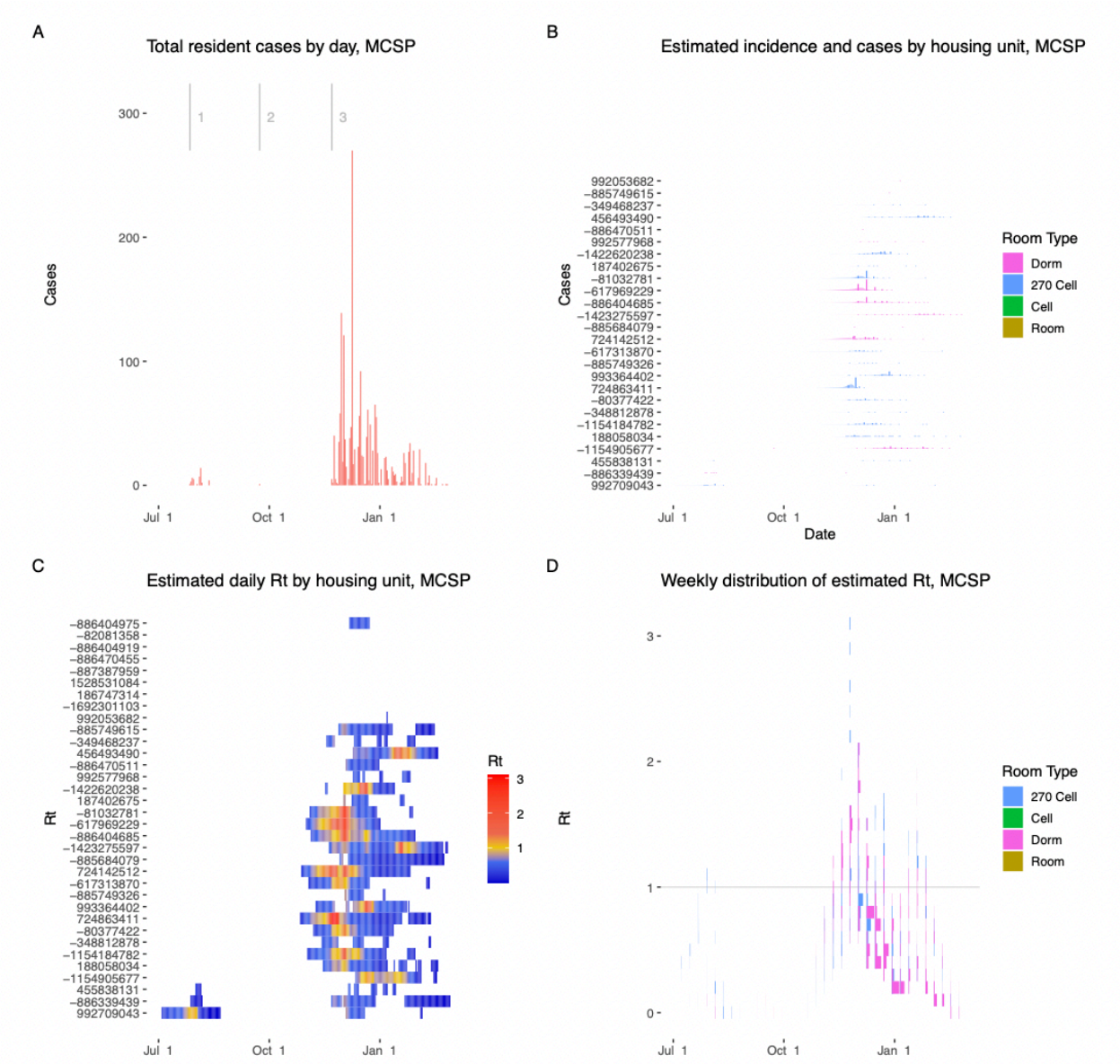


Figure A.23: **Results from MCSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

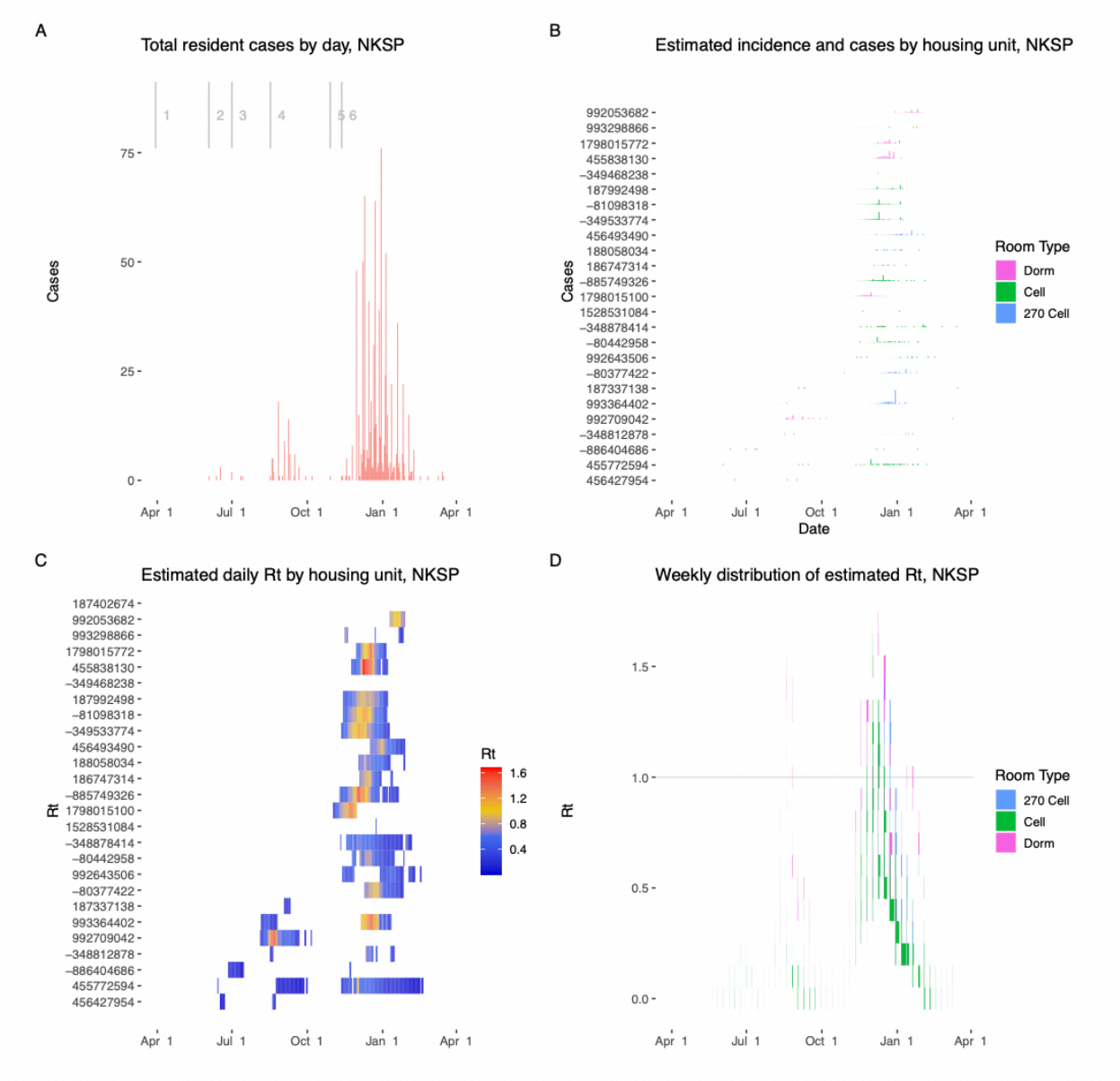


Figure A.24: **Results from NKSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

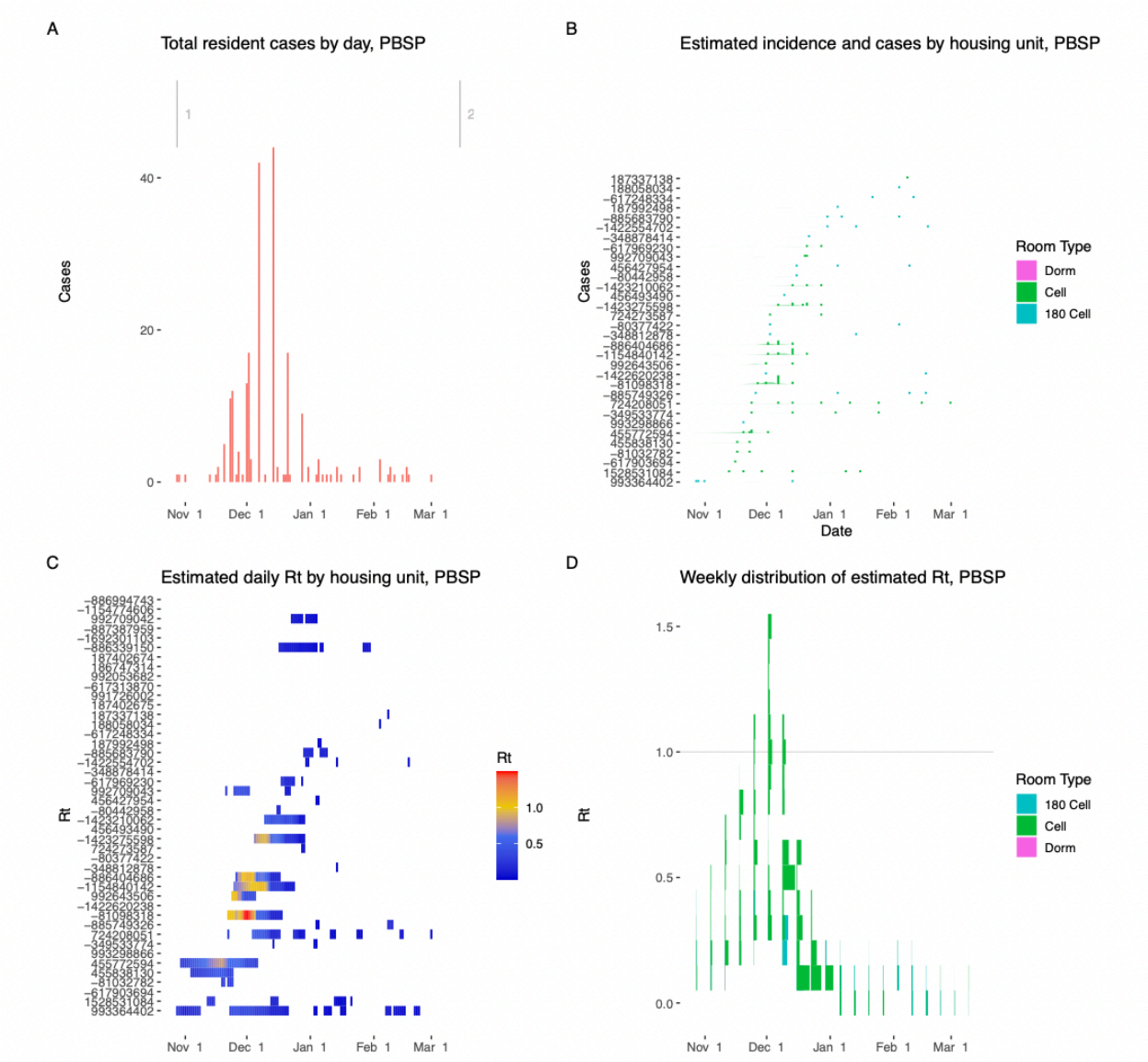


Figure A.25: **Results from PBSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

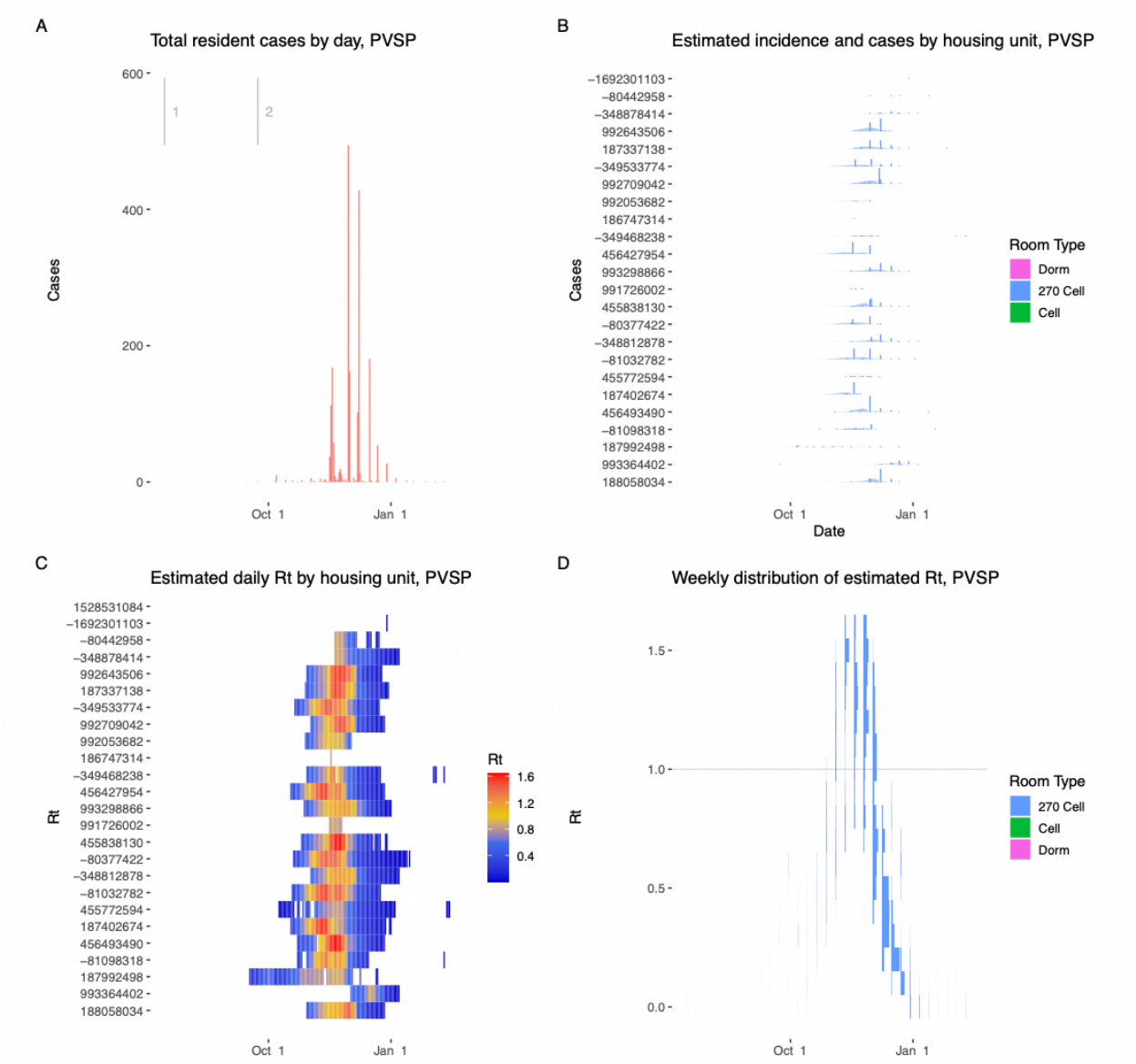


Figure A.26: **Results from PVSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

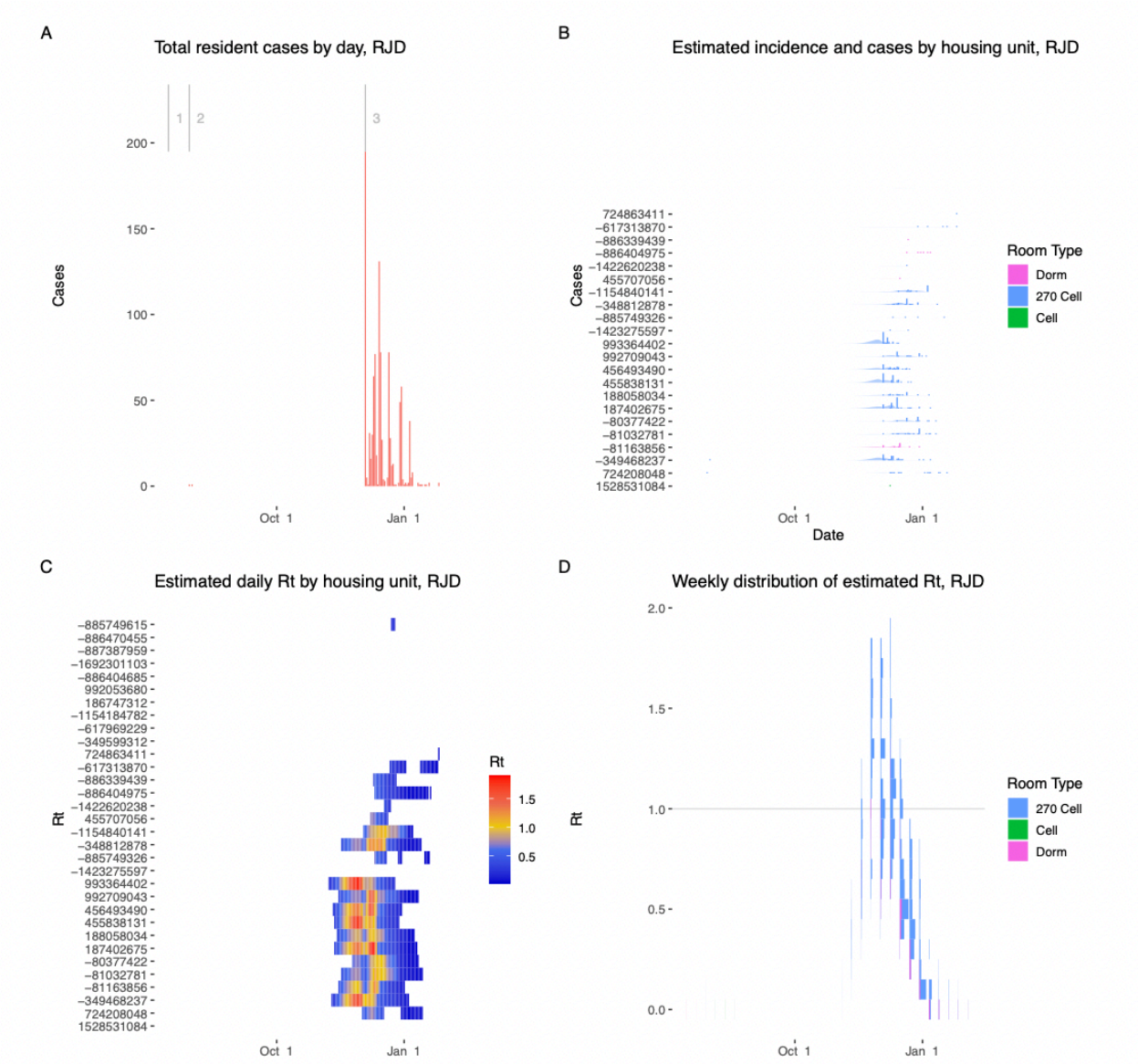


Figure A.27: **Results from RJD. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

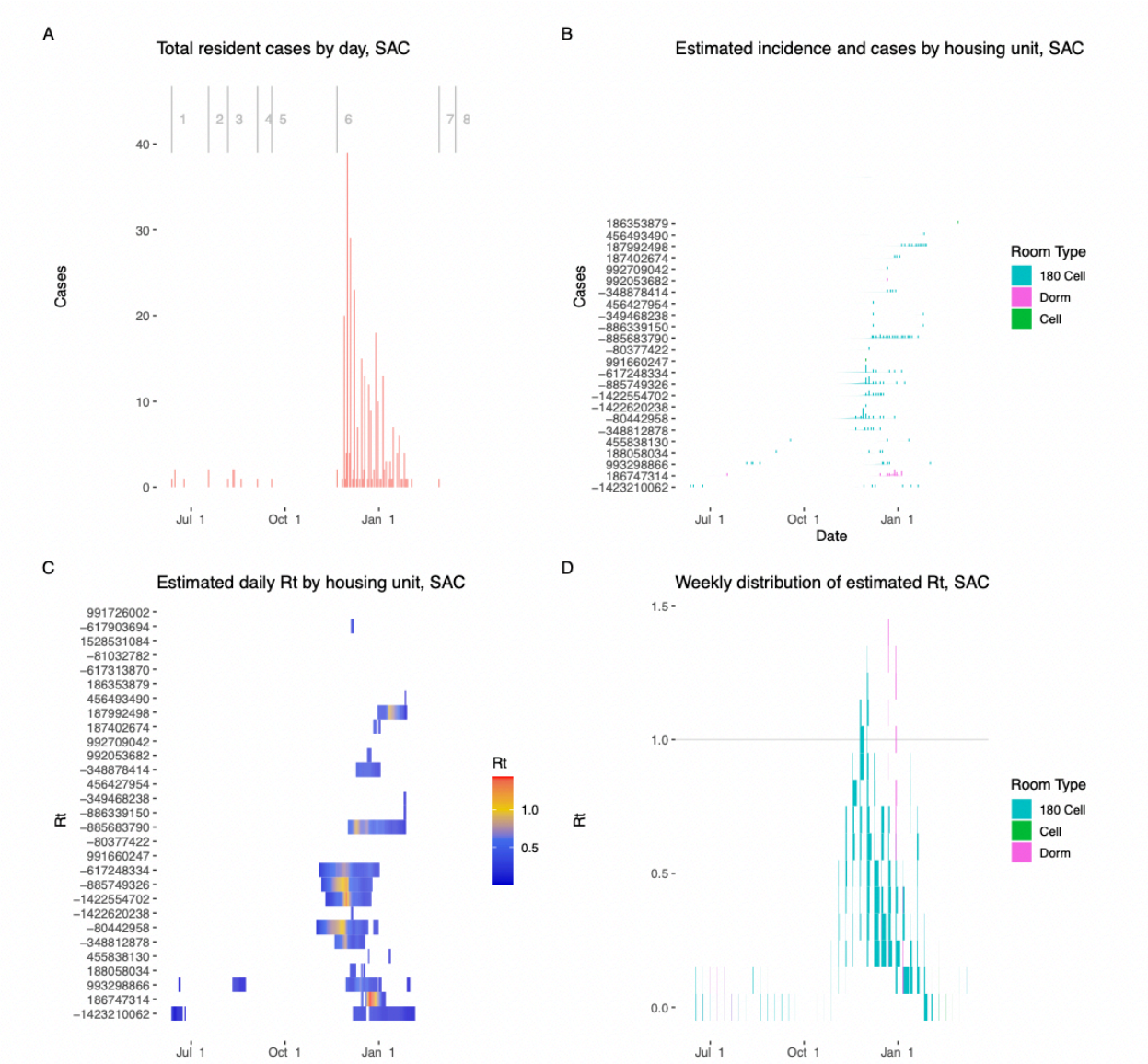


Figure A.28: **Results from SAC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

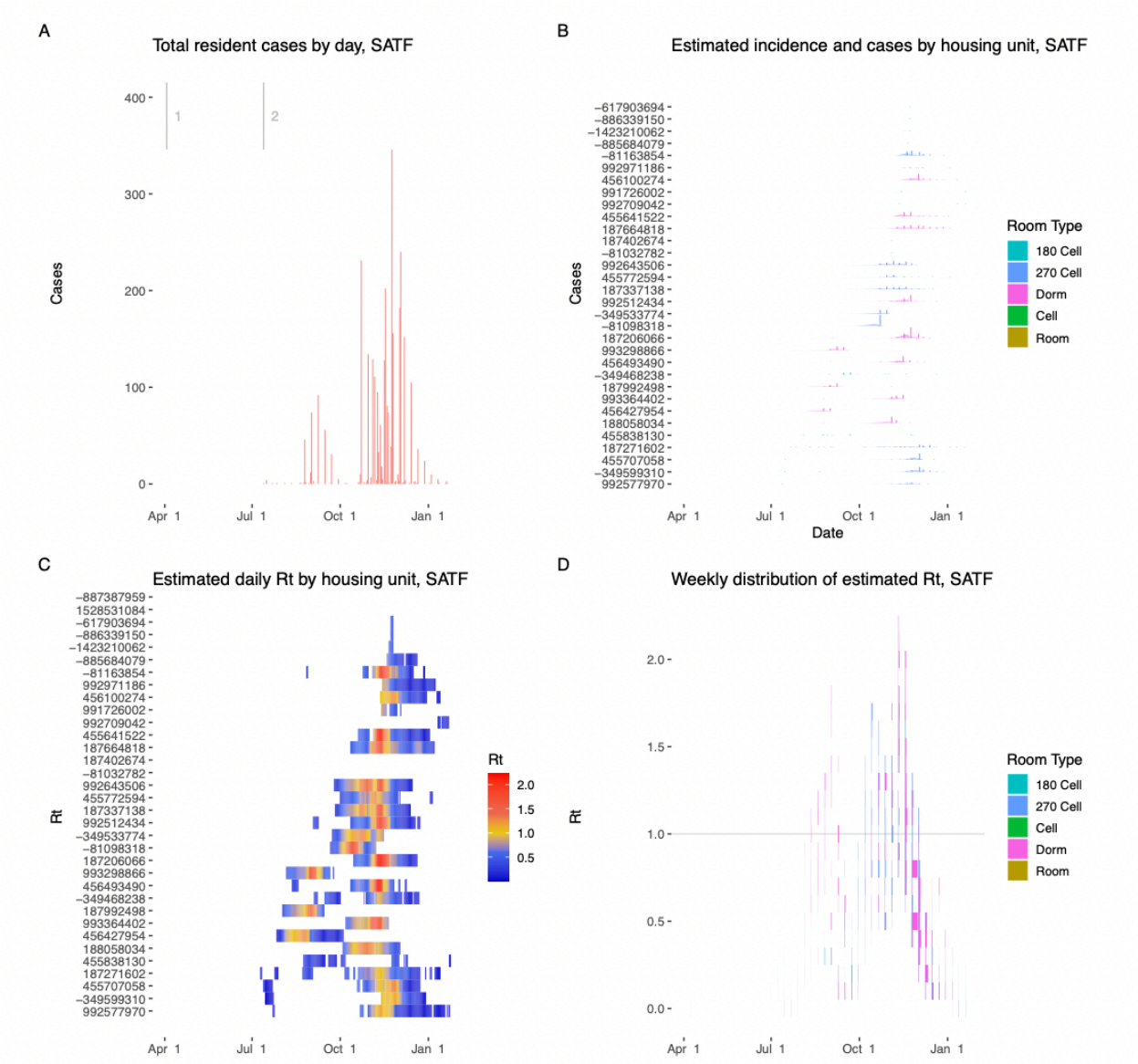


Figure A.29: **Results from SATF. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

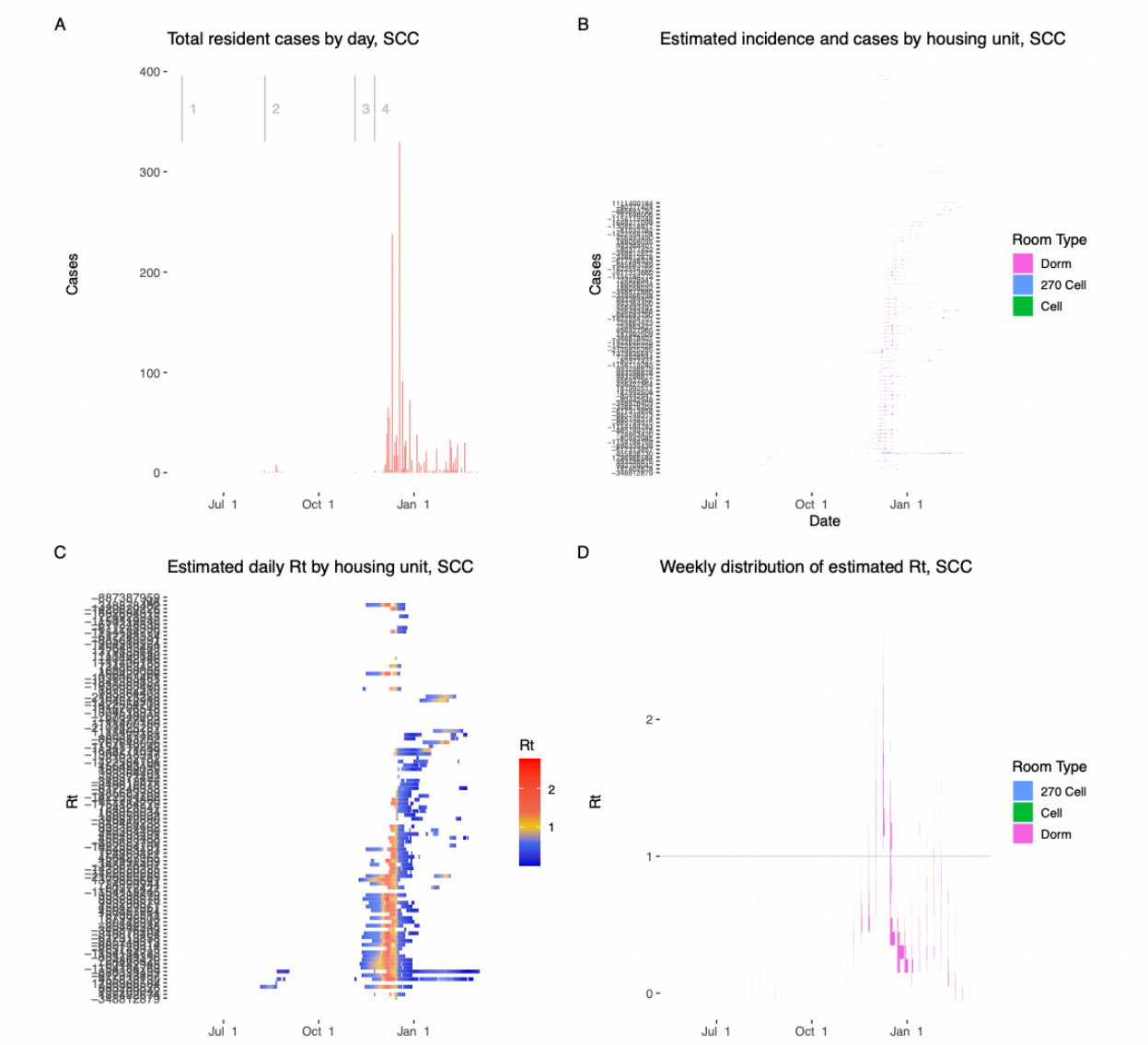


Figure A.30: **Results from SCC. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

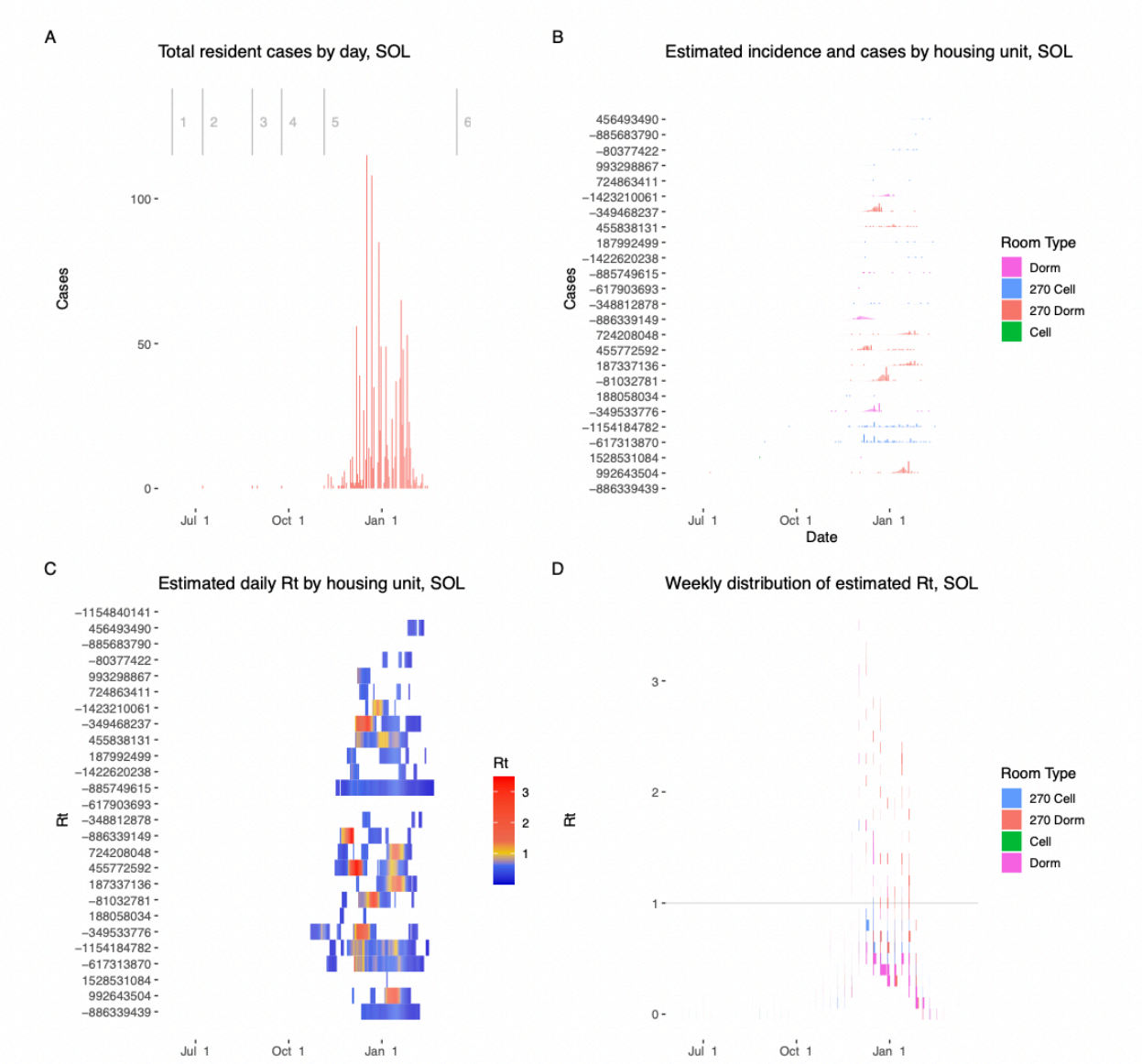


Figure A.31: **Results from SOL. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

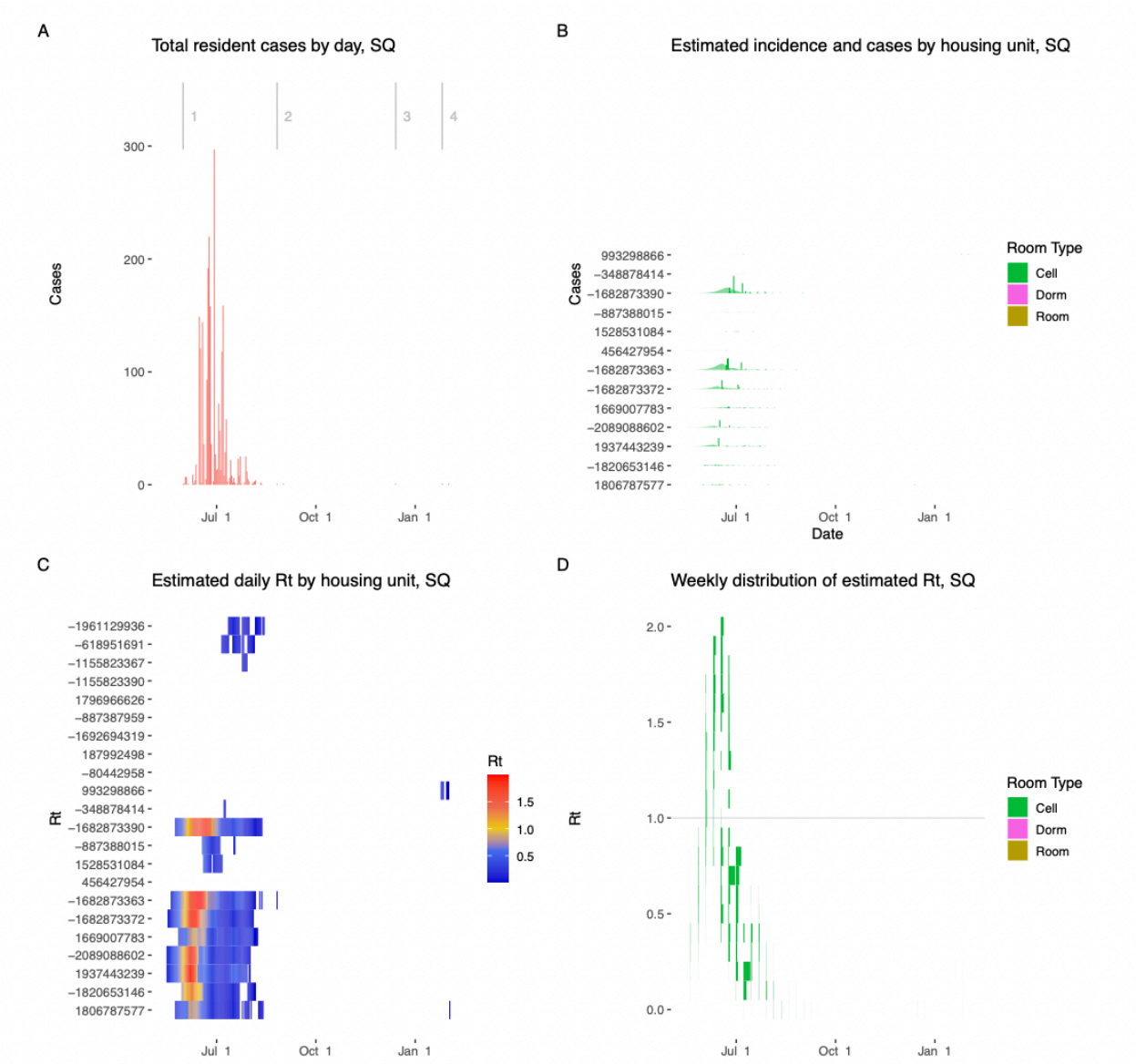


Figure A.32: **Results from SQ. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

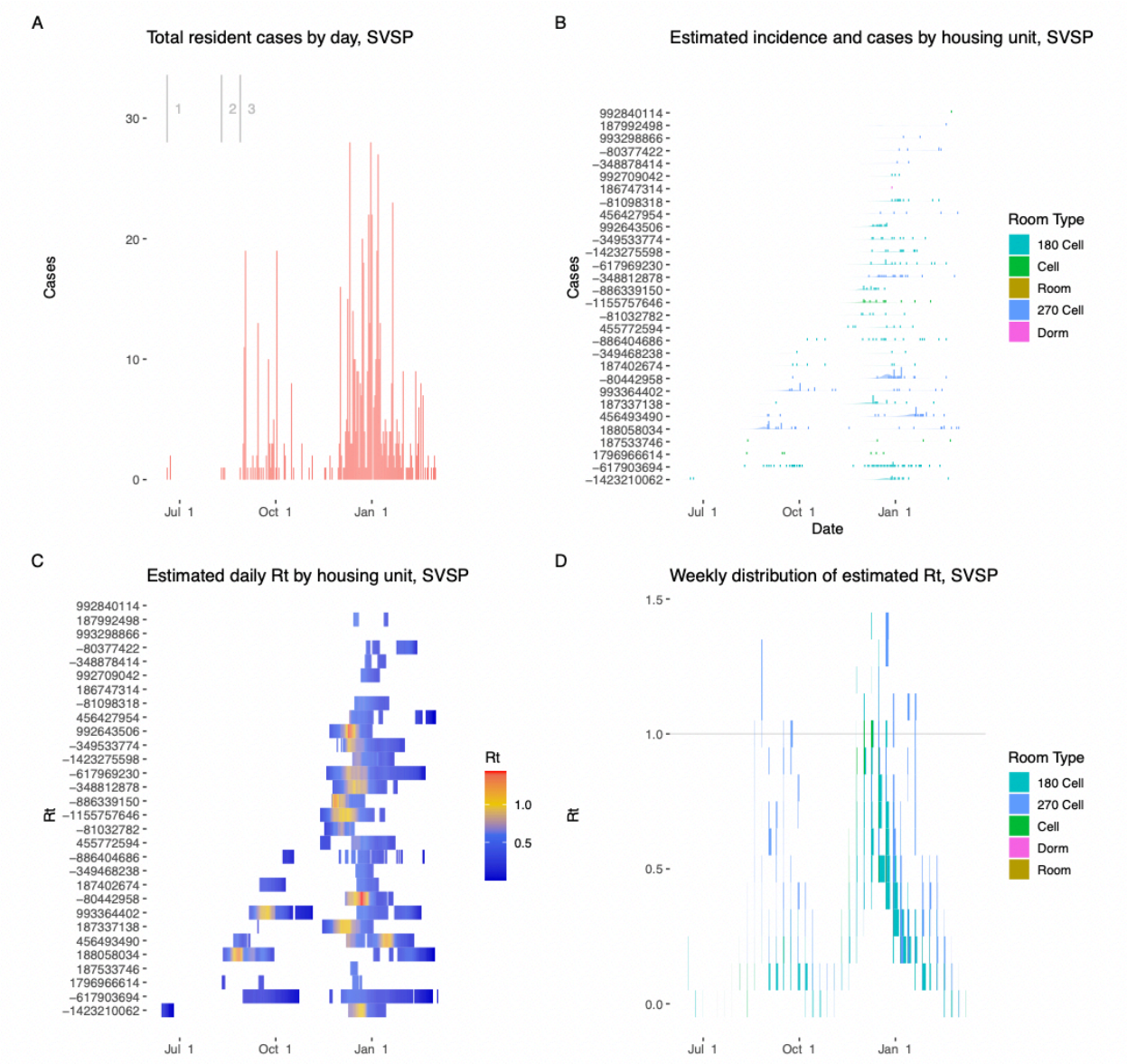


Figure A.33: **Results from SVSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

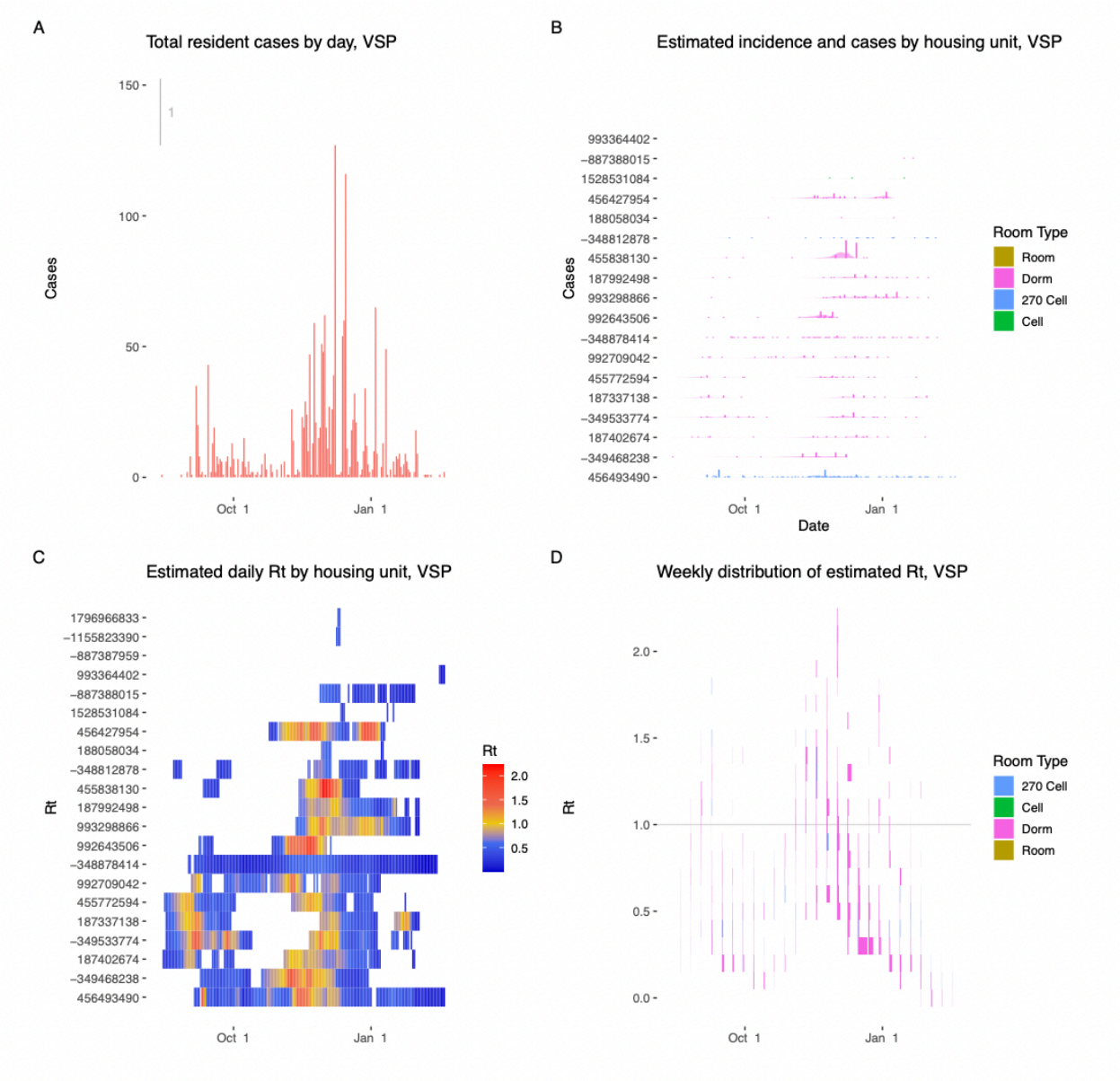


Figure A.34: **Results from VSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

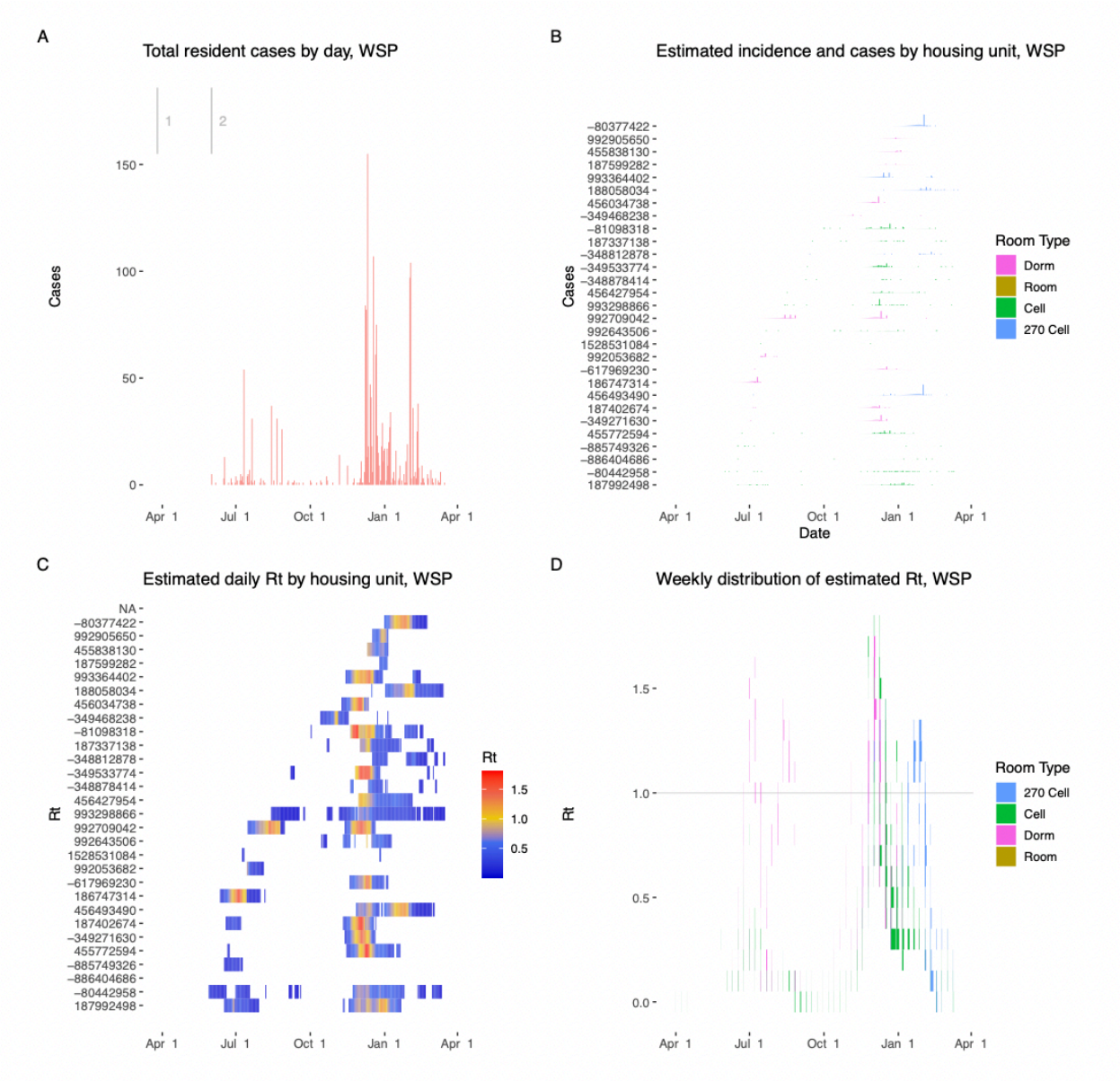


Figure A.35: **Results from WSP. A:** Cases detected per day. Starting date of each outbreak is marked by a vertical gray line. **B:** Cases detected per day by housing unit, together with estimated incidence in cases infected per day. Curves are colored by room type. Y-axis labels are housing unit ID numbers. **C:** Estimated effective R by day per housing unit, when estimated expected number of infectious residents exceeds 0.5. Y-axis labels are housing unit ID numbers. **D:** Distribution of R estimates by week, colored by room type.

Supplement S10.2. Mathematical methods used in estimation of daily reproduction numbers, incidence, and susceptible fraction by housing unit.

We estimate effective reproduction numbers and timing of transmission events by a technique based on Wallinga-Teunis estimation [3, 4, 6, 7, 13, 14]. The Wallinga-Teunis technique is a way of estimating a single time-varying reproduction number for an epidemic from a single series of daily case counts. For that, the key piece of information that is needed about the disease transmission process is the serial interval distribution, describing how likely a case is to be caused by a case reported a given number of days before. From that, likelihoods are derived for each possible transmission link, and reproduction numbers are estimated by the expected number of cases caused by a given case. The method described by Wallinga and Teunis [3,6,14] estimates case reproduction numbers, typically denoted R or R_c, the number of cases caused by a given source case over the source case's full disease progression, while a variant technique [4, 6] estimates effective reproductive numbers (R_t, or R_e), describing transmission rates on a single day, such that the number would be the case reproduction number if conditions were unchanging in time.

We describe here a technique for estimating multiple daily effective reproduction numbers describing transmission in multiple subpopulations, as well as case reproduction numbers and several other quantities, when data is available describing an outbreak in a structured population. Specifically, we describe the use of a data set including multiple positive and negative test results, symptom onset dates, and daily movements in a population structured across multiple locations, to estimate the dates of transmission events and effective reproduction numbers by location by day. This approach may be generalizable to other structured transmission processes.

Briefly, to place our exposition in context, the key steps of the Wallinga-Teunis technique are as follows. Assume a set of cases x with case reporting dates T_x, and serial interval distribution σ, such that $\sigma(\Delta t)$ is the probability that a randomly selected source case and secondary case have reporting dates separated by Δt days. Let $T(x)$ be the random variable describing the reporting date of any case x. Write the likelihood of a transmission link between any two distinct cases:

$$\begin{aligned} w(x \to y) &= L(\, x \to y \,|\, T(y) - T(x) = T_y - T_x \,) \\ &= \mathbb{P}(\, T(y) - T(x) = T_y - T_x \,|\, x \to y \,) \\ &= \sigma(T_y - T_x). \end{aligned}$$

Assume N total cases. For a given secondary case y, the probability that a given x is the source case for y is derived by a Bayesian step, with a prior assumption that all x other than y have equal probability $1/(N-1)$ of being the source case, and that serial intervals are

uniformly distributed with probability c per day. Then

$$\begin{aligned}
p(x \to y) &= \mathbb{P}(\, x \to y \,|\, T(y) - T(z) = T_y - T_z \text{ for all } z \neq y \,) \\
&= \frac{\mathbb{P}(\, T(y) - T(z) = T_y - T_z \text{ for all } z \neq y \,|\, x \to y \,)\ \mathbb{P}(\, x \to y \,)}{\mathbb{P}(\, T(y) - T(z) = T_y - T_z \text{ for all } z \neq y \,)} \\
&= \frac{\mathbb{P}(\, T(y) - T(z) = T_y - T_z \text{ for all } z \neq y \,|\, x \to y \,)\ \mathbb{P}(\, x \to y \,)}{\sum_{x' \neq y} \mathbb{P}(\, T(y) - T(z) = T_y - T_z \text{ for all } z \neq y \,|\, x' \to y \,)\ \mathbb{P}(\, x' \to y \,)} \\
&= \frac{c^{N-2}\, w(x \to y)/(N-1)}{\sum_{x' \neq y} c^{N-2}\, w(x' \to y)/(N-1)} \\
&= \frac{w(x \to y)}{\sum_{x' \neq y} w(x' \to y)}.
\end{aligned}$$

Given probabilities p for all potential transmission links, the case reproduction number $R(x)$ for each case x is then estimated by the expected number of transmission links from x:

$$R(x) = \sum_y p(x \to y).$$

Our method uses the same step of Bayesian inference to infer probabilities for all possible transmission links, while extending the above method in several ways. We proceed in two main steps. First, dates of positive and negative test results and symptom onsets are used to construct a probability distribution of days on which each individual was likely infected, and on which they were likely infectious. Second, those distributions are used together with daily movements of individuals to construct likelihoods $w(x \to y, t)$ for occurrence of each potential transmission link on each day, and transmission probabilities $p(x \to y, t)$ are inferred by a Bayesian update from the ensemble of $w(x \to y, t)$. From that we derive daily effective reproduction numbers $R_t(x)$ per individual and per location, as well as case reproduction numbers and daily incidence per location.

B.1 Estimation of individual incidence and infectiousness profile

We use these distributions to estimate the timing of individuals' incidence and infectiousness by using a parametric likelihood model based on incidence date t_0 and incubation period t_i. For individual x we are given a collection $T^p_+(x)$ and $T^p_-(x)$ of dates of positive and negative RT-PCR tests, $T^a_+(x)$ and $T^a_-(x)$ of dates of positive and negative antigen tests, and $T_s(x)$ of (zero or one) symptom onset dates, which we notate as a vector $T(x) = (T^p_+(x), T^p_-(x), T^a_+(x), T^a_-(x), T_s(x))$.

Sensitivity of RT-PCR and antigen testing as a function of time since infection and incubation period have been fit from studies on test sensitivity after symptom onset [10, 12]. We

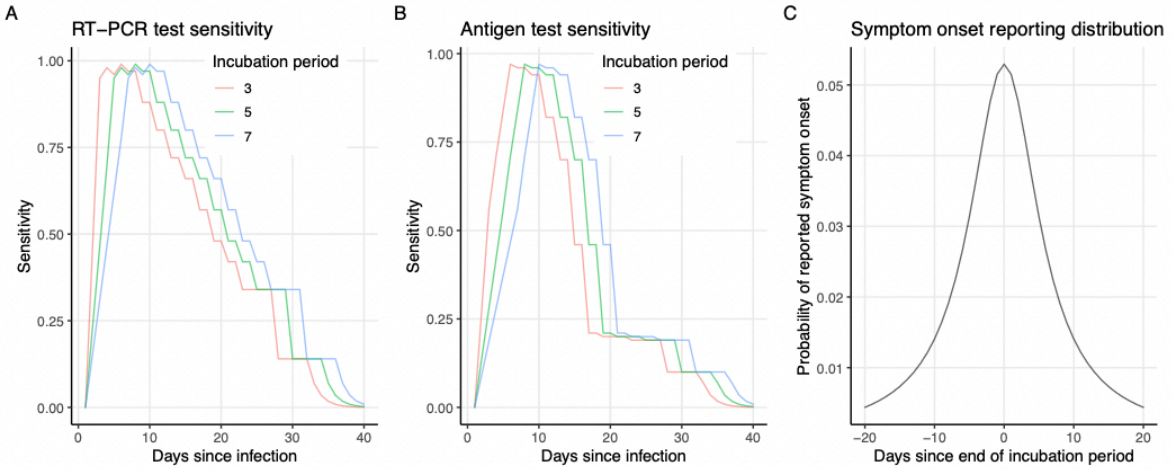


Figure B.1: **Estimated test sensitivities and symptom reporting distribution. A.** Probability of positive RT-PCR test given infection, as a function of time since infection, for three example choices of incubation period. **B.** Probability of positive antigen test given infection, as a function of time since infection, for three example choices of incubation period. **C.** Probability distribution of reported date of symptom onset, as a function of time since (or before) end of incubation period.

use these as a probability $p^p_+(t_+|t_0,t_i)$ for positive and $(p^p_-(t_-|t_0,t_i) = 1 - p_+(t_-|t_0,t_i))$ negative RT-PCR test results given infection date and symptom onset, and similarly $p^a_+(t_+|t_0,t_i)$ and $p^a_-(t_-|t_0,t_i)$ for antigen tests (Figure B.1A, B).

We model the distribution of reported symptom onset dates as randomly perturbed from the theoretical symptom onset date, given wide observed variance in reported dates relative to positive test results, using a Cauchy distribution $p_s(t_s|t_0,t_i)$ with center at zero days from the end of the incubation period and scale parameter 6 days (Figure B.1C).

For a given infection date and incubation period, we can use the above sensitivity curves to provide a likelihood from the known testing and symptom data:

$$\begin{aligned} L_{\mathrm{t}}(t_0,t_i;x) &= L(\,t_0,t_i\,|\,T(x)\,) \\ &= \mathbb{P}(\,T^p_+(x),T^p_-(x),T^a_+(x),T^a_-(x),T_s(x)\,|\,t_0,t_i\,) \\ &= \prod_{t_+\in T^p_+(x)} p^p_+(t_+|t_0,t_i) \prod_{t_-\in T^p_-(x)} p^p_-(t_-|t_0,t_i) \\ &\qquad \prod_{t_+\in T^a_+(x)} p^a_+(t_+|t_0,t_i) \prod_{t_-\in T^a_-(x)} p^a_-(t_-|t_0,t_i) \prod_{t_s\in T_s(x)} p_s(t_s|t_0,t_i). \end{aligned}$$

We estimate the unknown parameters t_0 and t_i by a Bayesian update from a naive prior:

let t_0 be uniform with daily probability ϵ, and let the prior distribution for t_i be a log-normal distribution $p_i(t_i)$ with mean 5.42 days and sd 2.7 days [8]. Then

$$\begin{aligned}&\mathbb{P}(\, t_0, t_i \,|\, T_+^p(x), T_-^p(x), T_+^a(x), T_-^a(x), T_s(x)\,) \\ &\quad = \frac{\mathbb{P}(\, T_+^p(x), T_-^p(x), T_+^a(x), T_-^a(x), T_s(x) \,|\, t_0, t_i\,)\, \epsilon\, p_i(t_i)}{\sum_{t_0'} \sum_{t_i'} \mathbb{P}(\, T_+^p(x), T_-^p(x), T_+^a(x), T_-^a(x), T_s(x) \,|\, t_0', t_i'\,)\, \epsilon\, p_i(t_i')}.\end{aligned}$$

Ferretti et al. [5] provide the best known estimates of the time intervals between infection, symptom onset, and transmission events. The infectious period is correlated with the time of symptom onset in individuals who develop symptoms. Infectiousness increases gradually from infection to symptom onset, and the infectious period tends to increase with the incubation period. The time from onset of symptoms to a given transmission event ("TOST") is best fit by a skew-logistic distribution parametrized by the incubation period t_i:

$$p_{tost}(t|t_i) = \begin{cases} \frac{e^{-(t-\mu)/\sigma}}{(1+e^{-(t-\mu)/\sigma})^{\alpha+1}} & \text{for } t \geq 0 \\ \frac{e^{-(t\tau/t_i-\mu)/\sigma}}{(1+e^{-(t\tau/t_i-\mu)/\sigma})^{\alpha+1}} & \text{for } t < 0 \end{cases}$$

with $\mu = -4.00$ days, $\sigma = 1.85$ days, $\alpha = 5.85$, $\tau = 5.42$ days.

That yields a distribution of incidence dates and infectious periods, with incidence distribution

$$w_i(t_0; x) = \sum_{t_i} \mathbb{P}(\, t_0, t_i \,|\, T_+^p(x), T_-^p(x), T_+^a(x), T_-^a(x), T_s(x)\,)$$

and infectiousness distribution

$$w_\lambda(t; x) = \sum_{t_0} \sum_{t_i} p_{tost}(\, t - (t_0 + t_i) \,|\, t_i\,)\; \mathbb{P}(\, t_0, t_i \,|\, T_+^p(x), T_-^p(x), T_+^a(x), T_-^a(x), T_s(x)\,).$$

Although these quantities are derived from the posterior values of the above Bayesian estimation, we will sometimes refer to them as prior or raw incidence and infectiousness, because they are used as inputs to the second Bayesian step described below, which yields a posterior estimate of incidence among other quantities.

Likelihood and probability of transmission links

Whereas the derivation of transmission probabilities from likelihoods we reviewed above uses a serial interval distribution applied to the intervals between cases' reporting dates, we have multiple dates describing the disease progression of each individual, and so we must adapt the method. We note that the serial interval from case x to y is in fact the sum of multiple intervals: the interval from onset of x's symptoms to transmission from x to y, plus the interval from infection of y to onset of symptoms of y, plus the interval from symptom onset of y to detection of y, minus the interval from symptom onset of x to detection of x. It can

also be decomposed as the interval from the transmission date to detection of y, plus the interval from detection date of x to the transmission event. Given distributions $w_i(s)$ and $w_\lambda(s)$ of incidence and daily infectiousness at s days after the detection of a case, the serial interval distribution is expressed by a convolution of probability distributions:

$$\sigma(\Delta t) = \sum_s w_\lambda(s)\ w_i(s - \Delta t),$$

where $w_\lambda(s)\ w_i(s - \Delta t)$ is the probability that the transmission event occurred s days after the detection of case x and that case y was detected Δt days after case x, given transmission from x to y.

We use this formulation without case detection dates, to construct likelihoods of transmission events from the distributions w_i and w_λ, together with daily movements of individuals. When two individuals x, y have the same location on a given day t, we derive a likelihood of transmission from x to y on day t from their infectiousness and incidence, respectively:

$$w(x \to y, t) = w_\lambda(x, t)\ w_i(y, t).$$

When their locations are not the same, transmission is assumed less likely by a factor $\alpha < 1$.

We model one CDCR institution at a time, while individual prison residents are sometimes moved from one institution to another. We assume transmission between specific residents to have zero likelihood when either is not at the institution being modeled. Instead, to avoid pathological results, we assume a constant probability of infection λ_{outside} applied to individuals on days they are not at the institution. Similarly, we assume a constant small force of infection λ_{inside} on residents within the institution, to allow for the possibility of transmission to residents from staff, visitors, or other sources.

Let $B(x, t)$ stand for the location (building) of x on day t, and let F stand for the set of locations that are within the institution being modeled. Then the above likelihood generalizes to

$$\begin{aligned} w(x \to y, t) &= L(\, x \to y \text{ on day } t \,|\, T(x) = T_x, T(y) = T_y \,) \\ &= \begin{cases} w_\lambda(x, t)\ w_i(y, t) & \text{if } B(x, t) = B(y, t), B(x, t) \in F, B(y, t) \in F, \\ \alpha\ w_\lambda(x, t)\ w_i(y, t) & \text{if } B(x, t) \neq B(y, t), B(x, t) \in F, B(y, t) \in F, \\ 0 & \text{otherwise.} \end{cases} \end{aligned}$$

Along with that, the above constant infection rates provide a likelihood that a case is an index case, that is, one whose transmission source is outside the population being modeled:

$$\begin{aligned} w_{\text{index}}(y, t) &= L(\, y \text{ an index case on day } t \,|\, T(y) = T_y \,) \\ &= \begin{cases} \lambda_{\text{inside}}\ w_i(y, t) & \text{if } B(y, t) \in F, \\ \lambda_{\text{outside}}\ w_i(y, t) & \text{otherwise.} \end{cases} \end{aligned}$$

For notational purposes that will be helpful below, we notate the above as

$$w(x \to y, t) = \alpha(x, y, t)\ w_\lambda(x, t)\ w_i(y, t),$$

where $\alpha(x, y, t)$ is either 1, α, or 0, and

$$w_{\text{index}}(y, t) = \lambda_{\text{index}}(y, t)\ w_i(y, t),$$

where $\lambda_{\text{index}}(y, t)$ is either λ_{inside} or λ_{outside}.

Let $T_x = (T^p_+(x), T^p_-(x), T^a_+(x), T^a_-(x), T_s(x))$ be the list of dates recorded for each case x, for brevity, and let $T(x)$ be the random variable from which that is sampled. We can then use the various above likelihoods to infer transmission probabilities per pair per day, by Bayesian inference with an uninformed prior assumption of uniform probability c for values of the T vector, and uniform probability d of transmission per pair per day:

$$\begin{aligned}
p(x \to y, t) &= \mathbb{P}(\, x \to y \text{ on day } t \,|\, T(z) = T_z \text{ for all } z\,) \\
&= \frac{\mathbb{P}(\, T(z) = T_z \text{ for all } z \,|\, x \to y \text{ on day } t\,)\ \mathbb{P}(\, x \to y \text{ on day } t\,)}{\mathbb{P}(\, T(z) = T_z \text{ for all } z\,)} \\
&= \mathbb{P}(\, T(z) = T_z \text{ for all } z \,|\, x \to y \text{ on day } t\,)\ \mathbb{P}(\, x \to y \text{ on day } t\,)\ / \\
&\quad \Big[\sum_{t'} \Big[\ \sum_{x' \neq y} \mathbb{P}(\, T(z) = T_z \text{ for all } z \,|\, x' \to y \text{ on day } t'\,)\, \mathbb{P}(\, x' \to y \text{ on day } t'\,) + \\
&\qquad \mathbb{P}(\, T(z) = T_z \text{ for all } z \,|\, y \text{ an index case on day } t'\,)\, \mathbb{P}(\, y \text{ an index case on day } t'\,)\ \Big]\Big];
\end{aligned}$$

or

$$\begin{aligned}
p(x \to y, t) &= \frac{c^{N-2}\, w(x \to y, t)\, d}{\sum_{t'} \Big[\sum_{x' \neq y} c^{N-2}\, w(x' \to y, t')\, d + c^{N-1}\, w_{\text{index}}(y, t')\Big]} \\
&= \frac{w(x \to y, t)}{\sum_{t'} \Big[\sum_{x' \neq y} w(x' \to y, t') + (c/d)\, w_{\text{index}}(y, t')\Big]}.
\end{aligned}$$

The constant factor c/d can be absorbed into the values of the constants λ_{inside} and λ_{outside}.

These transmission link probabilities do not in general sum to one, because there is some probability of being an index case:

$$p_{\text{index}}(y, t) = \frac{(c/d)\, w_{\text{index}}(y, t)}{\sum_{t'} \Big[\sum_{x' \neq y} w(x' \to y, t') + (c/d)\, w_{\text{index}}(y, t')\Big]}.$$

Estimation of effective reproduction number

Since this procedure estimates the timing as well as source of each case's infection, it can be used to estimate both case and effective reproduction numbers. An individual's case reproduction number is estimated as in the standard Wallinga-Teunis method. The total probability of transmission from x to y is $p(x \to y) = \sum_t p(x \to y, t)$, and the case reproduction number is

$$R(x) = \sum_y p(x \to y).$$

If needed, this estimate can be adjusted as in [3] when some of case x's infectious period was spent away from the institution, or had not yet been observed when the data was recorded.

An effective reproduction number R_t is a description of conditions at a moment in time, equal to the number of cases that would be produced by a case over the case's entire history, if those conditions were held constant. The relation between case and instantaneous reproduction numbers is the reconstruction of the case $R(x)$ from the instantaneous $R_t(x,t)$ over time:

$$R(x) = \sum_t R_t(x,t)\, w_\lambda(x,t).$$

These conditions can be satisfied by defining an individual's effective reproduction number on day t as a ratio of incidence to infectiousness:

$$R_t(x,t) = \sum_y p(x \to y, t)/w_\lambda(x,t).$$

Here we present a mathematical derivation of this estimate, and a means of estimating its variance and confidence intervals.

For notation, assume a population $\mathbf{X}$ of individuals. Every case y has an unknown day of infection $t_0(y)$. Every non-index case has an unknown source case $s(y)$ and we can put $s(y) = \emptyset$ for an index case. A transmission network is a choice of two values per case for these unknowns:

$$\mathbf{T} = (\,(s_y, t_y) \text{ for } y \in \mathbf{X}\,).$$

The Wallinga-Teunis estimate of transmission links assumes that the source case and infection date of one case are independent of others', so that the probability structure is the product of their probabilities:

$$\begin{aligned}\mathbb{P}(\,\mathbf{T} = (\,(s_y, t_y) \text{ for } y \in \mathbf{X}\,) \,|\, \text{data}\,) &= \prod_{y \in \mathbf{X}} \mathbb{P}(\,(s(y), t_0(y)) = (s_y, t_y) \,|\, \text{data}\,) \\ &= \prod_{y \in \mathbf{X}} p(s_y \to y, t_y).\end{aligned}$$

Assume each individual x has an unobserved daily effective reproduction number $R_t(x,t)$, and generates a Poisson number of secondary cases with mean $R_t(x,t)\,w_\lambda(x,t)$ on day t.

We want a probability structure for the variables $R_t(x,t)$ based on data, which we will derive using the Wallinga-Teunis estimate for transmission networks:

$$\begin{aligned}
&\mathbb{P}(\, R_t(x,t) = R_{x,t} \text{ for all } x,t \,|\, \text{data}\,) \\
&\quad = \sum_{\text{all networks } \mathbf{T}} \mathbb{P}(\, R_t(x,t) = R_{x,t} \text{ for all } x,t \,|\, \mathbf{T} = (\,(s_y,t_y)\,)\,)\;\mathbb{P}(\,\mathbf{T} = (\,(s_y,t_y)\,) \,|\, \text{data}\,)
\end{aligned}$$

The second factor of that expression is the Wallinga-Teunis estimate. The first factor needs to be defined using Bayes's theorem. For readability let $dR_{x,t}$ be shorthand for the infinitesimal interval $[R_{x,t}, R_{x,t} + dR_{x,t})$:

$$\begin{aligned}
&\mathbb{P}(\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t \,|\, \mathbf{T} = (\,(s_y,t_y)\,)\,) \\
&\quad = \frac{\mathbb{P}(\,\mathbf{T} = (\,(s_y,t_y)\,) \,|\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t\,)}{\mathbb{P}(\,\mathbf{T} = (\,(s_y,t_y)\,)\,)} \\
&\quad = \frac{\mathbb{P}(\,\mathbf{T} = (\,(s_y,t_y)\,) \,|\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t\,)}{\int \mathbb{P}(\,\mathbf{T} = (\,(s_y,t_y)\,) \,|\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t\,)}
\end{aligned}$$

The likelihood of a network given a collection of R_t values depends on each R_t only through the number of secondary cases attributed to it: let $r_{x,t}(\mathbf{T}) = \#\{y | (s_y,t_y) = (x,t)\}$ where $\mathbf{T} = (\,(s_y,t_y)\,)$, and

$$\begin{aligned}
&\mathbb{P}(\,\mathbf{T} = (\,(s_y,t_y)\,) \,|\, R_t(x,t) = R_{x,t} \text{ for all } x,t\,) \\
&\quad = \prod_{x,t} \mathbb{P}(\,\#\{(s(y),t_0(y)) = (x,t)\} = r_{x,t}(\mathbf{T}) \,|\, R_t(x,t) = R_{x,t}\,) \\
&\quad = \prod_{x,t} \frac{(R_{x,t}\,w_\lambda(x,t))^{r_{x,t}(\mathbf{T})}\,e^{-R_{x,t}\,w_\lambda(x,t)}}{r_{x,t}(\mathbf{T})!}.
\end{aligned}$$

We take an uninformative prior for R_t defined by $R_t(x,t)\,w_\lambda(x,t) \sim \text{Gamma}(\varepsilon,\varepsilon)$ with vanishingly small ε, independent for each x,t. Independence gives us

$$\begin{aligned}
&\mathbb{P}(\, R_t(x,t) \in dR_{x,t} \text{ for all } x,t \,|\, \mathbf{T} = (\,(s_y,t_y)\,)\,) \\
&\quad = \frac{\prod_{x,t} \mathbb{P}(\,\#\{(s(y),t_0(y)) = (x,t)\} = r_{x,t}(\mathbf{T}) \,|\, R_t(x,t) = R_{x,t}\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t}\,)}{\int \prod_{x,t} \mathbb{P}(\,\#\{(s(y),t_0(y)) = (x,t)\} = r_{x,t}(\mathbf{T}) \,|\, R_t(x,t) = R_{x,t}\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t}\,)} \\
&\quad = \frac{\prod_{x,t} \mathbb{P}(\,\#\{(s(y),t_0(y)) = (x,t)\} = r_{x,t}(\mathbf{T}) \,|\, R_t(x,t) = R_{x,t}\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t}\,)}{\prod_{x,t} \int \mathbb{P}(\,\#\{(s(y),t_0(y)) = (x,t)\} = r_{x,t}(\mathbf{T}) \,|\, R_t(x,t) = R_{x,t}\,)\;\mathbb{P}(\, R_t(x,t) \in dR_{x,t}\,)} \\
&\quad = \prod_{x,t} \mathbb{P}(\, R_t(x,t) \in dR_{x,t} \,|\, \mathbf{T} = (\,(s_y,t_y)\,)\,)
\end{aligned}$$

where each $R_t(x,t)$ can be inferred independently from $\mathbf{T}$ using only the relevant number of secondary cases.

To infer a posterior distribution from the number of secondary cases, we note that the gamma distribution is a conjugate prior for the Poisson distribution of events, and the posterior is known to be

$$R_t(x,t)\, w_\lambda(x,t) \sim \text{Gamma}(\, r_{x,t}(\mathbf{T}), 1\,)$$

(we take $w_\lambda(x,t)$ as a known constant for these steps), which makes the mean of $R_t(x,t)$ equal to $r_{x,t}(\mathbf{T})/w_\lambda(x,t)$ and its variance $r_{x,t}(\mathbf{T})/w_\lambda(x,t)^2$.

Returning to the problem of estimation from data, let $G(\, R \,|\, r_{x,t}(\mathbf{T})\,)$ be the density function of the above gamma distribution, then

$$\begin{aligned}
&\mathbb{P}(\, R_t(x,t) \in dR_{x,t} \,|\, \text{data}\,) \\
&\quad = \sum_{\text{all networks } \mathbf{T}} \mathbb{P}(\, R_t(x,t) \in dR_{x,t} \,|\, \mathbf{T}\,)\; \mathbb{P}(\, \mathbf{T} = (\,(s_y,t_y)\,) \,|\, \text{data}\,) \\
&\quad = \sum_{\text{all networks } \mathbf{T}} G(\, R_{x,t} \,|\, r_{x,t}(\mathbf{T})\,)\, dR_{x,t}\; \mathbb{P}(\, \mathbf{T} = (\,(s_y,t_y)\,) \,|\, \text{data}\,) \\
&\quad = \sum_r G(\, R_{x,t} \,|\, r\,)\, dR_{x,t}\; \mathbb{P}(\, r_{x,t}(\mathbf{T}) = r \,|\, \text{data}\,).
\end{aligned}$$

The random variable $r_{x,t}(\mathbf{T})$ is a sum of Bernoulli random variables,

$$r_{x,t}(\mathbf{T}) = \sum_y 1(x \to y, t),$$

whose probabilities $p(x \to y, t)$ are known. The expected value of $R_t(x,t)$ is then

$$\begin{aligned}
\mathbb{E}(\, R_t(x,t) \,|\, \text{data}\,) &= \sum_r \mathbb{E}(\, R_{x,t} \,|\, r\,)\; \mathbb{P}(\, r_{x,t}(\mathbf{T}) = r \,|\, \text{data}\,) \\
&= \sum_r (r/w_\lambda(x,t))\; \mathbb{P}(\, r_{x,t}(\mathbf{T}) = r \,|\, \text{data}\,) \\
&= \mathbb{E}(\, r_{x,t}(\mathbf{T}) \,|\, \text{data}\,)/w_\lambda(x,t) \\
&= \frac{\sum_y p(x \to y, t)}{w_\lambda(x,t)}.
\end{aligned}$$

Assuming the effective number of terms of the sum is reasonably large, a normal approximation can be used to estimate confidence intervals for $R_t(x,t)$ numerically, using its mean

and variance:

$$\begin{aligned}
\mathrm{Var}(\, R_t(x,t) \,|\, \mathrm{data}\,) &= \sum_r \mathrm{Var}(\, R_{x,t} \,|\, r\,)\ \mathbb{P}(\, r_{x,t}(\mathbf{T}) = r \,|\, \mathrm{data}\,) \\
&= \sum_r (r / w_\lambda(x,t)^2)\ \mathbb{P}(\, r_{x,t}(\mathbf{T}) = r \,|\, \mathrm{data}\,) \\
&= \mathbb{E}(\, r_{x,t}(\mathbf{T}) \,|\, \mathrm{data}\,) / w_\lambda(x,t)^2 \\
&= \frac{\sum_y p(x \to y, t)}{w_\lambda(x,t)^2}.
\end{aligned}$$

Because of the role of the infectiousness profile $w_\lambda()$ in the relation between R_t and case reproduction numbers, we consider $w_\lambda()$ to be a natural weighting for the daily reproduction numbers, and use it as a weighting for the R_t values when constructing statistics and data visualization. When considering R_t values at the level of housing units, we use the sum of infectiousness over the housing unit as a weighting term.

Effective reproduction number at aggregate level

Is the effective reproduction number in a building best estimated by the average of individuals' R_t? What is its distribution? Here we estimate it directly from the transmission network distribution.

Using the notation from the previous section, we posit a single unobserved parameter $R_t(A,t)$ associated with location A on day t, such that transmissions from individuals in location A are a Poisson process with rate $R_t(A,t)\, w_\lambda(A,t)$, with $w_\lambda(A,t) = \sum_{\{\, x \,|\, B(x,t)=A \,\}} w_\lambda(x,t)$, and estimate the value of $R_t(A,t)$ directly.

Given a transmission network $\mathbf{T}$, the number of transmission events from A at t is

$$\begin{aligned}
r_{A,t}(\mathbf{T}) &= \sum_{\{x | B(x,t)=A\}} \sum_y 1(x \to y, t) \\
&= \sum_{\{x | B(x,t)=A\}} r_{x,t}(\mathbf{T}).
\end{aligned}$$

An uninformative gamma prior for $R_t(A,t)$ gives a posterior estimate of

$$R_t(A,t)\, w_\lambda(A,t) \sim \mathrm{Gamma}(r_{A,t}(\mathbf{T}), 1),$$

with mean $\mathbb{E}(R_t(A,t)|\mathbf{T}) = r_{A,t}(\mathbf{T}) / w_\lambda(A,t)$ and variance $\mathrm{Var}(R_t(A,t)|\mathbf{T}) = r_{A,t}(\mathbf{T}) / w_\lambda(A,t)^2$.

Across realizations of the transmission network, we obtain

$$\begin{aligned}\mathbb{P}(\, R_t(A,t) \in dR_{A,t} \,|\, \text{data}\,) \\ &= \sum_{\mathbf{T}} \mathbb{P}(\, R_t(A,t) \in dR_{A,t} \,|\, \mathbf{T}\,)\, P(\, \mathbf{T} = (\,(s_y, t_y)\,)\,|\,\text{data}\,) \\ &= \sum_{\mathbf{T}} G(\, R_{A,t} \,|\, r_{A,t}(\mathbf{T})\,)\, dR_{A,t}\, P(\, \mathbf{T} = (\,(s_y, t_y)\,)\,|\,\text{data}\,) \\ &= G(\, R_{A,t} \,|\, r\,)\, dR_{A,t}\, P(\, r_{A,t}(\mathbf{T}) = r \,|\, \text{data}\,).\end{aligned}$$

As with $R_t(x,t)$, the estimate of $R_t(A,t)$ from data is a mixture of gamma variables with mean

$$\begin{aligned}\mathbb{E}(\, R_t(A,t) \,|\, \text{data}\,) &= \sum_{\{x|B(x,t)=A\}} \sum_y p(x \to y, t)/w_\lambda(A,t) \\ &= \sum_{\{x|B(x,t)=A\}} \frac{w_\lambda(x,t)}{w_\lambda(A,t)} \mathbb{E}(R_t(x,t)|\text{data})\end{aligned}$$

and variance

$$\begin{aligned}\text{Var}(\, R_t(A,t) \,|\, \text{data}\,) &= \sum_{\{x|B(x,t)=A\}} \sum_y p(x \to y, t)/w_\lambda(A,t)^2 \\ &= \frac{\sum_{\{x|B(x,t)=A\}} w_\lambda(x,t)^2 \,\text{Var}(R_t(x,t)|\text{data})}{w_\lambda(A,t)^2}.\end{aligned}$$

This means the mean estimate is a weighted average of the individual means by infectiousness, not a straight average, and the variance is smaller than the individual estimates' variances, because $w_\lambda(x,t) < 1$.

Estimation of other observables

The probability that an individual was infected on a given day is

$$I(y,t) = \sum_x p(x \to y, t) + p_{\text{index}}(y,t).$$

This can be termed the expected incidence of case y on day t. Note that this is the posterior incidence mentioned earlier, in distinction to the prior incidence $w_i(y,t)$ that is estimated from test and symptom reports without taking into account likelihood of transmission events. The true incidence in a location, in terms of the number of people infected in a location on a day (in contrast to the number of cases detected per location per day), is estimated by

$$I(A,t) = \sum_{\{x|B(x,t)=A\}} I(x,t).$$

The susceptible fraction in a location is estimated in terms of the number of individuals not yet infected. Let $N(A,t)$ be the total number of individuals in location A on day t. Then individual susceptibility is estimated by

$$S(x,t) = 1 - \sum_{t'<=t} I(x,t)$$

and the susceptible fraction in a location is

$$s(A,t) = \frac{S(A,t)}{N(A,t)}$$

where $S(A,t) = \sum_{\{x|B(x,t)=A\}} S(x,t)$.

The force of infection can be estimated by the expected rate of new infections per day per susceptible individual, either for an individual or for a location. For an individual y it is

$$\lambda(y,t) = I(y,t)/S(y,t),$$

and for a location

$$\lambda(A,t) = I(A,t)/S(A,t).$$

Section 12 Supplement

CMC, California Men's Colony

- Supplemental Presentation S12.CMC

SQ, San Quentin State Prison

- Supplemental Text S12.SQ
- Supplemental Presentation S12.SQ

SATF, Substance Abuse Treatment Facility and State Prison, Corcoran

- Supplemental Presentation S12.SATF1
- Supplemental Presentation S12.SATF2

CMF, California Medical Facility

- Supplemental Text S12.CMF
- Supplemental Presentation S12.CMF

CTF, Correctional Training Facility

- Supplemental Text S12.CTF

CCWF, Central California Women's Facility

- Supplemental Presentation S12.CCWF

RJD, Richard J. Donovan Correctional Facility

- Supplemental Presentation S12.RJD

CIM, California Institution for Men

- Supplemental Presentation S12.CIM

CIW, California Institution for Women

- Supplemental Presentation S12.CIW

SOL (California State Prison, Solano)

- Supplemental Presentation S12.SOL

California State Prisons During the COVID-19 Pandemic

A Report by the CalPROTECT Project

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