Across the United States, rates of COVID-19 infection are highest in neighborhoods with people with low incomes and high proportions of people from racial and ethnic minority groups.1–4 Crowded, multigenerational housing conditions have been an important driver of these disparities.5,6 In San Francisco, single-room occupancy hotels (known as SROs) make up the largest supply of low-cost housing; SRO residents include older adults, adults with disabilities, people living with HIV, migrant workers, and children.7 Most SROs in San Francisco were built in the early 20th century; have communal toilets, showers, and kitchens; and are located in neighborhoods with high rates of chronic health conditions that increase the risk of COVID-19 morbidity,8 including asthma, diabetes, and hypertension.7 Although intended to house 1 or 2 individuals, a single 8 × 10-foot room in an

### Keywords
COVID-19, congregate living, single-room occupancy, outbreak management, disease surveillance
SRO is often shared by multigenerational families or workers with low incomes.7

Given the shared rooms and facilities and often poorly ventilated conditions in SROs, SRO residents are less able than people in traditional housing (ie, non–SRO residents) to adhere to and benefit from nonpharmaceutical interventions (NPIs), for example, social distancing and sheltering in place, which were the primary tools for COVID-19 infection prevention in the prevaccine era. To guide the deployment of preventive interventions in SROs, the San Francisco Department of Public Health (SFDPH) implemented a geocoding strategy to proactively identify COVID-19 outbreaks in SROs. Geocoding has been used to identify influenza outbreaks in long-term care facilities8 but has not previously been used as part of communicable disease surveillance and response in SROs.

**Purpose**

At the onset of the COVID-19 pandemic, in March 2020, SFDPH’s COVID Command Center established an SRO outbreak response team, and in May 2020, the San Francisco Board of Supervisors passed an emergency ordinance aimed at preventing COVID-19 in SROs.10 The SRO outbreak response team aimed to identify SRO outbreaks with the use of geocoding, deploy outbreak-responsive field testing to identify cases, and use results to support isolation and quarantine to mitigate spread. We describe the SRO outbreak response team’s multipronged response to COVID-19 prevention and outbreak control and the epidemiology of COVID-19 among people living in SROs, during a period that preceded widespread availability of COVID-19 vaccines in San Francisco.

**Methods**

**COVID-19 Case Identification and Investigation**

All laboratory-based COVID-19 test results among San Francisco residents are mandated to be reported to the SFDPH (California Code of Regulations §2500, §2593, §2641.5-2643.20, and §2800-2812 reportable diseases and conditions). As of March 2020, there were 521 SROs in San Francisco according to a list maintained by the San Francisco Department of Building Inspection.11 The SRO outbreak response team geocoded and geospatially matched the addresses of all newly reported COVID-19 test results to that list.12 First, after the SRO outbreak response team deidentified the address data within a secure structured query language (SQL) server within the SFDPH, the team extracted data using feature manipulation engine software and geocoded the data using ArcGIS World Geocoder (Esri) and the Geocoding Application Programming Interface (Google). Once the SRO outbreak response team uploaded the geocoded data back to the SQL server, an automated SQL server agent job notified the team about all people with positive test results who resided at addresses matching SRO buildings.

For each new COVID-19 case during the analytic period (from March 1, 2020, through February 28, 2021), a case investigator elicited information on close contacts and referred the close contacts to testing.13 For people with positive COVID-19 test results who were unable to safely isolate at home, including residents who shared a bedroom or bathroom, the SRO outbreak response team offered referrals to an isolation and quarantine hotel in San Francisco and to a wage-replacement program from the San Francisco Office of Economic and Workforce Development.14 Household contacts of SRO residents were also referred to these hotels, when available. SRO residents with positive COVID-19 test results and their contacts who declined rooms at isolation and quarantine hotels were offered delivery of food and other supplies.

**SRO Outbreak Response Team Response Protocol**

The SRO outbreak response team comprised multidisciplinary staff members trained in case investigation, contact tracing, and field-based outreach and education and included nurses, social workers, health workers, and staff from partnering community-based organizations. The team reviewed daily the automated list of all newly diagnosed COVID-19 cases at SRO addresses. When a first COVID-19 case was identified at an SRO address, team staff notified the property manager (without disclosing identifying information) and provided guidance about mitigating the spread of COVID-19 in SROs.15 When members of 3 households in an SRO building received a positive test result for COVID-19 within 14 days, the building was identified as experiencing an outbreak, which initiated the mobilization of field-based staff to conduct voluntary on-site testing and provide residents with COVID-19 education, supplies (eg, face masks, hand sanitizer), and referrals to resources. During on-site testing, field team nurses collected swabs for polymerase chain reaction testing for SARS-CoV-2. Additional rounds of on-site testing were conducted if COVID-19 cases suggested within-building transmission.

An outbreak was deemed to be resolved when 28 days passed with no new cases of COVID-19 among residents in the building. An SRO could have multiple outbreaks during the analytic period. The SRO outbreak response team considered all COVID-19 cases identified from the date of an on-site SRO testing event until the outbreak had resolved as “SRO outbreak cases,” regardless of whether residents were tested on-site or at another location.

**Outcome Measures and Data Analysis**

We selected the analytic period as the first year of the COVID-19 pandemic because NPIs, case findings, and isolation and quarantine were the primary tools for the mitigation of COVID-19 and COVID-19 vaccines were not yet widely...
We calculated test positivity from all conclusive tests + number of negative tests). We compared the 3-month test positivity rate among SRO residents with COVID-19 cases among non–SRO residents to have 1 or more comorbidities and be asymptomatic at the time of the case interview (Table 1). Among SRO residents, SRO outbreak cases did not differ from SRO non-outbreak cases in median age, sex, race and ethnicity, or known comorbidity, but were more likely to speak Spanish.

Although SRO residents accounted for 2.1% to 3.2% of the total San Francisco population, in spring 2020, they represented 7.2% of people in San Francisco diagnosed with COVID-19. The proportion of COVID-19 cases among SRO residents decreased during the analytic period (4.8% in summer, 2.4% in autumn, and 2.9% in winter). The 3-month case rate per 100 000 population in spring 2020 was significantly higher among SRO residents (617.4 [95% CI, 575.4-767.4] to 1044.4 [95% CI, 895.1-1193.7]) than among San Francisco residents overall (301.9 [95% CI, 290.4-313.5]). For the remainder of the analytic period, the 3-month case rate among SRO residents was lower or not significantly
different from San Francisco residents, based on nonoverlapping 95% CIs (data not shown).

The proportion of deaths from COVID-19 among SRO residents, by period, was 5.8% in spring, 7.5% in summer, 2.7% in autumn, and 3.6% in winter. During the entire analytic period, the case fatality rate among SRO residents was 1.8% (95% CI, 1.1%-2.6%) compared with 1.5% (95% CI, 1.4%-1.7%) citywide. The death rate per 100 000 population was either the same or higher among SRO residents (78.6 [95% CI, 45.7-111.4] to 122.2 [95% CI, 71.1-173.3]) compared with San Francisco residents (60.3 [95% CI, 55.2-65.5]). During the worst COVID-19 surge of the year, if the upper limit of the citywide death rate of 39.1 (95% CI, 34.9-43.3) (ie, 43.3 deaths per 100 000 people) was applied to the upper estimate of the SRO population (28 000), at most 12 deaths would be expected. During this period, 12 residents of SROs had died.

The SRO outbreak response team responded to outbreaks at 52 SROs, which involved 421 cases of COVID-19 (35% of all SRO resident cases). The proportion of positive test results was consistently and significantly higher in outbreak SROs than in non-outbreak SROs and versus non–SRO residents throughout the analytic period (Table 2).

**Lessons Learned**

Consistent with the concern that SRO residents would be at elevated risk for COVID-19 acquisition and morbidity, in spring 2020, SRO residents had a significantly higher case rate and represented a disproportionate number of COVID-19 deaths as compared with the general population in San Francisco. During this period, citywide shelter-in-place orders were in effect; however, because many SRO residents are essential workers living in a crowded congregate setting, the protective benefit of shelter-in-place was minimal in this population. For the remainder of the analytic period (through February 28, 2021) and despite 2 COVID-19 surges, a disparity in COVID-19 case rates for SRO residents did not occur. The relative incidence of COVID-19 and the proportion of COVID-19 deaths among SRO residents both declined after the first 3 months of the pandemic and was proportionate to the rate among the general population of San Francisco by winter 2021. The Latinx community in San Francisco was disproportionately affected by COVID-19, as reflected in the number of COVID-19 cases among SRO residents and SRO outbreak cases in particular.

The use of geocoding to identify SROs with outbreaks and rapidly deploy on-site testing enabled the SRO outbreak response team to promptly identify and isolate cases and quarantine contacts. The higher proportion of asymptomatic (vs symptomatic) COVID-19 cases among SRO residents suggested that an outbreak-responsive, mass testing strategy was effective in identifying people with presymptomatic or asymptomatic COVID-19 who might have experienced delayed diagnosis or none at all without this strategy. Modeling studies support the hypothesis that case finding and contact tracing, when combined with effective isolation and quarantine, can interrupt transmission chains and avert hospitalizations.
Table 1. Characteristics of confirmed COVID-19 cases among non–SRO and SRO residents, San Francisco, California, March 1, 2020–February 28, 2021\textsuperscript{a}

| Characteristic | Non–SRO residents\textsuperscript{b} (n = 34 155) | All residents\textsuperscript{b} (n = 1201) | Non-outbreak cases\textsuperscript{c} (n = 780) | Outbreak cases\textsuperscript{c} (n = 421) |
|---------------|-------------------------------------------------|---------------------------------|----------------------------------|----------------------------------|
| People interviewed | 22 675 (66.4) | 897 (74.7)\textsuperscript{d} | 563 (72.2) | 334 (79.3) |
| Race and ethnicity | | | | |
| Asian | 6154 (18.0) | 236 (19.7) | 166 (21.3) | 70 (16.6) |
| Black or African American | 1957 (5.7) | 80 (6.7) | 52 (6.7) | 28 (6.7) |
| Hispanic or Latino/a, all races | 14 165 (41.5) | 585 (48.7)\textsuperscript{d} | 361 (46.3) | 224 (53.2) |
| White | 7385 (21.6) | 180 (15.0)\textsuperscript{d} | 133 (17.1) | 47 (11.2) |
| Language | | | | |
| Cantonese or Mandarin | 1027 (3.0) | 100 (8.3)\textsuperscript{d} | 61 (7.8) | 39 (9.3) |
| English | 16 241 (48.8) | 437 (36.4)\textsuperscript{d} | 311 (39.9) | 126 (29.9) |
| Spanish | 9090 (26.6) | 468 (39.0)\textsuperscript{d} | 265 (34.0)\textsuperscript{e} | 203 (48.2) |
| Sex | | | | |
| Female | 16 046 (47.0) | 376 (31.3)\textsuperscript{d} | 259 (33.2) | 117 (27.8) |
| Male | 17 885 (52.4) | 813 (67.7)\textsuperscript{d} | 510 (65.4) | 303 (72.0) |
| Age group, y | | | | |
| <18 | 3846 (11.3) | 74 (6.2)\textsuperscript{d} | 30 (3.9)\textsuperscript{e} | 44 (10.5) |
| 18-30 | 8954 (26.2) | 226 (18.8)\textsuperscript{d} | 162 (20.8) | 64 (15.2) |
| 31-40 | 7448 (21.8) | 248 (20.7) | 154 (19.7) | 94 (22.3) |
| 41-50 | 4994 (14.6) | 213 (17.7)\textsuperscript{d} | 143 (18.3) | 70 (16.6) |
| 51-60 | 3825 (11.2) | 189 (15.7)\textsuperscript{d} | 128 (16.4) | 61 (14.5) |
| 61-70 | 2527 (7.4) | 158 (13.2)\textsuperscript{d} | 104 (13.3) | 54 (12.8) |
| 71-80 | 1333 (3.9) | 63 (5.3) | 42 (5.4) | 21 (5.0) |
| ≥81 | 1224 (3.6) | 30 (2.5) | 17 (2.2) | 13 (3.1) |
| Age, median (IQR), y | 36 (26-51) | 43 (31-58)\textsuperscript{d} | 43 (31-57) | 42 (30-58) |
| No. of symptoms\textsuperscript{f} | | | | |
| 0 | 4983 (14.6) | 251 (20.9)\textsuperscript{d} | 106 (13.6)\textsuperscript{e} | 145 (34.4) |
| ≥1 | 21 557 (63.1) | 735 (61.2) | 513 (65.8)\textsuperscript{e} | 222 (52.7) |
| Unknown | 7615 (22.3) | 215 (17.9)\textsuperscript{d} | 161 (20.6)\textsuperscript{e} | 54 (12.8) |
| No. of comorbidities\textsuperscript{g} | | | | |
| 0 | 11 788 (34.5) | 434 (36.1) | 269 (34.5) | 165 (39.2) |
| ≥1 | 6459 (18.9) | 352 (29.3)\textsuperscript{d} | 215 (27.6) | 137 (32.5) |
| Unknown | 15 908 (46.6) | 415 (34.6)\textsuperscript{d} | 296 (38.0)\textsuperscript{e} | 119 (28.3) |
| Deaths | 525 (1.5) | 23 (1.9) | 16 (2.1) | 7 (1.7) |

Abbreviations: IQR, interquartile range; SRO, single-room occupancy hotel.
\textsuperscript{a}SROs are defined by San Francisco Administrative Code Section 41.4.11 Confirmation of SARS-CoV-2 infection was made by nucleic acid amplification testing. Non–SRO residents were residents of San Francisco residing in other settings.
\textsuperscript{b}Unless otherwise indicated.
\textsuperscript{c}Cases were considered outbreak cases when 3 households in the SRO building tested positive for COVID-19 within 14 days; cases were considered non-outbreak cases when COVID-19 cases occurred in SRO buildings without outbreaks.
\textsuperscript{d}Significantly different (\textit{P} < .05) from the corresponding value for non–SRO residents in unadjusted logistic regression models with SEs adjusted for clustering by address.
\textsuperscript{e}Significantly different (\textit{P} < .05) from the corresponding value for SRO outbreak cases in unadjusted logistic regression models with SEs adjusted for clustering by address.
\textsuperscript{f}Significantly different (\textit{P} < .05) from the corresponding value for non–SRO residents based on Wilcoxon rank sum (Mann–Whitney) test.
\textsuperscript{g}Cough, fever, headache, muscle ache, lack of smell or taste, chills, rhinorrhea, sore throat, shortness of breath, diarrhea, abdominal pain, vomiting.
\textsuperscript{h}Former or current smoker, cardiovascular disease, diabetes, lung disease, immune compromised condition, neurological disease, liver disease, renal disease.
Bringing linguistically and culturally appropriate testing and prevention services to SROs is an effective way of reaching a population that is vulnerable to acquisition of COVID-19. The SRO outbreak response team and community-based partners provided services beyond testing, such as linkages to eviction prevention and delivery of food, diapers, and formula. A similar “Test to Care” model in San Francisco demonstrated that providing supportive services as part of a package with testing helped facilitate isolation and quarantine.20

Because our study was an observational analysis, we had several unknowns with regard to the effects that the SRO outbreak response team had on stopping the spread of COVID-19 in SROs and minimizing COVID-19 morbidity and mortality among SRO residents; thus, we cannot claim that the SRO outbreak response team had a causal effect on the epidemiology of COVID-19 in SROs. Although the team encouraged NPIs (eg, social distancing, wearing face masks, seeking testing when symptomatic), we could not differentiate the impact of these NPIs on COVID-19 spread from other efforts of the SRO outbreak response team. Differential changes in testing behavior of SRO residents versus non–SRO residents may have contributed to changes in relative case rates over time. The 4 periods that we compared in this analysis combined months that had different case rates; thus, we may have underestimated magnitudes of differences between the periods. Because of the lack of precise information about the size and demographic characteristics of the SRO population during the analytic period, we could not estimate one rate for SRO residents or determine whether observed differences reflected characteristics of SRO residents in general or characteristics of the subgroup of SRO residents who became infected. Death rates were not age-adjusted, and rates calculated from small numbers of cases may be unstable. Some of the asymptomatic cases identified through mass testing likely represented previous infections rather than recent infections.

Geocoding of newly reported COVID-19 cases facilitates prompt identification of outbreaks in a congregate setting and targets deployment of mass testing, which is critical to controlling outbreaks. Although our group focused on SROs, these methods can be applied to any setting for which a list of addresses is available. This case study illustrates that it is possible to mobilize a multidisciplinary group to reach out to a diverse population at risk of infection and morbidity during a pandemic and provides a foundation for future public health work in this community.

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Table 2. Average COVID-19 positivity rate by single-room occupancy hotel (SRO) residency and outbreak status, San Francisco, California, March 1, 2020–February 28, 2021

| Category                        | Spring (March 1–May 31, 2020) | Summer (June 1–August 31, 2020) | Autumn (September 1–November 30, 2020) | Winter (December 1, 2020–February 28, 2021) | Annual total |
|---------------------------------|-------------------------------|---------------------------------|----------------------------------------|---------------------------------------------|--------------|
| SRO outbreak cases             |                               |                                 |                                        |                                             |              |
| Unduplicated                   | 64                            | 167                             | 31                                     | 159                                         | 421          |
| Negative test                  | 135                           | 578                             | 340                                    | 2143                                        | 3196         |
| Positivity rate, % (95% CI)    | 33.8 (27.3-40.3)              | 24.8 (21.7-27.8)                | 8.4 (5.5-11.1)                         | 7.5 (6.4-8.5)                               | 12.7 (11.5-13.7) |
| SRO non-outbreak cases         |                               |                                 |                                        |                                             |              |
| Unduplicated                   | 124                           | 174                             | 128                                    | 354                                         | 780          |
| Negative tests                 | 944                           | 2033                            | 3609                                   | 7373                                        | 13 959       |
| Positivity rate, % (95% CI)    | 14.7 (12.6-16.8)              | 10.2 (9.0-11.4)                 | 4.0 (3.3-4.6)                         | 5.4 (4.9-5.9)                               | 6.4 (6.0-6.8) |
| Non–SRO residents              |                               |                                 |                                        |                                             |              |
| Unduplicated                   | 2439                          | 6762                            | 6358                                   | 17 395                                      | 32 954       |
| Negative tests                 | 25 017                        | 91 503                          | 176 383                                | 491 652                                     | 784 555      |
| Positivity rate, % (95% CI)    | 11.5 (11.1-11.8)              | 8.30 (8.1-8.5)                  | 4.2 (4.2-4.3)                         | 4.1 (4.0-4.1)                               | 4.9 (4.8-4.9) |
| All San Francisco residents    |                               |                                 |                                        |                                             |              |
| Unduplicated                   | 2627                          | 7103                            | 6517                                   | 17 908                                      | 34 155       |
| Negative tests                 | 26 096                        | 94 114                          | 180 332                                | 501 168                                     | 801 710      |
| Positivity rate, % (95% CI)    | 11.7 (11.4-12.1)              | 8.5 (8.3-8.6)                   | 4.3 (4.2-4.3)                         | 4.1 (4.0-4.1)                               | 4.9 (4.9-4.9) |

aSROs are defined by San Francisco Administrative Code Section 41.4.11 Confirmation of SARS-CoV-2 infection was by polymerase chain reaction testing. Non–SRO residents were residents of San Francisco residing in other settings.
bUnless otherwise indicated.
cases were considered outbreak cases when 3 households in the SRO building tested positive for COVID-19 within 14 days; cases were considered non-outbreak cases when COVID-19 cases occurred in SRO buildings without outbreaks.
dNonoverlapping 95% CIs are significantly different (P < .05).
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