

# Assessing Testing Strategies and Duration of Quarantine in Contact Tracing for SARS-CoV-2: A Retrospective Study of San Francisco's COVID-19 Contact Tracing Program, June–August 2020

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We sought to assess the proportion of elicited close contacts diagnosed with coronavirus disease 2019 at the start of and before exiting quarantine in San Francisco. From June 8 to August 31, 6946 contacts were identified: 3008 (46.3%) were tested, 940 (13.5%) tested positive, and 90% tested positive in the first 9 days of quarantine.

**Keywords.** contact tracing; COVID-19; epidemiology; quarantine; testing.

Contact tracing, in combination with the quarantining and testing of contacts, is considered a key element of any coronavirus disease 2019 (COVID-19) response [1–3]. Mounting evidence that up to half of persons with COVID-19 are entirely asymptomatic, including contacts identified in contact tracing efforts [4–6], has highlighted the importance of ensuring that contact tracing efforts successfully link all elicited close contacts to testing during quarantine. Leveraging data from the San Francisco Department of Public Health (SFDPH) case investigation and contact tracing program [7], we aimed to investigate the proportion of elicited close contacts who developed COVID-19 during their 14-day postexposure quarantine period and the proportion of those who were asymptomatic. In addition, we sought to determine when during quarantine most

secondary cases were likely to have been identified, as to better understand if the duration of quarantine could be abbreviated for a subset of contacts, contingent of negative “exit” test.

## METHODS

Data from case investigations for all individuals with a positive severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) reverse transcriptase polymerase chain reaction (RT-PCR) test result in San Francisco from June 8 to August 31, 2020, were extracted from the public health database. Cases were defined as any individual with a laboratory-confirmed diagnosis of COVID-19. Contacts were identified by cases and defined in accordance with the current Centers for Disease Control and Prevention (CDC) criteria [8]. Close contacts were then defined as *household contacts* (HCs) if the case reported that the contact lived in the same dwelling unit and sharing common spaces or *nonhousehold contacts* (NHCs) if the case reported that the contact was exposed in a nonhousehold setting, such as workplaces, classrooms, transportation vehicles, etc. [9].

All contacts, reached by the SFDPH contact tracing team, were instructed to quarantine at home or in an isolation and quarantine hotel for 14 days following the date of last exposure to the index case, in accordance with CDC guidance at that time. Contacts were also referred for SARS-CoV-2 RT-PCR testing during quarantine regardless of symptoms. All those who tested negative at the start of quarantine were then referred for a second test toward the end of quarantine.

## Patient Consent

This work was conducted as part of SFDPH's COVID-19 surveillance; institutional review board approval and informed consent from cases and contacts were not required.

## Main Outcomes and Measures

To assess the impact of the SFDPH contact tracing program, we sought to determine (1) the proportion of contacts who were tested during their quarantine for SARS-CoV-2; (2) of those who tested negative or had an indeterminate result at the first test, those who got a second test; and (3) of all those who got tested, the overall proportion that tested positive. Sociodemographic and clinical characteristics of contacts at the initial contact tracing interview, including contact type (HCs vs NHCs), were summarized using descriptive statistics; proportions testing positive were compared using chi-square testing, with significance set at  $P = .001$ . A deterministic match based on personal identifiers was performed between contact and testing databases to (1) exclude contacts who were known to have tested positive for COVID-19 before the date of last exposure with the

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case; (2) deduplicate previously named household contacts; and (3) ascertain testing results. Survival curves for time from last exposure to positive test were plotted using the Kaplan-Meier method and compared with a log-rank test to determine the probability of testing positive. All analyses were conducted with R Statistical Software, version 4.0.2.

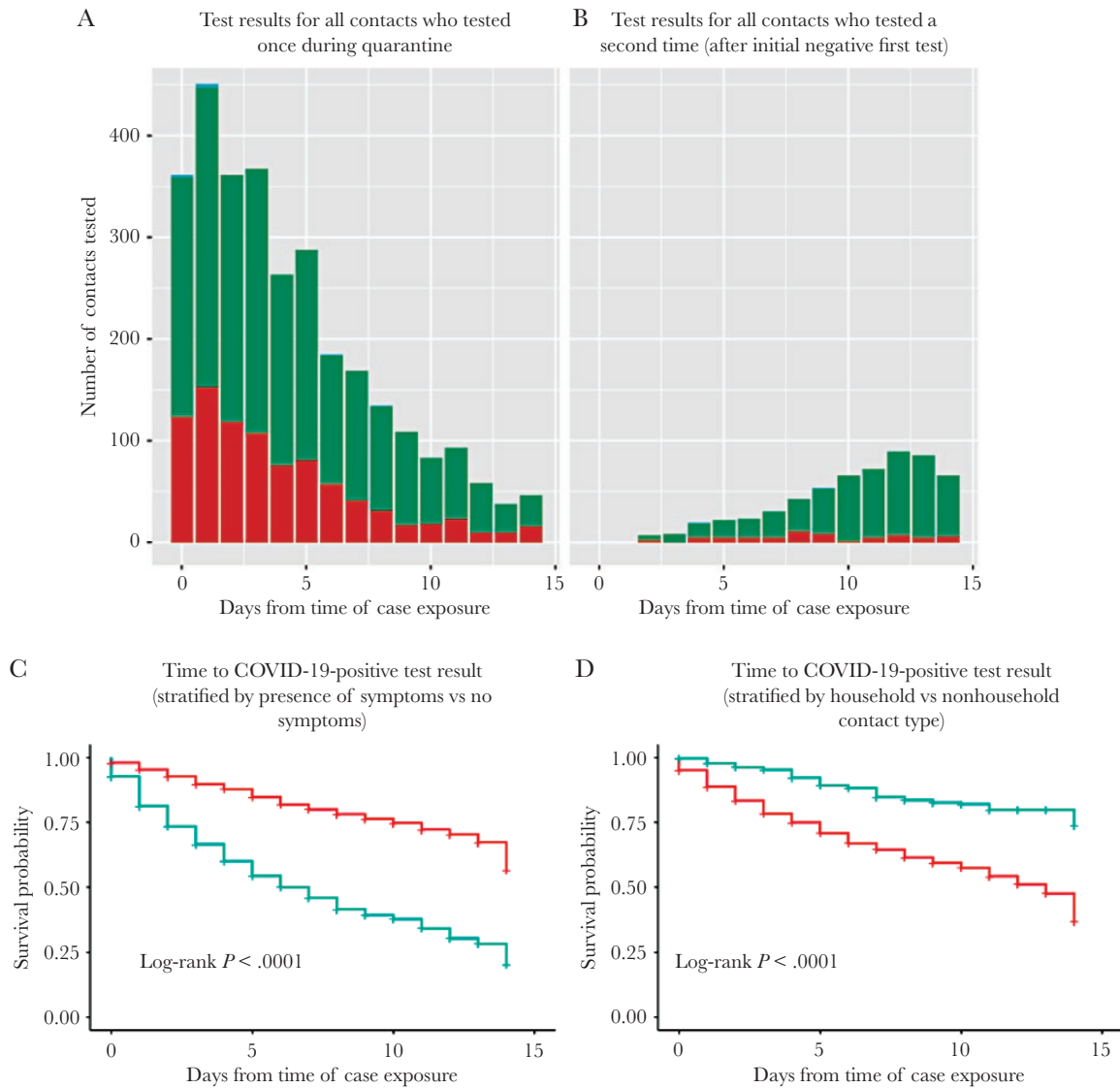
## RESULTS

### Outcomes of Case Investigation and Contact Tracing

Between June 8 and August 31, 2020, a total of 2506 laboratory-confirmed cases reported to SFDPH identified at least 1 contact. From interviews with those cases, 6946 close contacts not

previously positive for COVID-19 (in the 90 days pre-exposure) were elicited, 3008 (43.3%) of whom were tested during their postexposure window and 880 (29.3%) tested positive at their first test. Among 2128 contacts who initially tested negative, the majority ( $n = 1586$ , 72.6%) did not get retested. However, 582 (27.3%) completed a second test, and 60 (10.3%) additional positive secondary cases were identified (Figure 1A; Supplementary Tables 1–3). Notably, 90% (880/940) of all those testing positive tested positive by day 9 of quarantine.

Symptom data were collected from 4990 contacts (71.8% of all contacts elicited) during the initial interview, and, of the 1237 (24.8%) contacts endorsing symptoms, 791 (63.9%) were tested and 412 (52.1%) tested positive. Among 379



**Figure 1.** A, Histogram of test results for those tested at least once during quarantine (red indicating negative result, green indicating positive result). B, Histogram of test results for those tested a second time during quarantine, after an initial negative first test (red indicating negative result, green indicating positive result). C, Kaplan-Meier curves showing time to positive COVID test result stratified by presence of symptoms (red line representing results for contacts with no symptoms, green indicating results for contact with symptoms). D, Kaplan-Meier curves showing time to positive COVID test result, stratified by contact type (red line representing household contacts, green representing nonhousehold contacts). Abbreviation: COVID, coronavirus disease.

symptomatic contacts who initially tested negative or indeterminate, 132 (34.8%) received a second test and 23 (17.4%) subsequently tested positive (Figure 1B; Supplementary Table 4, Supplementary Figure 1). Among 3753 asymptomatic contacts, 1964 (52.3%) were tested, of whom 1601 (81.5%) had a negative or indeterminate result and 363 (18.5%) tested positive. Among 1601 asymptomatic contacts with an initial negative or indeterminate test result, 423 (26.4%) received a second test, among whom 31 (7.3%) tested positive upon repeat testing. Of the 31 secondary cases who were asymptomatic at the initial interview, 11 were symptomatic at or after the second test. Taken together, asymptomatic contacts accounted for 47.5% (394/829) of all secondary cases. Among contacts for whom symptom data were available, those with symptoms were more likely to get tested compared with those who did not have symptoms (63.9% [791/1237] vs 52.3% [1964/3753];  $P < .001$ ). Moreover, the probability of testing positive earlier in quarantine was greater among contacts with symptoms compared with those without ( $P < .001$ ) (Figure 1C).

Of 6616 contacts for whom contact type data were collected (95.2% of all contacts elicited), 5345 (80.8%) were HCs, among whom 2381 (44.5%) were initially tested and 786 (33.0%) tested positive (Supplementary Table 5). Among 1595 HCs who initially tested negative or indeterminate, 448 (28.1%) received a second test and 53 (11.8%) subsequently tested positive at a later point during quarantine. Among 1271 (19.2%) NHCs, 495 (38.9%) were tested and 68 (13.7%) tested positive. Among 427 NHCs who initially tested negative, 109 (25.5%) received a second test and 2 (1.8%) subsequently tested positive, 1 of whom had symptoms at the initial interview. Of note, 36 (51.4%) of the secondary cases identified from nonhousehold exposures reported symptoms. Among all contacts for whom contact type data were available, HCs were more likely to get tested compared with NHCs (44.5% [2381/5345] vs 25.5% [109/1271];  $P < .001$ ).

As the Kaplan-Meier curve (Figure 1D) illustrates, the probability of testing positive earlier in quarantine was greater among HCs compared with NHCs ( $P < .0001$ ; with 84.3% [59/70] of secondary cases among NHCs testing positive before day 7).

## CONCLUSIONS

To our knowledge, this is the first report assessing the utility of a 2-test strategy to ascertain the proportion of contacts who developed COVID-19 during the 14-day quarantine period after exposure to an index case. We believe that these findings have at least 3 critical programmatic implications for contact tracing programs.

First, we highlight how NHCs, especially those without symptoms, may be less likely to test positive after day 7 of quarantine. These data highlight how a longer quarantine may be unnecessary for NHCs, especially in the absence of symptoms

and contingent on a negative exit test after day 7, assuming that the exit test is performed with a highly sensitive RT-PCR assay. These findings are consistent with research elsewhere demonstrating that the secondary attack rate among NHCs is substantially lower when compared with HCs [9, 10]. Given significant social and economic costs, not to mention the public health challenges of ensuring adherence to a 14-day quarantine recommendation, our findings highlight the need for rigorous research to determine if more efficient but equally effective quarantine and testing strategies may be appropriate for NHCs. Moreover, our findings validate the current CDC guidance that a 10-day duration of quarantine for all asymptomatic close contacts is an acceptable alternative to 14 days [11].

Second, our findings underscore the importance of testing all contacts, regardless of symptoms, as 47.5% (394/829) of those testing positive endorsed no symptoms at initial interview and would have been missed if testing had been restricted to only those with symptoms. This finding builds on substantial recent research on the importance of testing asymptomatic contacts [4, 12–14].

Third, this report highlights the possible utility of repeat testing for contacts both at the start of and then before exiting quarantine. Although only 27.3% (582/2128) of all eligible contacts got a second test during quarantine, 10.3% (60/582) of those were positive. Recognizing that resource constraints and logistical challenges make repeat testing challenging, we assert that a prioritized approach to repeat testing may be helpful. First testing contacts with symptoms at the time of the start of quarantine or at the contact tracing interview, or at the onset of symptoms if symptoms develop later; and then testing asymptomatic contacts before exiting quarantine. Such an approach is supported by modeling analyses demonstrating that testing on exit from quarantine can reduce 14-day quarantine by 50% [15] and also by contact tracing programmatic data from Vermont, where testing contacts at day 7 was found to be useful in determining who could exit quarantine early [16].

## Limitations

Our analysis has several limitations. We note that the proportion of contacts who were tested is low, a reflection of the fact that even despite SFPDPH guidance recommending 2 tests, many contacts were reluctant or lacked adequate resources to get tested. We speculate that more contacts may have been tested during quarantine than captured in this analysis, including a proportion that was tested before being notified by the contact tracing team; unfortunately, the process of reconciling the contact tracing database and the COVID-19 test results database was imperfect. Rapid SARS-CoV-2 antigen detection assays were not being widely used in San Francisco at the time of this study, but have since been shown to increase speed and uptake of testing among close contacts [17]. While we note that false-negative RT-PCR results have been reported [18] and could

have led to an underestimate of the secondary attack rate among tested contacts, we speculate that this was unlikely to have impacted our findings. Finally, we only collected data on the presence of *typical* symptoms, as listed by the CDC [8], and not on less typical symptoms; as such, we may have under-reported those who had atypical presentations.

## CONCLUSIONS

This analysis provides robust evidence for tracing and testing all contacts of COVID-19 cases during quarantine. Moreover, these data support the policy of testing all elicited close contacts, regardless of symptoms, as critical to mitigating COVID-19 transmission. More research is necessary to determine if a shorter quarantine period for close contacts, in particular NHCs, contingent on robust exit testing, can minimize economic impacts as well as COVID-related public health risks.

## Supplementary Data

Supplementary materials are available at Open Forum Infectious Diseases online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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