High Community Transmission of SARS-CoV-2 Associated with Decreased Contact Tracing Effectiveness for Identifying Persons at Elevated Risk of Infection – Vermont

1. Epidemic Intelligence Service, Centers for Disease Control and Prevention, Atlanta, GA
2. Vermont Department of Health
3. Career Epidemiology Field Officer, Center for Preparedness and Response, Centers for Disease Control and Prevention, Atlanta, GA
4. CDC, COVID-19 Response Team, Centers for Disease Control and Prevention, Atlanta, GA

Corresponding author: Brian Borah, rhz7@cdc.gov

Running title: Vermont COVID-19 contact tracing
ABSTRACT

Vermont contact tracing (CT) consistently identified people at risk for COVID-19. However, the prevalence ratio (PR) of COVID-19 among contacts compared with noncontacts when viral transmission was high (PR = 13.5; 95% CI: 13.2–13.9) was significantly less than when transmission was low (PR = 49.3; 95% CI: 43.2–56.3).

Keywords: SARS-CoV-2, COVID-19, contact tracing, effectiveness, Vermont
INTRODUCTION

Case investigation and contact tracing (CICT) is a core public health activity that seeks to break chains of disease transmission and has been used for decades to control the spread of numerous communicable agents [1]. CICT starts when an infected person (index case) is interviewed and asked to identify people exposed to infection during the index case’s infectious period. Trained public health professionals then notify exposed persons to offer postexposure treatment (if available) and guidance about how to protect themselves and prevent further spread of disease. CICT programs seek to decrease disease burden across a population by focusing interventions among exposed persons they can identify; CICT is therefore effective only when the risk for infection among identified exposed persons is greater than that among the general population.

Since early 2020, CICT has been employed extensively worldwide to mitigate the spread of SARS-CoV-2, the virus that causes COVID-19. Although models [2,3] indicate CICT can slow or stop the spread of SARS-CoV-2, data concerning effectiveness are limited [1]. Moreover, CICT is time-consuming, resource-intensive, and challenging to implement [4,5]. Its success to mitigate SARS-CoV-2 spread depends on both internal performance metrics including timeliness and completeness [2,6] as well as external circumstances including viral contagiousness, asymptomatic transmission [7], public participation [6], and community disease prevalence [8].

How varying levels of these external circumstances affect COVID-19 CICT remains poorly understood.

During March 2020, the Vermont Department of Health (VDH), a centralized state health department, initiated a COVID-19 CICT program after the first Vermont resident with laboratory-confirmed SARS-CoV-2 infection was identified. During March 2020–November 2021, VDH attempted to interview every index case and notify every exposed person (close
contact) identified among the public. To compare effectiveness of Vermont’s COVID-19 CICT over time, we assessed rates of COVID-19 among close contacts and among people not identified as close contacts (noncontacts) at regular intervals throughout the pandemic.

**METHODS**

We used data from the National Electronic Disease Surveillance System Base System, a CDC-developed information system used by VDH to manage all reported electronic and non-electronic COVID-19 laboratory results from hospitalized and non-hospitalized Vermont residents and all index case interview records (including questionnaires to solicit close contacts), to identify people who sought SARS-CoV-2 reverse transcription polymerase chain reaction (RT-PCR) testing during May 3, 2020–October 30, 2021. Residents of long-term–care and correctional facilities were excluded from the analysis. Recipients of antigen tests were also excluded because these results were inconsistently reported to VDH. We stratified the analysis period into 39, two-week periods based on specimen collection date and categorized people as index cases if any of their RT-PCR test results within a two-week period were positive. People who were tested were counted only once during any two-week period, but could be included again in subsequent periods.

From index case interview records, we determined who (among those who sought RT-PCR testing) had been reported to VDH as a close contact during the 14 days before their test. VDH initially defined a COVID-19 close contact as anyone within six feet of an infected person for at least 15 consecutive minutes; this changed to 15 cumulative minutes on October 21, 2020 [9]. Test-seeking people from the general population who had not been reported to VDH as close
contacts in the preceding 14 days were categorized as noncontacts. Attack rates (ARs) and prevalence ratios (PRs) were calculated for the entire period and for each two-week period. We calculated AR as the number of persons tested positive for COVID-19 (index cases) per total people who sought testing, and PR as AR among close contacts divided by AR among noncontacts. Two-week periods were also grouped into four SARS-CoV-2 community transmission levels based on mean weekly COVID-19 incidence, as defined by CDC: low, moderate, substantial, or high transmission levels corresponded to mean weekly incidence of <10, 10–49.99, 50–99.99, and ≥100 new cases per 100,000 persons, respectively [10]. We calculated COVID-19 incidences for each two-week period using official Vermont case counts as reported by CDC [11]. PRs and 95% confidence intervals for COVID-19 among close contacts to COVID-19 among noncontacts were calculated for each transmission level. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy [12].

RESULTS
Two peaks of SARS-CoV-2 transmission occurred in Vermont during the analysis period (Figure 1a). Among 1,984,588 people who sought SARS-CoV-2 PCR testing, 34,898 (1.76%) met our index case definition; this closely approximated the case count reported by CDC (36,249 cases). Overall, 11,638 of 34,898 (33.4%) index cases were close contacts. COVID-19 ARs were 22.4% (11,638/51,930) among close contacts and 1.20% (23,260/1,932,658) among noncontacts. Median number of index cases per two-week period was 724 (range: 57–2,784 index cases). ARs among close contacts (range: 9.33%–34.6%) remained above ARs among noncontacts (range: 0.13%–2.64%) for every two-week period (Figure 1a).
Overall, prevalence of COVID-19 was 18.6 times greater among close contacts compared with noncontacts (PR = 18.6; 95% CI: 18.2–19.0). Maximum PR of COVID-19 among close contacts to COVID-19 among noncontacts was 212 (95% CI: 162–278) and occurred during October 18–October 31, 2020, when average community viral transmission level was moderate; minimum PR was 4.9 (95% CI: 4.5–5.3) and occurred during September 5–September 18, 2021 when community viral transmission level was high (Figure 1b). When two-week periods were grouped by community viral transmission level, PRs were similar for 13 periods of low viral transmission (PR = 49.3; 95% CI: 43.2–56.3) and five periods of moderate viral transmission (PR = 51.7; 95% CI: 46.1–58.0). PRs were significantly lower when viral transmission was at substantial and high levels; PR was 27.0 (95% CI: 25.6–28.4) during six periods of substantial transmission, and 13.5 (95% CI: 13.2–13.9) during 15 periods of high transmission (Figure 1c).

DISCUSSION

Vermont devoted substantial resources to its COVID-19 CICT program. RT-PCR tests, which were free for Vermont residents, were the predominant testing method used and were consistently reported to VDH regardless of result. Vermont’s CICT metrics (including percentage of index cases interviewed, percentage of index cases naming close contacts, percentage of close contacts notified, and outreach timeliness) indicate that its program performed well, compared with 13 other U.S. jurisdictions, and that the public willingly participated [5].

During every two-week period, ARs of COVID-19 among close contacts were higher than that among noncontacts, demonstrating CICT in Vermont consistently identified people at risk for COVID-19. During periods of low and moderate transmission, CICT identified close contacts
who were ~50 times more likely to have COVID-19 than noncontacts (Figure 1c). However, the
effectiveness of CICT at identifying people at risk for COVID-19 was significantly less when
community viral transmission increased beyond moderate levels; above this threshold,
prevalence of COVID-19 among close contacts approached prevalence of COVID-19 among
noncontacts.

These findings indicate that the public health benefit of CICT diminished during periods of
increased transmission. One possible explanation for these findings is that, during transmission
surges, CICT programs were unable to identify an adequate number of close contacts at risk for
COVID-19; CICT staff might have become overwhelmed by increasing caseloads and unable to
fully interview all index cases to elicit close contacts. However, the possibility exists that
worsened CICT performance (e.g. timeliness) might have contributed to a rise in transmission.
CICT effectiveness might also have been influenced by viral variants (with different
transmissibility and incubation periods) and changes in public guidance, statewide mitigation
strategies, and public behaviors over time.

Index cases previously identified by VDH as close contacts represent instances in which CICT
had opportunities to intervene and break chains of viral transmission. Notably, only one-third of
index cases had been previously identified as close contacts. This indicates that, despite
aggressive efforts, VDH was unable to identify the majority of close contacts, and that CICT was
insufficient as a sole strategy for disease control [6].

Findings in this report are subject to at least six limitations. First, our exclusion criteria might
have resulted in an underestimation of index cases and close contacts. Second, test-seeking
behaviors might have differed between close contacts and noncontacts, and changed over time.
Third, this analysis only considers one measure of CICT; timeliness of close contact notification,
adherence of close contacts to recommended guidelines, and other measures that determine CICT’s effectiveness to mitigate SARS-CoV-2 spread were not analyzed. Fourth, index cases might have notified their own close contacts without reporting them to VDH. Fifth, people might have been counted more than once if they had persistent positive PCR tests ≥14 days or reinfections. Sixth, we only attempted to compare the relative effectiveness of Vermont’s CICT program across time and did not attempt to measure its absolute effectiveness on disease prevalence, hospitalizations, or deaths.

CICT is an important public health tool to mitigate spread of communicable diseases, but it requires substantial time and resources. In Vermont, COVID-19 CICT was most effective at identifying people at higher risk for COVID-19 during periods of low and moderate viral transmission, but appears insufficient as a sole mitigation strategy.

ACKNOWLEDGMENTS
We thank everyone from both Vermont Department of Health and contracted agencies who contributed time and energy to the COVID-19 case investigation and contact tracing program in Vermont. A special thanks as well to Natalie Kwit, Julia Brennan, and Kristine Bisgard for their invaluable guidance and feedback on this report.

SUPPLEMENT SPONSORSHIP
This article appears as part of the supplement “Vaccines, Variants, and Vigilance: Strengthening the COVID-19 Public Health Response through Partnerships and Collaborations”, supported by
the Infectious Diseases Society of America through Cooperative Agreement NU50CK000574 with the U.S. Centers for Disease Control and Prevention.

DISCLAIMER:

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

FUNDING: none

CONFLICTS OF INTEREST: MF reports that they received support from the Vermont Department of Health. All other others report no conflicts.
References


Figure 1: COVID-19 among close contacts and noncontacts in Vermont by two-week intervals during May 3, 2020–October 30, 2021

(a) The COVID-19 attack rate (AR) among close contacts (green line) was higher than the AR among noncontacts (orange line) for every two-week period. (b) The prevalence ratio (PR) (blue line) of COVID-19 among close contacts to COVID-19 among noncontacts had an inverse relationship with mean weekly COVID-19 incidence; 95% CIs are represented by the shaded blue area. (c) When two-week periods were grouped by CDC-defined community transmission levels, PRs (blue dots; 95% CIs depicted by error bars) decreased significantly during periods of substantial and high transmission.
Figure 1
165x95 mm (.73 x DPI)
Please excuse the presence of this and the following test pages, which have been added to a small number of article PDFs for a limited time as part of our process of continual development and improvement.
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do
eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad
minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex
ea commodo consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint
occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit
anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing
elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut
enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi
ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint
occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit
anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing
elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut
enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi
ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint
occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit
anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing
elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut
enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi
ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in
voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint
occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit
anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing
elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.
Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Exceperter sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Exceperter sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Exceperter sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Exceperter sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.