

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

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16 **Running title:** Vermont COVID-19 contact tracing

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1 **ABSTRACT**

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

6

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

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## 1 INTRODUCTION

2 Case investigation and contact tracing (CICT) is a core public health activity that seeks to break  
3 chains of disease transmission and has been used for decades to control the spread of numerous  
4 communicable agents [1]. CICT starts when an infected person (index case) is interviewed and  
5 asked to identify people exposed to infection during the index case's infectious period. Trained  
6 public health professionals then notify exposed persons to offer postexposure treatment (if  
7 available) and guidance about how to protect themselves and prevent further spread of disease.  
8 CICT programs seek to decrease disease burden across a population by focusing interventions  
9 among exposed persons they can identify; CICT is therefore effective only when the risk for  
10 infection among identified exposed persons is greater than that among the general population.  
11 Since early 2020, CICT has been employed extensively worldwide to mitigate the spread of  
12 SARS-CoV-2, the virus that causes COVID-19. Although models [2,3] indicate CICT can slow  
13 or stop the spread of SARS-CoV-2, data concerning effectiveness are limited [1]. Moreover,  
14 CICT is time-consuming, resource-intensive, and challenging to implement [4,5]. Its success to  
15 mitigate SARS-CoV-2 spread depends on both internal performance metrics including timeliness  
16 and completeness [2,6] as well as external circumstances including viral contagiousness,  
17 asymptomatic transmission [7], public participation [6], and community disease prevalence [8].  
18 How varying levels of these external circumstances affect COVID-19 CICT remains poorly  
19 understood.

20 During March 2020, the Vermont Department of Health (VDH), a centralized state health  
21 department, initiated a COVID-19 CICT program after the first Vermont resident with  
22 laboratory-confirmed SARS-CoV-2 infection was identified. During March 2020–November  
23 2021, VDH attempted to interview every index case and notify every exposed person (close

1 contact) identified among the public. To compare effectiveness of Vermont’s COVID-19 CICT  
2 over time, we assessed rates of COVID-19 among close contacts and among people not  
3 identified as close contacts (noncontacts) at regular intervals throughout the pandemic.

## 4 5 **METHODS**

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

18 From index case interview records, we determined who (among those who sought RT-PCR  
19 testing) had been reported to VDH as a close contact during the 14 days before their test. VDH  
20 initially defined a COVID-19 close contact as anyone within six feet of an infected person for at  
21 least 15 consecutive minutes; this changed to 15 cumulative minutes on October 21, 2020 [9].

22 Test-seeking people from the general population who had not been reported to VDH as close

1 contacts in the preceding 14 days were categorized as noncontacts. Attack rates (ARs) and  
2 prevalence ratios (PRs) were calculated for the entire period and for each two-week period. We  
3 calculated AR as the number of persons tested positive for COVID-19 (index cases) per total  
4 people who sought testing, and PR as AR among close contacts divided by AR among  
5 noncontacts. Two-week periods were also grouped into four SARS-CoV-2 community  
6 transmission levels based on mean weekly COVID-19 incidence, as defined by CDC: low,  
7 moderate, substantial, or high transmission levels corresponded to mean weekly incidence of  
8  $<10$ ,  $10-49.99$ ,  $50-99.99$ , and  $\geq 100$  new cases per 100,000 persons, respectively [10]. We  
9 calculated COVID-19 incidences for each two-week period using official Vermont case counts  
10 as reported by CDC [11]. PRs and 95% confidence intervals for COVID-19 among close  
11 contacts to COVID-19 among noncontacts were calculated for each transmission level. This  
12 activity was reviewed by CDC and was conducted consistent with applicable federal law and  
13 CDC policy [12].

14

## 15 **RESULTS**

16 Two peaks of SARS-CoV-2 transmission occurred in Vermont during the analysis period (Figure  
17 1a). Among 1,984,588 people who sought SARS-CoV-2 PCR testing, 34,898 (1.76%) met our  
18 index case definition; this closely approximated the case count reported by CDC (36,249 cases).  
19 Overall, 11,638 of 34,898 (33.4%) index cases were close contacts. COVID-19 ARs were 22.4%  
20 (11,638/51,930) among close contacts and 1.20% (23,260/1,932,658) among noncontacts.  
21 Median number of index cases per two-week period was 724 (range: 57–2,784 index cases). ARs  
22 among close contacts (range: 9.33%–34.6%) remained above ARs among noncontacts (range:  
23 0.13%–2.64%) for every two-week period (Figure 1a).

1 Overall, prevalence of COVID-19 was 18.6 times greater among close contacts compared with  
2 noncontacts (PR = 18.6; 95% CI: 18.2–19.0). Maximum PR of COVID-19 among close contacts  
3 to COVID-19 among noncontacts was 212 (95% CI: 162–278) and occurred during October 18–  
4 October 31, 2020, when average community viral transmission level was moderate; minimum  
5 PR was 4.9 (95% CI: 4.5–5.3) and occurred during September 5–September 18, 2021 when  
6 community viral transmission level was high (Figure 1b). When two-week periods were grouped  
7 by community viral transmission level, PRs were similar for 13 periods of low viral transmission  
8 (PR = 49.3; 95% CI: 43.2–56.3) and five periods of moderate viral transmission (PR = 51.7; 95%  
9 CI: 46.1–58.0). PRs were significantly lower when viral transmission was at substantial and high  
10 levels; PR was 27.0 (95% CI: 25.6–28.4) during six periods of substantial transmission, and 13.5  
11 (95% CI: 13.2–13.9) during 15 periods of high transmission (Figure 1c).

12

## 13 **DISCUSSION**

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

21 During every two-week period, ARs of COVID-19 among close contacts were higher than that  
22 among noncontacts, demonstrating CICT in Vermont consistently identified people at risk for  
23 COVID-19. During periods of low and moderate transmission, CICT identified close contacts

1 who were ~50 times more likely to have COVID-19 than noncontacts (Figure 1c). However, the  
2 effectiveness of CICT at identifying people at risk for COVID-19 was significantly less when  
3 community viral transmission increased beyond moderate levels; above this threshold,  
4 prevalence of COVID-19 among close contacts approached prevalence of COVID-19 among  
5 noncontacts.

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

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

20 Findings in this report are subject to at least six limitations. First, our exclusion criteria might  
21 have resulted in an underestimation of index cases and close contacts. Second, test-seeking  
22 behaviors might have differed between close contacts and noncontacts, and changed over time.  
23 Third, this analysis only considers one measure of CICT; timeliness of close contact notification,

1 adherence of close contacts to recommended guidelines, and other measures that determine  
2 CICT's effectiveness to mitigate SARS-CoV-2 spread were not analyzed. Fourth, index cases  
3 might have notified their own close contacts without reporting them to VDH. Fifth, people might  
4 have been counted more than once if they had persistent positive PCR tests  $\geq 14$  days or  
5 reinfections. Sixth, we only attempted to compare the relative effectiveness of Vermont's CICT  
6 program across time and did not attempt to measure its absolute effectiveness on disease  
7 prevalence, hospitalizations, or deaths.

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

12

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4 **DISCLAIMER:**

5 The findings and conclusions in this report are those of the author(s) and do not necessarily  
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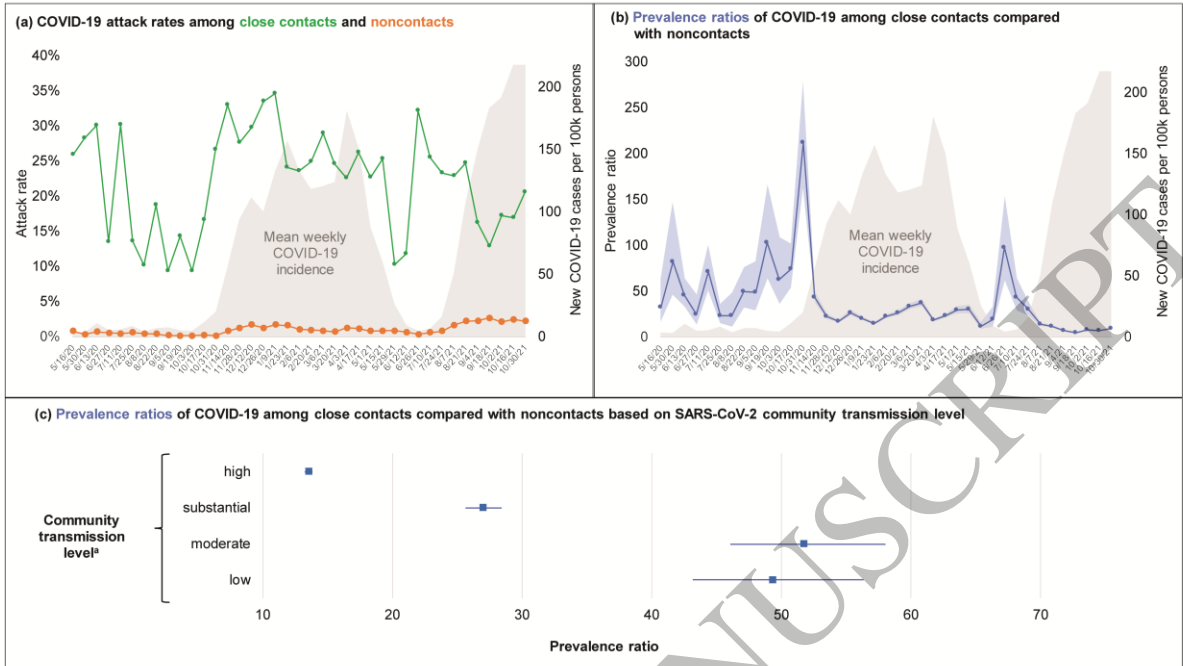
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1 **Figure 1:** COVID-19 among close contacts and noncontacts in Vermont by two-week intervals  
2 during May 3, 2020–October 30, 2021

3 (a) The COVID-19 attack rate (AR) among close contacts (green line) was higher than the AR  
4 among noncontacts (orange line) for every two-week period. (b) The prevalence ratio (PR) (blue  
5 line) of COVID-19 among close contacts to COVID-19 among noncontacts had an inverse  
6 relationship with mean weekly COVID-19 incidence; 95% CIs are represented by the shaded  
7 blue area. (c) When two-week periods were grouped by CDC-defined community transmission  
8 levels, PRs (blue dots; 95% CIs depicted by error bars) decreased significantly during periods of  
9 substantial and high transmission.

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\* Low, moderate, substantial, and high transmission levels were defined by a mean weekly COVID-19 incidence of <10, 10–49.99, 50–99.99, and ≥100 new cases per 100,000 persons, respectively.

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Figure 1  
165x95 mm (.73 x DPI)