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Original article

Efficacy of a student-led community contact tracing program partnered with an academic medical center during the coronavirus disease 2019 pandemic

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A B S T R A C T

Purpose: Contact tracing has proven successful at controlling coronavirus 2019 (COVID-19) globally, and the Center for Health Security has recommended that the United States add 100,000 contact tracers to the current workforce.
Methods: To address gaps in local contact tracing, health professional students partnered with their academic institution to conduct contact tracing for all COVID-19 cases diagnosed onsite, which included identifying and reaching their contacts, educating participants, and providing social resources to support effective quarantine and isolation.
Results: From March 24 to May 28, 536 laboratory-confirmed COVID-19 cases were contacted and reported an average of 2.6 contacts. Contacts were informed of their exposure, asked to quarantine, and monitored for the onset of symptoms. Callers reached 94% of cases and 84% of contacts. Seventy-four percent of cases reported at least one contact. Household members had higher rates of reporting symptoms (odds ratio, 1.65; 95% confidence interval, 1.19–2.28). The average test turnaround time decreased from 21.8 days for the first patients of this program to 2.3 days on the eleventh week.
Conclusions: This provides evidence for the untapped potential of community contact tracing to respond to regional needs, confront barriers to effective quarantine, and mitigate the spread of COVID-19.

Introduction

The novel coronavirus (severe acute respiratory syndrome coronavirus 2) caused a respiratory infection (coronavirus disease 2019 [COVID-19]) to spread rapidly throughout the world [1]. From March 6 to June 4, 2020, the pandemic led to 72,894 infections and 5667 deaths in the state of Pennsylvania [2]. Without an efficacious vaccine, suppression of local outbreaks is one of the most effective mitigation measures because presymptomatic and asymptomatic cases cause a significant amount of viral transmission [3,4]. The World Health Organization and the Centers for Disease Control and Prevention recommend that contact tracing be used to achieve this goal through the following measures: (1) rapid identification, (2) immediate isolation, and (3) rigorous tracking and precautionary self-isolation of close contacts of COVID-19-positive individuals and presumed positive cases [5].

Although effective, contact tracing requires comprehensive and coordinated public health resources to reach and monitor all contacts. Tracing contacts of confirmed and presumed cases prevents transmission of the virus before symptom onset [6]. Effective contact tracing involves minimizing the delay between symptom

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Biographical sketch: M.P. is a third-year medical student at Penn State College of Medicine. His research interests include public health methodology and epidemiology of communicable diseases.

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onset and isolation to ensure that cases are removed from the community to interrupt transmission [6,7]. However, self-imposed isolation presents numerous challenges for individuals to obtain essential supplies, such as food, medication, and cleaning supplies, particularly for those within socially vulnerable populations and those lacking education on infectious disease transmission [8,9]. Cultivating resources to address these needs and educate community members is essential to maximize the ability to comply with isolation and quarantine.

Given the urgent need for contact tracing in central Pennsylvania, health professional students from an academic medical center began a contact tracing program on March 16, 2020, under the guidance of public health professionals [10]. Our goals were to (1) conduct contact tracing and (2) identify socially vulnerable individuals and connect them to resources to enhance effective quarantining. The program leveraged health professional students pulled out of traditional courses at the outset of the COVID-19 pandemic within the United States. We used standard key performance indicators (KPIs) in the field of contact tracing to evaluate the efficacy of our program: contact-to-case ratio, percentage of contacts testing positive, time to initial call, exposure awareness, among others [11]. Here, we provide preliminary results to demonstrate the performance of a student-led contact tracing program affiliated with a tertiary care center, characterize the population served, and illustrate the value of locally curated social resources for overcoming barriers to isolation/quarantine.

Methods

Program design

Our team consisted of 150 medical, physician assistant, nurse practitioner, and graduate public health students (tracers) operating as part-time (averaging 8–11 hours) volunteers. This equates to approximately 36 full-time workers (30 hours weekly). We were notified of all reverse-transcription polymerase chain reaction COVID-19-positive cases (confirmed cases) diagnosed at our institution, a tertiary care and designated regional COVID-19 testing site, every 24 hours. Tracers called all confirmed cases to identify their exposed contacts (within six feet for at least 15 minutes) and evaluate social needs. Tracers called all contacts to (1) notify them that they had been exposed to a confirmed or presumed case, (2) monitor for emergent symptoms for 14 days after the last exposure to the case [12], (3) educate the contacts about self-quarantining measures, and (4) identify unmet social needs while maintaining the confidentiality of the original case per Health Insurance Portability and Accountability Act guidelines [13]. Contacts were monitored with a daily secure electronic survey or phone call. If a contact exhibited symptoms (1) as reported by the case, (2) on initial contact call, or (3) on a follow-up survey or call, they were offered COVID-19 testing, treated as a “presumptive case,” and their contacts were collected. All calls were made through our institution's operator, with a third-party translator service as needed. If a participant (case or contact) was unavailable, a voicemail with contact information was left. Participants were called once a day for the three consecutive days, often at different times, until they answered or were deemed “unable to contact.”

All data were managed in the Health Insurance Portability and Accountability Act–compliant Research Electronic Data Capture, and each case or contact was assigned a unique Research Electronic Data Capture identification number (RCID) [14]. Latencies from symptom onset to COVID-19 test, test to obtaining result, result to RCID creation, and RCID creation to call were KPIs used to monitor program timeliness. Contact-to-case ratio, number of cases reporting no contacts, number of contacts reporting symptoms, percent of contacts that test positive, and percent of contacts unaware of exposure were used to evaluate efficacy. This project was reviewed by the Penn State College of Medicine Human Subjects Protection Office and determined to be consistent with quality improvement and not research.

Interventions

We aimed to elicit participants' understandings of isolation and quarantine and identify barriers that prevented effective isolation and quarantining while educating participants about COVID-19. We created a COVID-19 information sheet based on Harvard University's COVID-19 Health Literacy Project, and recommendations from the Centers for Disease Control and Prevention and the World Health Organization with supplemental links to local resources addressing food and medication delivery, financial assistance, and mental health [15–17]. These documents were distributed to all participants in their preferred language via follow-up email.

We addressed food insecurity by sorting participants into one of three groups: (1) unable to travel for food (because of transportation barriers or household members being quarantined), (2) inability to afford food, or (3) both. To address these, we (1) emailed a list of local food and prescription delivery services, (2) referred to local food pantries, and (3) referred to an affiliate nonprofit that offered food delivery services directly from a food pantry. When we identified complex social needs beyond the scope of this project, such as wage loss and child-care issues, individuals were referred to the hospital's social work department. If an email address had been collected by the tracer, an automated email would be sent to participants at the end of the call, asking for suggestions and feedback about the program (Supplemental Table 1).

Statistical analysis

We compared the ages for confirmed cases, presumed cases, and asymptomatic contacts using a Kruskal–Wallis test to confirm a relationship followed by a Mann–Whitney *U* test with a Bonferroni adjustment because the ages of contacts were not normally distributed. We performed the χ^2 test to compare household to nonhousehold contacts becoming symptomatic and reported odds ratio and its 95% confidence interval. Additional information regarding statistical analysis is included in respective figure legends. Graphs were constructed using R Studio (Boston Massachusetts, http://www.rstudio.com/) and GraphPad Prism 8 (La Jolla California, www.graphpad.com) Figures were created using Adobe Illustrator.

Results

Demographics

From March 24 to May 28, the team called 1489 individuals. 536 were reverse-transcription polymerase chain reaction–confirmed cases of COVID-19. Nine hundred fifty-three were contacts exposed to people with COVID-19, of which 261 were treated as presumptive cases (Fig. 1A). The average age of confirmed cases, presumptive cases, and asymptomatic contacts was 44.7, 33.7, and 29.6, respectively, and decreased across groups ($P < .001$; Table 1).

Operations

Most confirmed or presumed cases (649, 93.9%) and asymptomatic contacts (517, 84.1%) agreed to participate in contact tracing. The average length of calls was 23.6 minutes for cases and 15.6 minutes for contacts. Remote translation services were used

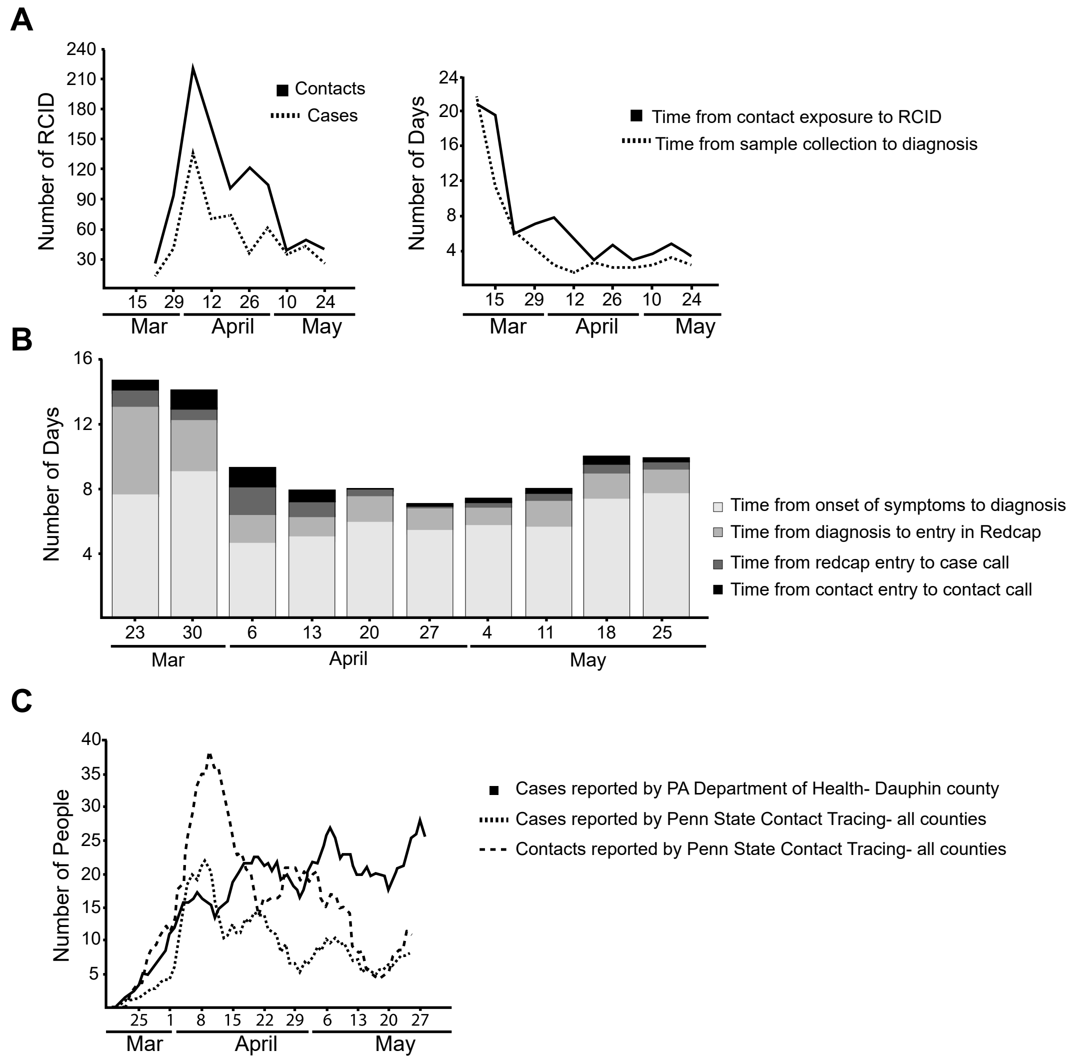

Fig. 1. (A1) Number of cases and their contacts that were identified each week from March 25 to May 27 and (A2) time from test order to result and time from contact exposure to entry into our system. (B) Average weekly total time from symptom onset to contact call divided into symptom onset to test, test to diagnosis, diagnosis to entry into database, entry to initial case call, time from contact entry to contact call. (C) Seven-day rolling average of daily cases reported by the Pennsylvania Department of Health for Dauphin County and diagnosed at Penn State Hershey Medical Center for all counties.

for 222 calls (14.9%). We completed 57.3% of calls on the first call attempt, 16.5% on the second, 6.7% on the third, 3.6% on the fourth, and 0.5% on the fifth. We were unable to complete 14.3% of our calls. One hundred fifty-two of the unsuccessful calls were because of four failed attempts to reach the individual, after which follow-up was discontinued. The remaining 105 unsuccessful calls were because of a variety of factors, including clerical errors ($n = 32$), missing or incorrect contact information ($n = 27$), refusal to participate ($n = 26$), and those deceased, out-of-state, or living in supervised group living situations (prisons, nursing homes, rehabilitation centers, and group homes; $n = 13$) and patients exposed greater than 14 days before ($n = 7$).

Timeliness

Confirmed cases were tested 1.8 ($n = 350$, SD 2.33) days on average after developing COVID-19-associated symptoms. The average test turnaround time was 5.2 ($n = 350$, SD 3.20) days, and case RCIDs were created on average 2.1 days ($n = 337$, SD 1.82) after diagnosis date. It then took 0.8 additional days ($n = 521$, SD 1.94) on average to make the first call attempt. Contacts RCID were added an average of 7.4 days ($n = 632$, SD 6.24) after the exposure date. It took 0.6 additional days ($n = 617$, SD 0.91) on average to make the first call attempt (Fig. 1B). From March 8 to May 28, the average test turnaround time decreased from 21.8 to 2.3 days, and the average time between contact exposure and RCID creation declined from 20.9 days to 3.4 days (Fig. 1C).

Key performance indicators

Confirmed cases identified an average of 2.6 contacts (median 2, interquartile range 1–4), and presumptive cases identified an average of 2.5 contacts (median 2, interquartile range 0–4). One hundred thirty-five cases (20.1%) identified household and non-household contacts, 331 (49.3%) only identified household contacts, 32 (4.8%) identified only nonhousehold contacts, and 174 (25.9%) did not identify any contacts. Forty-four confirmed cases and two presumptive cases were hospitalized at the time of the call. As of May 28, 2020, 295 contacts (27.8%) reported COVID-19-associated symptoms, after which a thorough history was obtained and

Table 1
Demographics and barriers to social distancing

Demographic or need	Total (%)	Confirmed cases (%)	Presumptive case (%)	Asymptomatic contacts (%)	Targeted interventions
	1489	536 (36.0)	261 (17.5)	692 (46.5)	N/A
Female	776 (52.1)	304 (56.7)	144 (55.2)	328 (47.4)	N/A
Male	680 (45.7)	232 (43.3)	115 (44.1)	333 (48.1)	N/A
Gender not reported	34 (2.3)	0	3 (1.2)	31 (4.5)	N/A
Mean age (SD)	36.6 (21.7)	44.7 (21.7)	33.7 (20.1)	29.6 (19.2)	N/A
Race					N/A
White	—	233 (43.4)	—	—	N/A
Black	—	51 (9.5)	—	—	N/A
Asian	—	51 (9.5)	—	—	N/A
Other	—	104 (9.5)	—	—	N/A
Not reported	—	98 (18.3)	—	—	N/A
Ethnicity					N/A
Non-Hispanic/Latino	—	348 (64.8)	—	—	N/A
Hispanic/Latino	—	77 (14.3)	—	—	N/A
Not reported	—	112 (20.9)	—	—	N/A
Household member of case	660 (69.3)	—	200 (76.6)	460 (66.6)	In-house social distancing resources
Preferred non-English language	208 (14.0)	70 (13.1)	43 (16.5)	95 (13.7)	Translator services, resources in preferred language
Household size	2.4	2.3	2.7	—	In-house social distancing resources
Average number of bathrooms	1.9	1.7	2.0	1.9	Resources on sharing bathrooms with COVID+
Barriers total, n	Total, n = 898 (%)	Confirmed cases, n = 301 (%)	Presumptive cases, n = 159 (%)	Asymptomatic contacts, n = 437 (%)	Targeted intervention
Difficulty obtaining	106 (11.8)	37 (12.3)	34 (21.4)	35 (8.0)	
Food	52 (5.8)	16 (5.3)	34 (21.4)	19 (4.3)	Referral to local food banks
OTC Meds	34 (3.8)	12 (4.0)	17 (10.7)	10 (2.3)	Referral to social work or families in need
Cleaning supplies	51 (5.7)	20 (6.6)	12 (7.5)	7 (1.6)	Referral to local grocery store delivery service who have cleaning supplies in stock
Household items	13 (1.4)	2 (0.7)	24 (15.1)	1 (0.2)	Referral to local grocery store delivery service
PPE	23 (2.6)	9 (3.0)	10 (6.3)	6 (1.4)	Referral to CDC's mask making video or referral to local community centers
Other	7 (0.8)	1 (0.3)	8 (5.0)	4 (0.9)	Intervention tailored to specific need
Need to leave house for	369 (24.8)	110 (36.5)	64 (40.3)	195 (44.6)	
Food	157 (17.5)	36 (12.0)	20 (12.6)	101 (23.1)	Referral to local grocery store delivery services
OTC Med	43 (4.8)	11 (3.7)	12 (7.5)	20 (4.6)	Referral to local drug stores medication delivery services
Social purposes	6 (0.7)	(0.0)	1 (0.6)	5 (1.1)	Encourage compliance with quarantine recommendations
Work	60 (6.7)	10 (3.3)	11 (6.9)	39 (8.9)	Offering work excuse letters
Caregiving	9 (1.0)	1 (0.3)	1 (0.6)	7 (1.6)	Referral to social work
Volunteering	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	Encourage compliance with quarantine recommendations
Visit doctor/hospital	59 (6.6)	37 (12.3)	12 (7.5)	10 (2.3)	Encourage telehealth visits if possible
Other	35 (3.9)	15 (5.0)	7 (4.4)	13 (3.0)	Intervention tailored to specific need
Facing challenges in quarantining/ social distancing	210 (23.4)	67 (22.3)	51 (32.1)	92 (21.1)	Intervention tailored to specific need
Unable to stay in one room in home	356 (39.6)	223 (74.1)	89 (56.0)	230 (52.6)	In-house social distancing resources
Lack of thermometer	—	—	—	106 (24.2)	Referral to local grocery store delivery services or drug store delivery services when thermometers were in stock

CDC = Centers for Disease Control and Prevention; N/A = not applicable; OTC = over-the-counter medicine; PPE = personal protective equipment.

physicians consulted. Two hundred sixty-one were made presumptive cases (88.5%). Of the 261 presumptive cases, 116 (44.4%) were symptomatic on the first case call. One hundred fourteen (43.7%) were symptomatic at the time of the initial contact call and reported an average of 3.3 symptoms. Thirty-one (11.9%) developed symptoms during the 14-day community follow-up and reported an average of 3.6 symptoms (Fig. 2A).

Of the 692 contacts that did not develop symptoms, 460 (66.5%) were household contacts and 232 (33.5%) were nonhousehold contacts. Of the 261 presumptive cases, 200 (76.6%) were household members and 61 (23.4%) were nonhousehold members (Fig. 2B). Household members had higher rates of developing symptoms consistent with COVID-19 infection (odds ratio, 1.65; 95% confidence interval, 1.19–2.28).

Interventions

One hundred fifty-six participants (10.5%) requested and received a work excuse letter. Eight hundred ninety-eight individuals were queried about quarantine difficulties, of which 106 (11.8%) reported difficulty obtaining resources and 369 (41.1%) reported having to leave the house during quarantine period. Contacts were asked to monitor their temperature, but 106 contacts (24.2%) reported not having a thermometer. There was a total of 126 individuals (8.4%) who received resources from our team, which most commonly addressed food insecurity (Fig. 3A–E).

COVID-19 testing was offered to all 261 presumptive cases, of whom 72 (27.5%) requested an ordered test. The other 189 (72.5%) either received tests from outside institutions or refused testing. Of those that requested a test, nine (12.5%) have a COVID-19 test pending completion, 13 (18.1%) never got tested, 26 participants (52.0%) tested positive, and 24 (48.0%) tested negative. Thirteen positive tests were from initial presumptive case calls, and 13 were from a contact or follow-up call. All 24 negative tests were from a contact or follow-up calls. COVID-19 test results were received within an average of 2.0 days.

Feedback

An automated feedback survey was sent to all participants who provided an email address (729, 49.0%). Of the 182 participants (25.0%) that responded, 163 (89.6%) described the call as helpful (Supplemental Table 2).

Discussion

Throughout the COVID-19 pandemic, contact tracing has been coordinated at the national, state, and local levels using a wide variety of nontraditional employees and volunteers [8]. Here, we summarize the KPIs and early results of a novel volunteer-based, health professional student-led contact tracing program partnered with a tertiary medical center. Our results illustrate the efficacy of community-based contact tracing efforts in quickly reaching cases, identifying their contacts, and supporting their efforts to self-quarantine. We also highlight how access to unique local resources enhances contact tracing efforts.

Our cases have identified an average of 2.6 close contacts that they exposed to COVID-19, which is lower than the 4.4 contacts per case reported in Shenzhen, China [18]. This may reflect the population characteristics in our service catchment area, a nine-county area that includes a small urban center as well as suburban and rural areas that has an 80-fold lower population density than Shenzhen, a metropolitan area [19,20]. Alternatively, this may provide evidence that community members adhered to the stay-at-home order and social distancing guidelines recommended by Pennsylvania's Governor Wolf from April 1 to June 4, 2020 [2,21]. It is important to note that although cases may voluntarily disclose the information of their close contacts, we are unable to mandate any individual to disclose contact information. Furthermore, after the stay-at-home order was implemented, individuals may have been less likely to report contacts out of shame or fear of consequences. Therefore, our contact-to-case ratio could reflect the real-world challenge of collecting contacts, and our average contacts per case of 2.6 may underestimate the true number of contacts of our cases.

Compared with contact tracing programs across the United States, our program has excelled at reaching participants and eliciting their contacts. We have reached 94% of cases and 84% of contacts, whereas other programs are only reaching 50–60% [22]. In addition, 74.1% of our presumed or confirmed cases reported at least one close contact, which is markedly higher than New York City's value of 35%–42% [22]. This may be explained by our health system's operator; community members may be more likely to respond to a recognizable caller ID from a reputable health care institution. These findings support the efficacy of local community-led contact tracing.

Furthermore, the Center for Health Security has recommended that the United States adds 100,000 contact tracers to the current workforce [23]. If our program of 36 full-time equivalent employees were adopted nationally on May 28, it would have required 116,794 full-time employees to manage the 1,719,827 cases to that date [24]. This figure, however, may underestimate the workforce required to trace the now exceeding 7 million documented COVID cases in the U.S. The ratio of household members to nonhousehold members

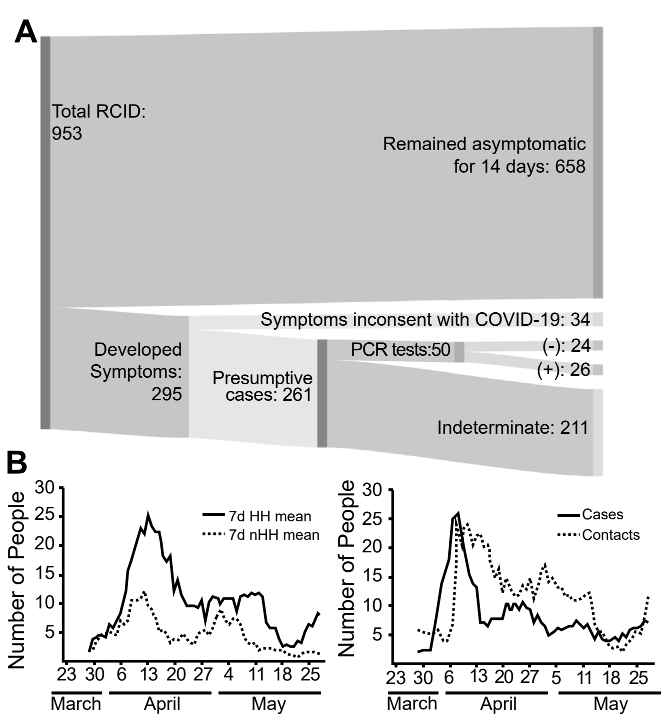

Fig. 2. (A) Sanky flow diagram of contacts, their development of symptoms, and subsequent testing. Two hundred eleven of 261 presumptive cases of COVID-19 status were indeterminable because they received testing outside our institution, refused testing, or their result was pending. (B1) Seven-day rolling average of household and nonhousehold contacts. (B2) Seven-day rolling average of cases and contacts from March 29 to May 28.

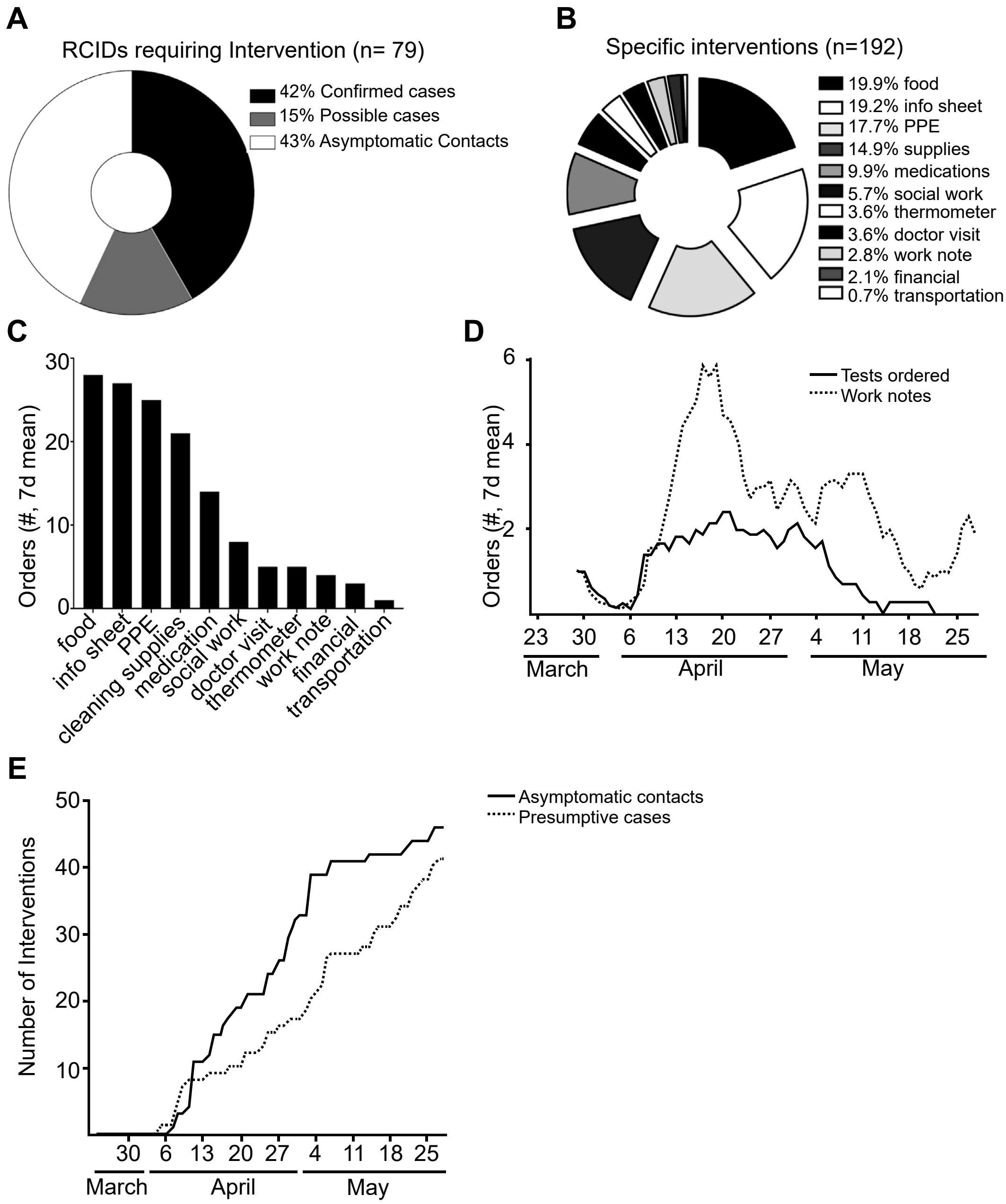

Fig. 3. (A) Pie chart of breakdown of contacts, cases, and possible cases. (B) Pie chart and (C) bar graph representing the frequency of intervention use. (D) Seven-day running average utilization of testing and work notes from March 23 to May 28. Interventions to (E) contacts and possible cases from March 23 to May 28.

reported by cases is 3.2:1. Two possible explanations include (1) the stay-at-home order has effectively limited exposure of non-household members [21] and (2) cases may be less likely to report contacts outside of the house, possibly because of stigma associated with COVID-19 [25]. We found that household contacts were 1.65 times more likely to become symptomatic than nonhousehold contacts, which is much lower than other reported household transmission (+6.3×) [18]. However, given that our presumed cases are not laboratory confirmed, this number may be skewed; household contacts may report symptoms at different rates than nonhousehold contacts.

Modeling suggests that the efficacy of contact tracing is maximized when contacts are reached quickly, many are identified, and presymptomatic transmission is limited [6]. It takes our program an average of 10.6 days from an original case's symptom onset to the first call to their contacts. Notably, seven of these days were beyond our control: 1.8 days from symptom onset to specimen collection and 5.2 days from collection to result. However, turnover was slower than 10.6 days when participants did not answer or return our calls. Although we reached 57.3% of participants with the initial call, 27.3% were not reached until the second, third, or fourth call.

Thus, a major limitation to our timeliness was testing latency. The mean time from sample collection to diagnosis decreased from 20.9 days to 3.4 days from March 8 to May 28, which parallels decreases in the overall time it took us to reach contacts. This suggests speed of contact tracing hinges, in part, on efficient testing infrastructure that minimizes time from sample collection to informing patients of their results. There has been widespread call for greater and faster testing capacity across the United States [23,26], and our data provide evidence that this is occurring, at least in part at our institution. Nevertheless, the average days between the onset of symptoms and our initial call to a cases' contacts of 10.6 days has room for improvement. The serial interval (time between symptom onset of the infector and symptom onset of the infected) of COVID-19 estimated at 4–7.5 days is significantly below our average speed [27,28]. Furthermore, recent modeling suggests that contact tracing with a 3-day delay to case isolation and contact quarantine is insufficient to curb the COVID-19 pandemic [29].

Although our team found 261 presumptive cases, we only were able to offer testing to 72 of these contacts. Fifty-two percent of those tested were positive, which was above the state's average of 22.2% [30]. Therefore, we are confident our tracing was identifying high-risk individuals. As availability of tests improves, we aim to test all contacts of cases because prior studies indicate that 44% of transmission occurs in the presymptomatic phase and up to 80.1% of cases are asymptomatic [3,31,32].

Contact tracing primarily slows the spread of disease by asking those who have been exposed to self-quarantine. It is ineffective if contacts did not have the means to self-isolate. Resources and incentives are an essential tool for encouraging quarantine for contacts [8], especially when 85% of exposed adult household contacts become infected [33]. Participants most frequently reported difficulty obtaining food, cleaning supplies, and medications. They reported leaving the house during their quarantine to obtain these items as well as attending doctor appointments. Although we met many of these needs with online delivery services, food pantries, and other resources, we were least able to adequately provide cleaning products and personal protective equipment.

We primarily received positive feedback about interactions with our contact tracing team. Many of the suggestions provided were inoperable; lack of knowledge of the efficacy of treatment options, previous awareness of exposure, and mixed opinions about call length were common areas of suggestion. There was feedback that we deemed operable, including expanding the resources we had available to offer to our participants, increasing clarity about the reason of the call, and increasing our knowledge base about quarantining strategies.

Limitations and future directions

This work has several limitations that must be noted. Test turnaround hinders the timeliness of our contact tracing program. Ideally in contact tracing, every contact is tested [31]. We tested all presumptive cases that wanted a test but were unable to test all contacts because of institutional limitations. Therefore, we were largely unable to confirm if many of our presumptive cases were truly COVID-19 positive, and all our asymptomatic contacts were truly COVID-19 negative. Participation in our program was entirely voluntary, which likely reduced the number of contacts elicited from cases. Our database is incomplete—some participants do not answer all questions, and we do not attempt to retroactively enter data once all contact information is collected. Finally, our data set is limited by iterative script changes that accumulated based on feedback and barriers to efficiency.

Our findings in the context of these limitations leave many questions unanswered. Future work may incorporate mathematical modeling to determine the impact of community-led contact tracing on local case burden and spread of disease. Further work should characterize which contacts are at risk of developing disease and the efficacy of these interventions in supporting quarantine and decreasing transmission. To continue to improve this program, we are prioritizing testing all contacts, decreasing the latency to reaching contacts, and continuously evaluating and improving the resources we provide.

Conclusions

Here, we outline the preliminary results of a volunteer student-led contact tracing program partnered with an academic health care institution. These data validate the efficacy of a student-led volunteer contact tracing program to respond to regional contact tracing needs, providing evidence for the untapped potential of community contact tracing. Finally, we highlight barriers to effective quarantine experienced by Pennsylvanians and propose interventions to enhance quarantine capabilities. Further work should characterize the underlying forces that limit the efficacy of contact tracing such as refusal to participate, barriers to effective isolation and quarantine, and limited testing capacity.

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Appendix

Supplemental Table 1
Sample of postcall feedback survey

Contact tracing postcall feedback survey	
1) You recently spoke to our contact tracing team at Penn State. Was it helpful to you?	_Yes _No
2) What's one thing we could do to make it more helpful?	

Supplemental Table 2
Call feedback survey general themes and suggestions

Topic	Helpful ($n = 163$)	Not helpful ($n = 19$)
Commending/thankful for call	Helpful/knowledgeable/great job/thank you (36)	Appreciate advice and concern (2), thorough information (1).
No significant suggestions	None/it was fine (54)	No suggestions (6)
Follow-up	Continue to follow-up (2), less follow-up (1), personalize follow-up (1), follow-up with employers (1), send follow-up information/up-to-date content about COVID to patients (1), Patient still waiting for test (1)	Faster follow-up (1)
Improve resources	Provide personal protective equipment (1), groceries, work notes (1), antibody testing (1), get more COVID tests (1), provide treatment for COVID (2)	Want more COVID tests (1), had difficulty obtaining work note (2)
Improve patient education	Want to know what happens postquarantine (1), inform what medications they should use (1), want more information (1), explain contact tracing better (1), explain antibody testing (1)	Want better explanation of contract tracing program at initiation of call (2), give more information on antibody testing/ donating plasma (1)
Duplicative	Gathering information already gathered by another caller (2)	Already aware exposed (1)
Communication	Inadequate explanation in voicemail (1), better connection/ phone service (2)	Want quicker response to voicemails (1) want increased consistency between callers (1), confused about when to return to work (1). Call not completed (1)

General themes including altering follow-up policies, improving resources available (including COVID test availability and treatment for COVID), improving patient education and reducing duplicative processes and inconsistency between different callers.