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Major Article

Implementation and effectiveness of a COVID-19 case investigation and contact tracing program at a large, urban midwestern university

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A B S T R A C T

Background: The University of Illinois Chicago (UIC) COVID-19 Contact Tracing and Epidemiology Program was critical to the university's COVID-19 incident response during the 2020-2021 academic year. We are a team of epidemiologists and student contact tracers who perform COVID-19 contact tracing among campus members. Literature is sparse on models for mobilizing non-clinical students as contact tracers; therefore, we aim to disseminate strategies that are adaptable by other institutions.

Methods: We described essential aspects of our program including surveillance testing, staffing and training models, interdepartmental partnerships, and workflows. Additionally, we analyzed the epidemiology of COVID-19 at UIC and measures of contact tracing effectiveness.

Results: The program was responsible for promptly quarantining 120 cases prior to converting and potentially infecting others, thereby preventing at least 132 downstream exposures and 22 COVID-19 infections from occurring.

Discussion: Features central to program success included routine data translation and dissemination and utilizing students as indigenous campus contact tracers. Major operational challenges included high staff turnover and adjusting to rapidly evolving public health guidance.

Conclusions: Institutes of higher education provide fertile ground for effective contact tracing, particularly when comprehensive networks of partners facilitate compliance with institution-specific public health requirements.

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Contact tracing is a critical strategy to control COVID-19 transmission.¹ However, barriers such as program costs hinder efforts to expand contact tracing in US health departments.² One potential solution is augmenting health departments by implementing community-based contact tracing programs. College campuses are optimal venues for such programs because their constituents possess skills in relevant disciplines, including the health sciences, public health, and social work. Students also have a propensity to serve as campus contact tracers by virtue of their general comfort with tech-driven processes and membership in the target community. Their indigenous grounding enables students to relate to the unique

stressors that COVID-19 imposes on university members, thereby promoting trust and rapport. Further, students benefit from engaging in public health initiatives, citing new skill development as an incentive.³

Leading up to fall 2020, universities were recognized as important sites of COVID-19 transmission after several outbreaks were associated with high-density congregate living arrangements and social gatherings with limited mask use.^{4,5} Additionally, while the individual risk to most undergraduate students was relatively low, US incidence was highest among adults aged 18-29 during summer 2020,⁶ eliciting concerns regarding their potential to infect more vulnerable persons.

With these issues in mind, the University of Illinois Chicago (UIC) instituted a corps of student contact tracers in August 2020 as a key element of their COVID-19 incident response. This program was approved by the Chicago Department of Public Health (CDPH) but

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functioned as an independent unit within UIC, and thus differed from university programs relying on local health departments to contact trace their constituents.⁷ Relevant literature within Institutes of Higher Education (IHEs) is limited but varied. Some universities have leveraged clinical personnel to spearhead contact tracing initiatives,^{3,8,9} while others published simulation models of COVID-19 transmission on college campuses or the impact of policies that include contact tracing among multiple mitigation strategies.¹⁰⁻¹² There is a paucity of literature offering practical models to mobilize non-clinicians as contact tracers. Therefore, we aim to describe the UIC COVID-19 Contact Tracing and Epidemiology Program (CCTEP) and examine its effectiveness during the 2020-2021 academic year.

METHODS

Context

UIC is a diverse, urban university in Chicago, Illinois, with a total student body of roughly 34,000, of whom 80% commute from off-campus locations throughout the city and suburbs.¹³ The university includes an academic medical center consisting of a 462-bed tertiary care facility (UI Health), pediatric hospital, 26 outpatient clinics, and 14 Federally Qualified Health Centers throughout Chicago. Nested within UIC is the School of Public Health (SPH), containing a wealth of epidemiological expertise, including connections to partners within UI Health and local health departments.

In summer 2020, campus leaders held a series of meetings to plan a safe re-opening during the upcoming fall semester, at which time approximately one-third of students were expected to resume in-person learning. These meetings resulted in two major public health interventions, launched in August 2020. First, UIC implemented a COVID-19 surveillance testing program, utilizing a saliva-based polymerase chain reaction (PCR) assay developed by UI Health's Molecular Laboratory. Initially, due to limited capacity, mandatory routine testing was limited to three groups deemed at disproportionate risk of acquiring and transmitting COVID-19 as a result of the nature of their activities (UIC Performing Arts and Athletics) or residing in a congregate living setting (Campus Housing). By February 8, 2021, there was a meaningful increase in testing capacity, precipitating a twice-weekly testing mandate for persons physically on campus.

Concurrently, UIC established CCTEP to (1) perform case investigation and contact tracing among campus members with COVID-19 infection or exposure, and (2) monitor and report on the evolving epidemiology of COVID-19 at UIC. The overall program budget was approximately \$673,000 during the first fiscal year. Funding consisted of grants as well as funding from the state of Illinois, which comprised approximately 63% and 37% of the budget, respectively.

Program structure

The program was staffed by a fully remote workforce of public health practitioners and student workers who performed case investigation and contact tracing (hereafter referred to as "contact tracers"), housed within the SPH (Fig 1). During case investigations, public health personnel offer isolation guidance to cases and attempt to elicit the names of all persons with whom they had close contact; staff then begin contact tracing by notifying the exposed individuals (i.e., contacts) of their exposure as rapidly as possible. Our contact tracers performed both case investigation and contact tracing, contrasting with the approach taken by most Illinois health departments. Our rationale for selecting this model was largely operational efficiency; dually trained student workers would be able to easily transition between case investigation and contact tracing, as needed based on rapidly evolving demands. We also anticipated that we would be

able to operate more effectively with fewer contact tracers by using this model, compared to building and training two teams.

An infectious disease physician and epidemiologist from the SPH Department of Epidemiology & Biostatistics (RCH) oversaw the program's design and implementation, collaborating with two full-time applied epidemiologists (EMS and JV). They hired and trained contact tracers, created workflows and interview scripts, and built a data-capture and reporting system in REDCap (Research Electronic Data Capture), a suite of HIPAA-compliant electronic data capture tools hosted at UIC.^{14,15}

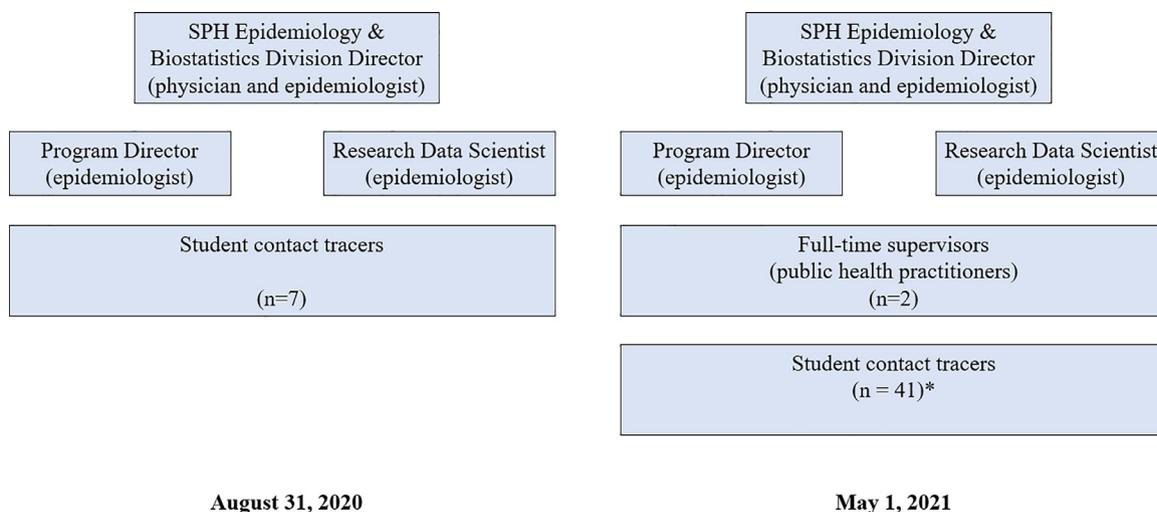
UIC Telecommunications designed and maintained a virtual (i.e., VoIP) phone system to support the call center, which operated approximately 80 hours per week, Monday through Sunday. Initially, EMS and JV managed day-to-day call center operations. However, they recruited two full-time, graduate-level supervisors to perform these duties in November 2020. By the end of fall 2020, the team grew to 41 graduate and undergraduate student contact tracers, collectively fluent in five languages and representing seven (44%) of UIC's colleges. In response to anonymous feedback solicited from contact tracers, we developed four "lead" positions to offer contact tracers additional on-the-job support and enhance overall engagement.

We collaborated closely with many other units throughout UIC, including (but not limited to) campus surveillance testing administrators (e.g., Incident Commander/Vice Chancellor for Administrative Services, Vice Chancellor for Innovation, Chief Technology Officer), Student Health Services, UI Health Infection Prevention and Control, Campus Housing, UIC Athletics and Performing Arts, and University Health Services (UHS) (the occupational health arm of UIC/UI Health.) We met routinely to discuss UIC's COVID-19 response, review epidemiologic data and emerging public health guidance, and plan interventions in response to current trends and active clusters.

We directly coordinated with UHS to perform case investigation, contact tracing, and travel counseling (for individuals traveling internationally or out of state), for all UIC and UI Health students and employees, contractual workers, and visitors. Initially, the team responsible for serving a given case or contact (UHS or CCTEP) depended on whether they were an employee or student, respectively. However, given the relative strengths of our teams and disproportionate burden of COVID-19 borne by the health system at the time, we reallocated responsibilities based on the nature of a person's role within the university. UHS handled UI Health employees and individuals with patient- or research-participant-facing duties, and CCTEP managed all other students and employees. We routed campus members to the appropriate "jurisdiction" using a discrete field in UI Health's electronic health record (EHR), which enabled automated reporting of most results to the appropriate team. We also developed a decision tool in REDCap to efficiently direct campus members who needed to self-report a positive COVID-19 test result obtained externally, potential exposures, symptoms, or travel.

Contact tracer training and onboarding

All interview and hiring decisions were made by RCH, EMS, and JV. Staff received encrypted laptops with softphones (Cisco IP Communicator 8.6.6.0) connected to the call center's phone line. Contact tracers' initial preparation involved independently completing the *COVID-19 Contact Tracing* online course, created by Johns Hopkins University, and training to promote compliance with the Health Insurance Portability and Accountability Act (HIPAA) and Family Educational Rights and Privacy Act (FERPA).¹⁶ Next, they completed two group trainings focusing on program-specific technology, procedures, and documentation. We utilized several systems in addition to the Cisco softphone and REDCap, including the University of Illinois BOX for file sharing, Microsoft Teams to communicate during shifts, and administrative data to verify campus members' contact information



*Includes 4 “lead” contact tracers
 Note: Contact tracers performed case investigation and contact tracing.

Fig 1. Comparison of UIC CCTEP’s organizational structure at program inception and 9 months later (August 31, 2020 – May 1, 2021).

and class schedules. Trainees utilized these systems in a test environment over several days before working.

Contact tracers’ on-the-job training included debriefing sessions with a supervisor after each of their first three case interviews (at minimum) to address outstanding questions, reconcile documentation issues, and verify fidelity to protocols. They also completed continuing education through refresher sessions and quizzes, weekly team meetings, regular documentation feedback from lead contact tracers, and optional one-on-one training. A team lecture series served primarily educational purposes but also provided opportunities for socialization during a time when many students expressed feeling isolated.

Contact tracing workflows

All positive PCR COVID-19 tests obtained through the COVID-19 surveillance program or another UI Health site were extracted from the EHR, promptly entered in REDCap, and assigned a record ID, representing a unique isolation episode. Laboratory and basic demographic information were sent to the Illinois Department of Public Health (IDPH) for all COVID-19 cases who tested positive at a UIC saliva testing or UI Health clinical site, in accordance with IDPH infectious disease reporting requirements.¹⁷ We shared contact tracing data with CDPH upon identifying an outbreak, defined as ≥ 5 cases linked by a single event with no alternative source of exposure. Additionally, we engaged with CDPH directly on clusters involving “mixing” with community members unaffiliated with the university so that they could ascertain, investigate, and contact trace potential cases.

Contact tracers utilized a REDCap report to prioritize cases whose initial interview was pending and call them as rapidly as possible to collect demographic information; assess symptoms and other epidemiologic information, including potential sources of exposure, recent travel, and healthcare utilization; and elicit UIC-affiliated close contacts. Additionally, they evaluated each person’s ability to isolate, disseminated resources to address potential barriers, and provided public health education. If the case reported participating in campus activities while infectious, we completed a secondary investigation, which involved interviewing the individual(s) responsible for supervising the activity to enhance information previously collected, including details regarding mitigation procedures, and occasionally to arrange for disinfection of spaces. Upon full completion of the

investigation, we communicated a high-level, de-identified summary of findings and recommendations to the case’s supervisor and self-identified points of contact from relevant departments and/or units. Furthermore, the UIC Environmental Health & Safety Office followed up on any mitigation issues by evaluating the incident and offering consultation to appropriate parties.

Similarly, we initiated outreach to contacts by creating a REDCap record, which fed into a report of pending contact interviews. Contact tracers assessed contacts for symptoms, defined quarantine and/or symptom-monitoring requirements, offered testing guidance, and elicited potential barriers to quarantine. The protocol for contacts who self-reported an exposure was identical, with an additional series of questions to verify that they had a meaningful exposure.^{18,19} Contacts who developed symptoms of COVID-19 at any point during the symptom-monitoring period were deemed presumptive cases until they received at least one negative PCR test²⁰ and were interviewed to elicit close contacts.

After the initial interview with a case or contact, contact tracers completed follow-up calls periodically throughout isolation or quarantine, respectively. Cases completed a minimum of two check-ins, on day-5 and day-9 of isolation. Contacts engaged in at least three check-ins, on days 5, 9, and 13 of symptom monitoring. During each follow-up call, contact tracers re-evaluated symptoms, assessed the status of previously reported barriers, and offered emotional and logistical support. Contact tracers called individuals reporting a risk factor for severe COVID-19, severe or worsening symptoms, or significant barriers to isolation or quarantine more frequently.²¹

To maximize the timeliness of contact tracing, we adopted a staged escalation approach with the goal of reaching all cases and contacts for initial interview within 48 hours of specimen collection or exposure notification, respectively.²² Contact tracers made up to three phone calls and one email attempt within the first 24 hours for each new case and contact, and a maximum of two call attempts per day for each of the remaining scheduled check-ins. We used a slightly more intensive approach for persons involved in a cluster, which we defined as two or more cases epidemiologically linked through a non-household setting. If these attempts were unsuccessful, we called the emergency contact on file and subsequently placed a registration hold (for students) or notified a supervisor or Human Resources representative (for employees). We coded individuals who did not complete an interview as “never reached” on the expected end

date of isolation (based on symptom onset or test date, whichever occurred first) or symptom monitoring (based on exposure date). We classified persons who completed the initial interview and missed the final call as “lost to follow-up.” We documented all contact attempts, escalation steps, and completed check-ins in REDCap, and reported descriptive statistics weekly to stakeholders.

Statistical analysis

All analytic data were collected for the purpose of our day-to-day operations and to facilitate evaluation of our program and operational model. Data were analyzed using R, version 1.3.1073 and SAS, version 9.4 (SAS Institute Inc., Cary, NC). The sample included all adult (≥ 18 years old) cases, contacts, persons under investigation (PUIs), and travelers who were entered in our database between August 31, 2020, and May 22, 2021 (N = 1,921). PUIs were defined as individuals presenting with symptoms within 14 days of exposure without a positive test. We selected May 22, 2021, as the end date because it marked 14 days after completion of the 2020–2021 academic year, and theoretically should capture individuals infected through the last day of in-person instruction. Individuals who entered our system but did not require monitoring (e.g., due to being a duplicate record) were closed out with documentation of the appropriate reason and excluded from analysis.

First, we performed univariate analysis on all variables, including box plots and histograms for continuous variables and frequency tables for categorical variables. We reported distributions of demographic variables among the sample overall and stratified by case status. In order to assess the degree to which our population reflected the epidemiology of Chicago, we compared trends in daily incidence to CDPH data over the same time period.²³ We also measured several contact tracing effectiveness indicators, including the timeliness of outreach,²⁴ using the time from specimen collection to interview (among cases) and time from identification to interview (among cases and contacts). Contact tracing completeness measures included the proportion of persons reached for interview, defined as the number who completed the first interview, divided by the sum of those who completed the first interview and those never reached. Public health impact was quantified by measuring the average number of UIC-affiliated contacts per case, proportion of contacts who converted to confirmed or presumptive cases within 14 days of exposure, number of infectious days elapsed at the time of the case interview, the prevalence of potential barriers to isolation or quarantine, and the degree to which our program readily offered resources to meet reported challenges. We multiplied the total number of contacts by the probability of conversion observed in our data to quantify the number of cases directly removed from the population before potentially infecting others. Lastly, we conservatively estimated the number of exposures and infections avoided due to contact tracing, based on the number of exposures that were directly prevented, the mean number of contacts per case, and conversion rate, which are illustrated in a series of formulas in Supplemental File 1. UIC’s Institutional Review Board determined that this investigation did not meet the definition of research as defined in 45 CFR 46.102(1).

RESULTS

Description of the population

From August 31, 2020, to May 22, 2021, CCTEP served 1,009 confirmed cases and 912 non-cases, including 746 contacts, 16 PUIs, and 150 persons requiring travel counseling (Table 1). Of the campus members who were confirmed cases upon entering our system and reported exposure data (N = 843), approximately 57% had a known exposure to a COVID-positive person prior to infection (data not presented).

Table 1

Selected characteristics of the UIC CCTEP service population, August 31, 2020 – May 22, 2021 (N = 1,921)

	Total N = 1,921 N (%)	Confirmed cases N = 1,009 N (%)	Non-cases* N = 912 N (%)
<i>Age group (n = 1,921)[†]</i>			
Age 18–22	1074 (55.9%)	494 (49.0%)	580 (63.6%)
Age 23–29	567 (29.5%)	367 (36.4%)	200 (21.9%)
Age 30–44	164 (8.5%)	102 (10.1%)	62 (6.8%)
Age 45–59	78 (4.1%)	33 (3.3%)	45 (4.9%)
Age ≥ 60	38 (2.0%)	13 (1.3%)	25 (2.7%)
<i>Gender (n = 1,699)</i>			
Male	761 (44.8%)	435 (46%)	326 (43.3%)
Female	934 (55.0%)	509 (53.8%)	425 (56.4%)
Non-binary	4 (0.2%)	2 (0.2%)	2 (0.3%)
<i>Race/ethnicity (n = 1,683)</i>			
Non-Latinx White	607 (36.1%)	312 (33.2%)	295 (39.7%)
Non-Latinx Black	225 (13.4%)	113 (12.0%)	112 (15.1%)
Non-Latinx Asian	335 (19.9%)	167 (17.8%)	168 (22.6%)
Non-Latinx Other	74 (4.4%)	40 (4.3%)	34 (4.6%)
Latinx	442 (26.3%)	307 (32.7%)	135 (18.1%)
<i>University affiliation (n = 1,706)</i>			
Undergraduate student	1203 (70.5%)	670 (70.2%)	533 (71.0%)
Graduate student	314 (18.4%)	200 (20.9%)	114 (15.2%)
Employee	189 (11.1%)	85 (8.9%)	104 (13.8%)
Resided in campus housing (n = 1,506)	438 (29.1%)	151 (17.6%)	287 (44.4%)
<i>Primary mode of transit to campus (n = 1,691)</i>			
Automobile	359 (21.2%)	207 (22.0%)	152 (20.3%)
Public transit	242 (14.3%)	151 (16.0%)	91 (12.1%)
Other (e.g., walking or biking)	559 (33.1%)	217 (23.0%)	342 (45.7%)
N/A (worked and/or attended classes remotely)	534 (31.6%)	368 (39.0%)	166 (22.2%)
<i>Membership in mandatory testing group (n = 1,640)</i>			
Campus Housing	344 (21.0%)	125 (13.7%)	219 (30.0%)
Athletics	71 (4.3%)	26 (2.9%)	45 (6.2%)
Performing Arts	22 (1.3%)	12 (1.3%)	10 (1.4%)
Belonged to >1 mandatory testing group	232 (14.1%)	81 (8.9%)	151 (20.7%)
Not in a mandatory testing group	971 (59.2%)	666 (73.2%)	305 (41.8%)

*Includes 746 contacts, 16 PUIs, and 150 persons requiring counseling pre- and/or post-travel.

[†]Gender, race/ethnicity, and academic level were self-reported and were missing from some records. The proportion missing ranged from 11.2% to 12.4%.

In additional analyses, we restricted our data to the 870 student cases and compared them to the general student population at UIC. This revealed a potential overrepresentation of certain subgroups. For example, undergraduates represented 77% of student cases despite accounting for only 65% of enrolled students; Latinx students accounted for 33% of cases, but 26% of enrollees.^{25,26}

The shape of the trend in daily incidence among our contact tracing population aligned closely with trends observed in Chicago, though at a fraction of the scale (Fig 2).

Contact tracing effectiveness

Approximately 96% of cases and contacts completed an initial interview, and of those, we retained 93% throughout isolation or symptom monitoring (Table 2).

Contact tracers reached most cases in about one day from specimen collection (median = 26.4, IQR = 20.9–48.7) and in roughly three hours after we received their lab results (median = 2.5, IQR = 0.5–18.5). Contacts were interviewed within a median of 13.6 hours from

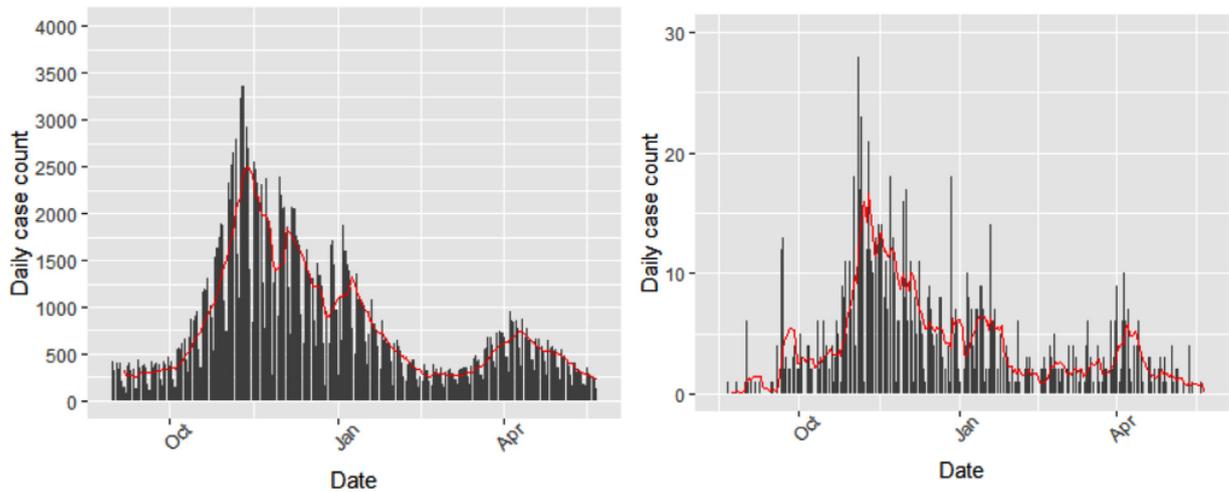


Fig 2. Comparison of daily COVID-19 incidence trends in the city of Chicago (left) and among UIC CCTEP population (right), with red line representing the 7-day rolling average (August 31, 2020 – May 22, 2021). Note: COVID-19 primary series vaccinations were initially offered to students on a staggered basis, beginning with medical students on December 29, 2020. Other students in Health Sciences Colleges were offered vaccination starting in spring 2021, and it was available to all students prior to fall 2021 semester. (Color version of figure is available online.)

the time they were identified (IQR = 0.8–37.7). There was a strong association between contact tracing productivity and incidence trends (Fig 3). Although timeliness of outreach declined during surges, the time from specimen collection to isolation rarely exceeded the standard benchmark of 48 hours.

Cases reported an average of 0.9 UIC-affiliated contacts, and approximately 17% of contacts converted to presumptive or confirmed cases (Table 2). Using these epidemiologic data, we conservatively estimated that contact tracing prevented an additional 132 exposures and 22 COVID-19 infections (Supplemental File 1). Lastly, we investigated 18 clusters on our campus, ranging in size from 4 to 65 persons. The potential for COVID-19 exposure and acquisition was greater within clusters compared to the overall population; cluster cases exposed an average of 2.7 persons, of whom 26% became

presumptive or confirmed cases. These data suggest that we avoided more than 100 infections among clusters alone by preventing them from propagating beyond first-generation contacts.

Lastly, approximately 47% of cases and 63% of contacts reported at least one potential barrier to isolation during the initial interview, and among those who reported barriers, 69% of cases and 82% of contacts received relevant resources immediately or in a follow-up e-mail. We aimed to find appropriate resources for those with remaining, unmet needs within 24 hours of completing the phone interview.

DISCUSSION

Our program provided rapid, thorough contact tracing to UIC campus members during the first academic year of operations, effectively halting transmission and sustaining a safe environment for in-person activities. We isolated 96% of reported cases, often within a day from the time of testing; quarantined nearly all contacts, commonly in less than 48 hours; and controlled 18 clusters from expanding into full-scale outbreaks and disrupting campus operations. The effectiveness with which we reached cases and contacts was superior to data published by CDPH, which interviewed approximately 74% of cases and 81% of contacts since August 1, 2020.²⁷ CDPH does not publicly report timeliness measures, though there is evidence that the average time to interview was well over 48 hours,²⁸ suggesting that our contact tracing program filled what would have been a substantial gap in contact tracing coverage. Our timeliness aligned with that of other university-based contact tracing programs, which generally report isolating cases within 24 hours of laboratory notification,^{7,8} but was substantially better than the performance of non-university-based programs, which reported delays due to laboratory processing and untimely program notification.^{3,12,28} As observed in other major cities, barriers to contact tracing in Chicago included the overwhelming volume of cases, particularly in fall 2020, and low community response rates. While population-based contact tracing efforts in US urban cities were characterized by a lack of timeliness and completeness, we propose that college campuses are a special setting where it can be highly effective, particularly when there is strong institutional and stakeholder support for the contact tracing process.

Additionally, we strove to ameliorate the burden of isolation and quarantine by offering logistical and social support to campus members. Nearly half of cases and almost 2 in 3 non-cases with complete

Table 2
UIC CCTEP contact tracing performance measures, August 31, 2020 – May 22, 2021 (N = 1,921)

	Median (IQR) / N (%)
<i>Timeliness</i>	
Hours from specimen collection to interview among cases (n = 843)	26.4 (20.9, 48.7)
Days infectious at first interview among cases (n = 843)*	5 (3.0, 7.0)
Hours from identification to interview	
Cases (n = 843)	2.5 (0.5, 18.5)
Contacts (n = 690)	13.6 (0.8, 37.7)
<i>Completeness</i>	
Reached for interview	
Cases (n = 882)	843 (95.6%)
Contacts (n = 715)	690 (96.5%)
Lost to follow-up during monitoring	
Cases (n = 843)	59 (7.0%)
Contacts (n = 690)	49 (7.1%)
<i>Potential public health impact</i>	
Average number of UIC contacts per case (n = 843)	0.9
Conversions among all contacts (n = 690)	120 (17.4%)
Tested positive (n = 120)	34 (28.3%)
Developed symptoms but did not report testing (n = 120)	86 (71.7%)
Reported ≥ 1 potential barrier to isolation or quarantine	
Cases (n = 818)	386 (47.2%)
Contacts (n = 392)	248 (63.3%)
Resource to address barrier provided during interview	
Cases (n = 386)	362 (93.8%)
Contacts (n = 248)	231 (93.1%)

*Positive PCR COVID-19 tests were obtained through the COVID-19 surveillance program, UI Health clinical sites, and self-report.

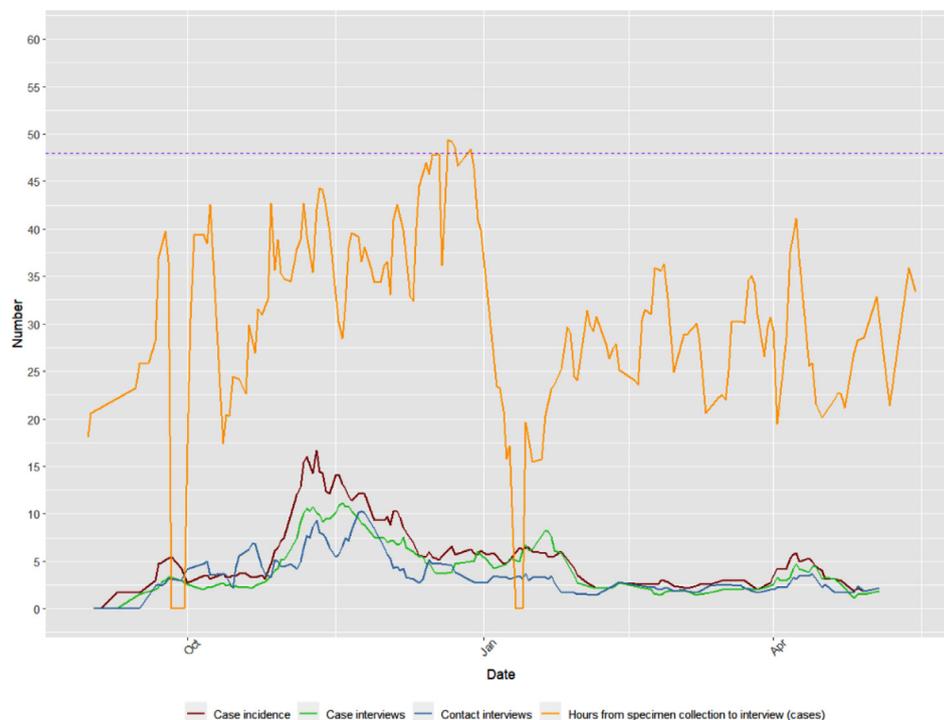


Fig 3. Comparison of contact tracing timeliness and productivity trends, August 31, 2020 – May 22, 2021. Note: All values plotted are expressed as a 7-day moving average. The dotted line represents the 48-hour benchmark for the number of hours from specimen collection to isolation.

resource evaluation data reported at least one potential barrier to isolation or quarantine, respectively. This aspect of our program expanded as the academic year progressed and the number of individuals completing repeated quarantines due to multiple exposures increased.²⁹ Evidence suggests that social support substantially promotes adherence to quarantine and isolation guidance.³⁰

In the descriptive analysis, we found that undergraduates were potentially overrepresented among cases relative to graduate students. This aligns with the common perception that undergraduate students are more likely to acquire and transmit COVID-19 than older students and employees, due primarily to high-density housing and social behavior.⁴ However, this finding is somewhat surprising given that the majority of in-person education during the reporting period occurred in the Health Sciences Colleges, which consisted largely of professional and graduate-level students and accounted for at least 57% of in-person learning during the 2020-2021 academic year. While risks from dormitories are perhaps less germane to UIC than most large universities due to the substantial commuter population, more than one-third of undergraduate cases and contacts who self-reported their housing status lived in a dormitory, suggesting that congregate living might have contributed to differences in incidence. It is also likely that membership in mandatory testing groups (UIC Performing arts, Athletics, and Campus Housing) partially explained the differential distribution of students by academic level. In our sample, approximately 34% of cases were affiliated with a mandatory testing group, and three quarters of cases required to test were undergraduates, suggesting potential selection bias.

Several operational aspects were instrumental to success during the initial stages of implementation, the first of which was recruiting staff from our target community. Community-based outreach is a widely documented strategy for engaging persons with substance use disorders in evidence-based harm reduction interventions (e.g., opiate substitution and syringe exchange programs).³¹⁻³³ In a similar way, our student contact tracers understood the challenges associated with being a student during a pandemic. Strong interpersonal

connections, coupled with high-level public health training and ongoing mentorship, likely bolstered contact tracers' capacity to engage with campus members. Individuals we served often expressed appreciation for timely, practical public health advice and referrals to resources helping them overcome barriers to isolation or quarantine. We also advised faculty to educate students proactively about opportunities to catch up on work and examinations should they need to miss class due to COVID-19.

Translating our epidemiologic data into public health action yielded wide-ranging benefits. Although infected persons commonly attended class while infectious, our individual case investigations showed that transmission was substantially more likely to occur socially in off-campus settings. We found this hypothesis to be true the following academic year, when we began systematically assessing possible classroom transmission events among all cases who attended at least one class while infectious. During the first four weeks of the fall 2021 semester, we investigated 90 cases who attended a total of 192 classes while infectious. Of these, we recorded one possible transmission event involving an unvaccinated contact, suggesting that masking and ventilation upgrades were highly preventive. These findings were shared with the campus community in periodic presentations and emails that promoted a sense of safety and security on campus, based on informal feedback from faculty, students, and staff. Detailed cluster analyses informed interventions, such as serial surveillance testing, to assess the potential amplification of clusters and interrupt transmission before propagated outbreaks could occur. Similarly, trends in contact tracing timeliness informed protocol changes—for example, in mid-November 2020, when incidence more than doubled over a two-week period, prompting two modifications. To prevent further delays in outreach, we began issuing detailed post-exposure guidance by email prior to calling contacts, allowing us to reach substantially more contacts than would have been possible by telephone alone. Additionally, we reduced the frequency of follow-up calls from daily to three periodic touch points. Robust epidemiologic reporting and the ability to

modify data collection protocols, scripts, and workflows in response to frequently updated guidance and policy was possible because we developed a homegrown data capture and management strategy as an alternative to the platform utilized by Illinois health departments.

Naturally, implementing an indigenous contact tracing program in a university poses challenges, including high turnover of student staff and the complexity of translating ever-evolving public health guidance into operational changes and policy. Our program's leadership team, also members of the UIC community before the pandemic, navigated these challenges by leveraging diverse skills in epidemiology, data management, program administration, and infectious disease medicine. We also relied greatly on our network of partners, especially those who developed and deployed UIC's surveillance testing program, a fundamental component of contact tracing.

This report has several limitations. First, CDPH limited our jurisdiction to UIC students and employees, while local health departments traced contacts unaffiliated with UIC, and early on our purview narrowed further to exclude students and employees with clinical or research-participant-facing duties. This precludes our ability to draw conclusions from our data extending beyond the segment we served. However, recognizing this limitation, we developed educational materials that infected or exposed campus members could share with non-UIC housemates to maximize adherence to household testing, isolation, and quarantine. Additionally, because we are largely a commuter college and do not have a firm sense of the students who were physically present on campus, comparisons between our service population and "enrolled" students may be biased, and furthermore, any differences measured across groups likely reflect disparities in community (vs. campus-based) transmission. Social desirability bias might have also contributed to underreporting of COVID-19 exposures and infections among university citizens, potentially deflating projections of public health impact.

Several other limitations center on generalizability. As previously described, our program benefitted from significant financial and professional support. UIC formally codified compliance with contact tracing as university policy, likely contributing to exceptional response rates. This context, combined with substantial reductions in in-person activity during the reporting period, may hamper the broader applicability of the findings. However, given that we internally developed all tools, systems, and strategies while relying nearly exclusively on existing university technologies and systems, our strategies should be adaptable by other IHEs. Lastly, the dynamic nature of COVID-19 limits the utility of our findings. Since the 2020–2021 academic year, major COVID-19 surges associated with the Delta and Omicron variants have occurred. Additionally, UIC mandated COVID-19 vaccination among all campus members prior to fall 2021 semester. Vaccines were unavailable to non-healthcare workers during most of the reporting period; only 53% of our service population completed the primary vaccination series by the end of May 2021, whereas the current prevalence of vaccination exceeds 95%. Readers should interpret our findings with these considerations in mind, and we encourage more universities to report on their pandemic response efforts to shed light on the broader feasibility of similar programs.

CONCLUSION

Our program served an integral role in UIC's pandemic response by successfully completing timely case investigation and contact tracing among university citizens, enabling a safe return to in-person activity in fall 2020. Additionally, we served as a critical epidemiologic resource, informing a wide range of university endeavors. Although contact tracing has been a somewhat ineffective population-level strategy for controlling COVID-19 transmission in large US

cities, IHEs provide fertile ground for effective contact tracing, particularly when comprehensive networks of partners are engaged to promote compliance with institution-specific public health policies. As such, our operational model and strategies hold promise for broader implementation of native contact tracing programs in other colleges and universities.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.ajic.2022.09.025>.

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