

Factors Influencing the Results of COVID-19 Case Outreach—Results From a California Case Investigation/Contact Tracing Program

Debora Barnes-Josiah, PhD, MSPH; Hemanth Kundeti, MS, MBA; Daniel Cramer, MA

ABSTRACT

Context: Considerable research has examined impacts of case investigation and contact tracing (CI/CT) programs on the spread of infectious diseases such as COVID-19, but there are few reports on factors affecting the ability of these programs to obtain interviews and acquire key information.

Objective: To investigate programmatic and case-specific factors associated with CI outcomes using data from the Public Health Institute's Tracing Health CI/CT program. Analyses were designed to detect variability in predictors of whether interviews and key information were obtained rather than quantify specific relationships.

Design: Logistic regression models examined variability in the predictive value of interview timeliness and respondent characteristics on outreach outcomes and interview results.

Setting and Participants: Participants were members of a large California health care network with a positive laboratory test for COVID-19 and outreach from January 1 to July 31, 2021.

Main Outcome Measures: The primary outcome was the result of outreach attempts: completed interview, refused interview, or failure to reach the infected person. Secondary outcomes considered whether respondents provided information on symptom onset, employment, and contact information or a reason for declining to provide information, and whether resource support was requested or accepted.

Results: Of 9391 eligible records, 65.6% were for completed interviews, 6.0% were refusals, and 28.3% were failed outreach. One-third of respondents (36.7%) provided information on contacts (mean = 0.97 contacts per respondent, 2.6 for those naming at least 1). Privacy concerns were the most common reasons for not providing contact information. Among respondent characteristics and interview timeliness, only race and number of symptoms showed statistically significant effects in all adjusted analyses.

Conclusions: Significant variation existed in outreach outcomes by subject characteristics and interview timeliness. CI/CT programs carefully focused to characteristics and needs of specific communities will likely have the greatest impact on the spread of COVID-19 and other communicable diseases.

KEY WORDS: case investigation, contact tracing, COVID-19, interview timeliness

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Correspondence: Debora Barnes-Josiah, PhD, MSPH, Tracing Health Program, Public Health Institute, 555 12th Street, Oakland, CA 94607 (dlbjosiah@gmail.com).

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COVID-19 is caused by the SARS-CoV-2 virus, part of a large family of coronaviruses that cause infectious diseases with predominantly respiratory transmission. Established public health measures to contain the spread of the disease include 3 key functions—case investigation (CI), contact identification, and contact tracing (CT).¹ Case investigation is typically accomplished through direct outreach to individuals with positive laboratory tests for COVID-19 to encourage isolation and offer resources and support. During this process, information is requested for contacts—persons who may have been exposed to the infected individual. Finally, CT involves outreach to these identified contacts to encourage and support their quarantine period. Prompt

and efficient identification of contacts can mitigate the spread of disease through swift implementation of quarantine.^{2,3} However, results are dependent on infected persons' willingness to be interviewed and to identify people they may have exposed. In addition to fear of scams and normal reticence about providing identifying information on family, friends, and coworkers, the politicization in the United States of the COVID-19 pandemic has exacerbated concerns around the misuse of information.⁴⁻⁷ Numerous smartphone-based "digital" or "contactless" methods of identifying and notifying potentially exposed persons are being developed but have not yet been widely adopted in the United States.⁸⁻¹⁰ In the absence of effective alternatives, traditional CI/CT programs remain a major tool. It is thus important to identify programmatic and target audience factors that may affect their effectiveness.¹¹

The California Contact Tracing Support Initiative (CCTSI) was launched in August 2020 as part of the Public Health Institute's Tracing Health program. The objectives of the initiative were to (1) reduce the spread of COVID-19 in the state through CI and CT, (2) improve trust in the CI/CT process by prioritizing the use of interviewers from local communities rather than relying on health department staff, and (3) offer resource support to persons in quarantine or isolation. The Initiative's design was based on then current guidance from the US Centers for Disease Control and Prevention (CDC) and included recommended process and outcome measures.¹

Objective

This study used CCTSI data to examine whether variation in programmatic and case-specific factors was associated with achieving specific CI goals. The primary study outcome was the result of outreach attempts: completed interviews, refused interviews, or failure to reach the infected person ("failed outreach"). Four secondary outcomes looked at whether answers were provided during completed interviews for symptom-onset date, employment, and contact information, and a reason for declining to provide contact information. The fifth secondary outcome was the respondent's need for resource support. Rather than quantifying specific relationships between predictive factors and these outcomes, the objective was to assess whether variability in the predictive factors affected the outcomes.

Methods

Staffing

Using employment Web sites and targeted outreach to community-based organizations, universities, and

employment centers, Tracing Health had hired more than 400 CI/CTs by mid-December 2020, reaching more than 600 by early June 2021. Approximately 90% of the CI/CT team identified as either bilingual or multilingual, with more than 30 languages spoken across the program. The CI/CT training was developed internally and included more than 100 hours of education and practical skill building, including interviewing techniques, Health Insurance Portability and Accountability Act (HIPAA) compliance, and data entry. All outreach staff were required to pass an open online CT course.¹² All activities were performed remotely.

Data source and management

The project received data on members of a large health care plan who resided in 17 California counties and had a positive laboratory test for COVID-19. Basic contact and demographic information on newly diagnosed persons was imported daily into a Microsoft Dynamics/Azure-based data platform (Microbe Awareness and Risk Intervention; "MARI"). Case investigators were matched to cases on language and ethnicity when possible and made outreach attempts using telephone numbers provided by the health care plan. The project protocol specified up to 3 calls over 24 hours, with 4 to 6 hours between attempts. The computer-assisted interview process involved verification of the initial data and gathering further information, including additional demographics, COVID-19 symptom-onset and status, health conditions, and employment-related factors. Interviewers provided isolation guidelines and offered referrals to a community resource coordinator for supports such as work letters or utilities assistance. The opportunity to opt into daily phone-based monitoring was available for residents of several counties. Information was also elicited on close contacts; respondents who reported symptoms were asked about contacts starting 2 days before symptom onset. The time frame began 2 days before the test date for nonsymptomatic respondents. When a name and telephone number were provided, a CT attempted to notify the contact of their exposure and assess their quarantine-related needs (see Supplemental Digital Content Figure 1, available at <http://links.lww.com/JPHMP/B42>, for an overview of the CCTSI process).

The MARI data platform consisted of multiple relational databases, containing information on test results, outreach progress, and information obtained during interviews. A database-specific identification number was autogenerated for each record and linked individuals across databases. The data were routinely scanned for duplicate test results and records for persons who had already been contacted through

CalCONNECT, California's health department-based COVID-19 CT and data management system. Because of COVID-19 retesting and reinfections, individuals could have more than 1 positive laboratory report during the project period and thus more than 1 MARI record identifier. Screening for multiple records was included in database quality checks and during the study analysis. Records were closed after achieving an interview with the COVID-19-positive person, contact, or proxy; a refusal to provide an interview; or when a supervisor deemed the outreach attempt to be unsuccessful.

Human participant compliance

Project data were collected as part of public health surveillance on behalf of the State of California. The Public Health Institute Institutional Review Board determined that informed consent was not required for this research. To minimize the potential for identifying participants during this analysis, all MARI identifiers were replaced with randomly generated alphanumeric identifiers that did not contain personal information. All participant-specific data were either aggregated across strata; recoded to yes, no, unknown, missing; or categorized to answer provided or not provided.

Study variables

The final status of each case investigation was coded as a 3-level variable: completed interview, refusal, or failed outreach. The combined data received from the testing laboratory and the health care plan contained information on individuals' age, race, ethnicity, gender, and residential zip code. Dichotomous yes/no indicators were constructed for age groups (younger than 18 years, 18-29, subsequent 10-year age groups, and 60+), ethnicity (Hispanic/Latinx), and primary language (English). Individual indicators were also created for race (Asian, Black/African American, White, other, missing), with multiple race included in other. Self-identified gender and transgender status were collapsed to male and female, then dichotomized as yes/no for male gender. Large numbers of records were initially missing data for race (24%) and gender (75%) but were supplemented by interview data when available. Zip codes were replaced by an urbanization designation (city, suburban, town, rural) using the Education Demographic and Geographic Estimates framework.¹³ After implementing eligibility requirements, only 14 records were categorized as "town" and were moved to a combined category with suburban.

Additional information available from completed interviews included ever being symptomatic for

COVID-19 (yes, no) and current symptom status (asymptomatic, still symptomatic, symptoms resolved). Respondents were asked about the occurrence of 20 symptoms asked individually (yes, no, and total number) and 11 comorbid conditions also asked individually (yes, no). Other symptom and comorbidity responses reported by the respondent were categorized as other. Relationships between respondents and their contacts were dichotomized for family (child, parent, spouse/partner, grandparent) versus other (colleague, friend, other). A dichotomous field (yes, no) was created for respondents who requested support in obtaining resources or accepted an offer of referral to a local resource coordinator. A dichotomous indicator (yes, no) was also created for persons with more than 1 distinct COVID-19 test result and thus multiple records.

The automated date/time stamp of the last telephone call in MARI was used as the record closure date/time for persons with failed outreach or who refused an interview. Because postinterview calls continued to respondents accepting monitoring, the initial interview date/time stamp was considered as record closure for completed interviews. Elapsed times were calculated from the positive laboratory test to the first call attempt and to record closure. For persons with a completed interview, elapsed times were also calculated from the symptom-onset date.

The primary study outcome was the status of the outreach attempt (completed interview, refusal, failed outreach). Secondary outcomes assessed whether (1) a symptom-onset date was provided, (2) a place of employment was provided (respondents younger than 60 years only), (3) name and telephone number were provided for 1 or more contacts, (4) a reason was provided if the respondent declined to provide information on contacts, and (5) support services were requested or accepted.

Eligible participants

The program began receiving data in early December 2020, coinciding with California as well as national surges in the number of COVID-19 cases. Early data quality was inconsistent, reflecting start-up issues with quality control, achieving timely data flows from the testing laboratories, and stakeholder-driven revisions to the interview script. The analysis period was thus set as January 1 through July 31, 2021, the program's official end date. Duplicate records and records for persons whose information had already been entered into CalCONNECT were not assessed for eligibility. Records for persons who were reported to be hospitalized, indisposed, deceased, or younger than 18 years were excluded. Finally,

only the earliest eligible record for each person was retained.

Statistical analyses

Basic descriptive statistics were calculated for all independent variables (demographic, health, and time intervals). Preliminary review of the data showed records that had not been closed within the study protocol, for example, during lower volume periods, some outreach attempts continued up to 3 months after the diagnostic test. Because such outliers disproportionately affected mean values for the call-related intervals, the time intervals are reported as medians. No data were truncated. The distributions of age groups, primary language, and residential urbanization level were compared across the 3 status outcomes using χ^2 tests. Comparisons of time intervals across the outcomes used multivariate analysis of variance.

The predictive values of the initial demographic and time interval variables for the status outcomes were first assessed in univariate logistic regression models, with completed interviews as the reference category and using fully formatted demographic variables. Subsequent adjusted models used the dichotomized levels of initially significant demographic fields. A similar process was used for the secondary study outcomes, using the 2-step process for the complete set of demographic and health fields and the need for support added to the set of predictive factors. The linear sequence of basic project events caused most time intervals to be highly correlated and they could not be tested simultaneously. For example, one-half of completed interviews (47.4%) was achieved on the first phone call and the interval for symptom onset to first call was highly correlated with the interval from symptom onset to interview (Pearson correlation coefficient = 0.996, $P < .001$). For consistency, the interval from diagnostic test to interview/record closure was used in all regression models as it was the only interval for which all records had a value.

Because the study objective was to detect variation in predictive values rather than quantify detailed relationships between respondent characteristics and outcomes, only significance levels from the regression models are presented for demographic variables rather than traditional measures such as odds ratios. The direction of effect is included for the symptom, resource, and timeliness variables as their implications are more generalizable. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, North Carolina) with a significance level of .05.

Results

A total of 13 263 records on coronavirus-infected persons were entered into the MARI database for January 1 through July 31, 2021 (see Supplemental Digital Content Figure 2, available at <http://links.lww.com/JPHMP/B43>, for the participant flowchart). Of these, 9391 records (70.8%) met the eligibility criteria and were included in the study. For the primary outcome, two-thirds (65.6%) of eligible records were completed interviews, 6.0% were refused interviews, and 28.3% were for persons unable to be reached (Table 1). The percentage of outreach attempts ending in completed interviews declined over time with most refusals occurring in the last 3 months of the project (see Supplemental Digital Content Figure 3, available at <http://links.lww.com/JPHMP/B44>, showing outreach outcomes over time). Although the distributions of age, primary language, and urbanization were significantly different across the 3 outcomes ($P < .01$, $P < .05$, $P < .001$, respectively), the actual differences were minor.

Additional information was available for persons who completed an interview (Table 1). Of these respondents, more than one-half (57.5%) identified themselves as White and 39.5% as Hispanic/Latinx; gender was missing or unknown for 19.4%. Most respondents reported having had COVID-19 symptoms (84.1%) and were symptomatic at the time of the interview (73.1%). An average of 4.5 symptoms were reported, the most common of which were cough (52.6%) and headache (47.7%) (see Supplemental Digital Content Table 1, available at <http://links.lww.com/JPHMP/B45>, for the full list of symptoms). One-third of respondents (32.0%) reported 1 or more preexisting health conditions, with asthma (9.2%), diabetes (8.5%), and hypertension (8.5%) the most common (see Supplemental Digital Content Table 2, available at <http://links.lww.com/JPHMP/B46>, for the full list of health conditions).

Over the 7-month study period, CIs made more than 20 000 calls with a mean of 2.3 calls for each infected person (Table 2). The median time from a positive diagnostic test to the first call attempt with any outcome was 32.0 hours (1.3 days); there was no statistically significant difference between test-to-first call intervals for completed interviews compared with refused interviews (31.0 and 34.7 hours, respectively). The difference in median time from the diagnostic test to a completed interview (35.3 hours [1.5 days]) versus a refused interview (37.9 hours [1.6 days]) was also not significant. Test-to-record closure and first call-to-record closure intervals were significantly longer for failed outreach than for completed and refused interviews.

TABLE 1
Characteristics of Respondents and Primary Study Outcomes

Demographics	Outreach Results												P
	Completed Interview			Refused			Outreach Failed			Total			
	n	% ^a	% ^b	n	% ^a	% ^b	n	% ^a	% ^b	n	%	% ^a	
All subjects	6161		65.6	568		6.0	2662		28.3%	9 391		100.0	
Age, y													.003
18-29	1289	20.9	62.8	136	23.9	6.6	629	23.6	30.6	2 054	21.9	100.0	
30-39	1292	21.0	63.9	131	23.1	6.5	600	22.5	29.7	2 023	21.5	100.0	
40-49	1139	18.5	66.8	93	16.4	5.5	472	17.7	27.7	1 704	18.1	100.0	
50-59	1118	18.1	69.3	96	16.9	5.9	400	15.0	24.8	1 614	17.2	100.0	
60-101	1323	21.5	66.3	112	19.7	5.6	561	21.1	28.1	1 996	21.3	100.0	
Total	6161	100.0		568	100.0		2 662	100.0		9 391	100.0		
Language													.02
English	5693	92.4	65.3	547	96.3	6.3	2 484	93.3	28.5	8 724	92.9	100.0	
Spanish	444	7.2	70.7	20	3.5	3.2	164	6.2	26.1	628	6.7	100.0	
Other	22	0.4	61.1	1	0.2	2.8	13	0.5	36.1	36	0.4	100.0	
Missing/unknown	2	0.0	66.7	0	0.0	0.0	1	0.0	33.3	3	0.0	100.0	
Total	6161	100.0		568	100.0		2662	100.0		9391	100.0		
Location													.001
City	2145	34.8	66.6	171	30.1	5.3	905	34.0	28.1	3221	34.3	100.0	
Suburban/town	1491	24.2	62.2	179	31.5	7.5	728	27.3	30.4	2398	25.5	100.0	
Rural	2521	40.9	66.9	218	38.4	5.8	1029	38.7	27.3	3768	40.1	100.0	
Unknown ^c	4	0.1	100.0	0	0.0	0.0	0	0.0	0.0	4	0.0	100.0	
Total	6161	100.0		568	100.0		2662	100.0		9391	100.0		
Race													
Asian	513	8.3											
African American	368	6.0											
White	3541	57.5											
Other	1153	18.7											
Missing/unknown	586	9.5											
Total	6161	100.0											
Ethnicity													
Hispanic/Latinx	2431	39.5											
Non-Hispanic/Latinx	3725	60.5											
Missing/unknown	5	0.1											
Total	6161	100.0											
Gender													
Male	2276	36.9											
Female	2689	43.6											
Missing/Unknown	1196	19.4											
Total	6161	100.0											

^a Column percent.

^b Row percent.

^c Zip codes that did not match to a location.

TABLE 2
Outreach Process Measures

	Outreach Results								
	Completed Interview		Refused Interview		Unable to Reach		Total		P
	Mean	Total Count	Mean	Total Count	Mean	Total Count	Mean	Total Count	
Number of calls	2.1	11 821	1.8	937 ^{a,b}	2.9	7282 ^a	2.3	20 040	<.001
Time Intervals, h	Median (Range)		Median (Range)		Median (Range)		Median (Range)		P^c
Diagnostic test to first call	31.0 (9.8-2353.6)		34.7 (11.6-179.9)		35.0 (11.9-1427.5) ^a		32.0 (9.8-2353.6)		.03
Onset of symptoms to first call	165.0 (3.9-2912.0)								
Diagnostic test to record closure ^d	35.3 (10.2-2353.8)		37.9 (11.8-206.0) ^b		58.3 (12.5-1932.1) ^a		38.8 (10.2-2353.8)		<.001
First call to record closure ^d	0.6 (0.01-240.0)		0.1 (0.01-95.3) ^b		0.2 (0.01-425.8) ^a		0.5 (0.01-425.8)		<.001

^aP < .05 in comparison with calls resulting in a completed interview.

^bP < .05 in comparison with calls resulting in failed outreach.

^cResults from analysis of variance tests using mean values.

^dFor completed interviews, record closure is the date/time of the first interview. For refused interviews and failed outreach, record closure is the date/time of the last telephone call.

The secondary outcomes assessed respondents' willingness to provide key information (Table 3). Most respondents (80.8%) provided an onset date of their symptoms while only one-third (33.6%) provided information on their place of employment. One-third of respondents (36.7%) were willing or

able to provide information on persons they may have exposed. In all, nearly 6000 contacts were named, of whom 69.8% were family members. The overall study average was 0.97 contacts per interviewed case; if at least 1 contact was named, the average was 2.6. However, respondents were frequently

TABLE 3
Secondary Study Outcomes

	Provided/Yes		Not provided/No		Total	
	N	% ^a	N	% ^a	N	% ^a
Symptom-onset date (provided/not provided)	4981	80.8	1180	19.2	6161	100.0
Place of employment (provided/not provided)	2073	33.6	4088	66.4	6161	100.0
Any contacts named ^b	2264	36.7	3897	63.3	6161	100.0
Mean number of contacts = 0.97						
Name and valid phone number for 1 or more contacts ^b	558	24.6	1706	75.4	2264	100.0
Mean number of contacts = 2.6						
Maximum number of contacts = 22						
Total number of contacts = 5953						
Named contact is family member ^c (yes/no)	4146	69.8	1793	30.2	5939	100.0
Reason for declining to identify contacts (provided/not provided)	1267	56.0	997	44.0	2264	100.0
Requested or accepted resources or support ^d (yes/no)	1165	18.9	4996	81.1	6161	100.0
Requested/accepted resource support	680	11.0	5481	89.0	6161	100.0
Requested work letter	437	7.1	5724	92.9	6161	100.0
Accepted daily monitoring	263	4.3	5898	95.7	6161	100.0

^aRow percent.

^bContacts can be named by more than 1 respondent.

^cChild, parent, grandparent, spouse, or partner.

^dRespondents can fit more than 1 category.

unable or unwilling to share additional information on their contacts, and a telephone number was provided for only one-quarter (24.6%). Approximately one-half (56.0%) of those declining to share information on contacts provided a reason, the most common of which involved privacy concerns, followed by contacts being family members or others already notified (data not shown). Relatively few respondents (18.9%) requested or accepted referral to a local resource coordinator (11.0%), a letter for their workplace (7.1%), or daily monitoring during their isolation period (4.3%).

Table 4 shows the results of the unadjusted and adjusted regression models predicting outreach results, using completed interviews as the reference. Both models showed significant effects of respondents' age, primary language, and residential location in predicting refused interviews and failed outreach. Time intervals from diagnostic test to record closure were significantly longer for failed outreach than for completed interviews ($P < .01$); however, the differences between refused and completed interviews were not significant.

Table 5 shows regression results for the 5 secondary outcomes using results of completed interviews. All demographic, health status, and time interval variables were significant predictors of 1 or more outcomes in unadjusted models. However, only respondent's race and number of reported COVID-19 symptoms showed significant effects in all adjusted models. The time interval from diagnostic test to the completed interview was significant only in adjusted models for providing the symptom-onset date and for requesting or accepting support. The direction of effect of the health status and symptom variables varied, with respondents who requested or accepted support more likely to provide contact information or a reason for refusing to do so. In contrast, respondents with higher numbers of symptoms were more likely to provide answers for all secondary outcomes. Longer times from diagnostic test to interview were associated with a lower likelihood of providing a symptom-onset date but a higher likelihood of requesting or accepting support.

TABLE 4
Logistic Regression Models Predicting the Result of Outreach Attempts

Predictive Factors	Refused Interview Versus Completed Interview ^a			Failed Outreach Versus Completed Interview ^a		
	Unadjusted ^b <i>P</i>	Adjusted		Unadjusted ^b <i>P</i>	Adjusted	
		<i>P</i>	Direction of Effect ^c		<i>P</i>	Direction of Effect ^c
Demographics						
Age, y	<.001			<.001		
18-29		.85			.002	
30-39		.001			.02	
40-49		Reference			Reference	
50-59		.021			.004	
60-101		.36			.92	
English language ^d	<.001	<.001		<.001	<.001	
Location						
City	<.001	.001			.02	
Suburban/town		Reference			Reference	
Rural		.82			.02	
Time interval, h						
Diagnostic test to record closure ^e	.54	.68	—	<.001	<.001	+

^aReference value.

^bUnadjusted models used the full categorical form of the age, language, and location variables.

^cSign of β estimate, provided for time interval only. +, longer intervals are more likely to end in a refused interview or failed outreach. —, longer intervals are less likely to result in a refused interview or failed outreach.

^dThree-level variable (English, Spanish, Other) in the unadjusted models; dichotomous (English, All other) in the adjusted models.

^eFor completed interviews, record closure is the date/time of the first interview. For refused interviews and failed outreach, record closure is the date/time of the last telephone call.

TABLE 5

Regression Models Predicting Whether Responses Were Provided for Key Fields During Completed Interviews

	Symptom-Onset Date Provided			Place of Employment Provided ^a			Any Contacts Named			Reason for Refusal Provided			Requested/Accepted Support					
	P	Adjusted	Direction of Effect ^b	P	Adjusted	Direction of Effect ^b	P	Unadjusted	Adjusted	Direction of Effect ^b	P	Unadjusted	Adjusted	Direction of Effect ^b	P	Unadjusted	Adjusted	Direction of Effect ^b
Demographics^c																		
Age, y	<.001			<.001			.04		.92		<.001			.60		<.001		.16
18–29		.61	Reference		<.001					Reference				Reference				Reference
30–39		Reference			Reference													
40–49		.20	<.001		.14					.42				.42				<.001
50–59		.45	.003		.33					.02				.02				<.001
60–69		.001			.09					<.001				<.001				.08
Race	<.001			<.001			<.001											<.001
Asian		<.001	.003		.01					.003				.003				<.001
African American		<.001	.61		.21					.16				.16				<.001
Other		.01	.99		.02					<.001				<.001				<.001
White		Reference			Reference					Reference				Reference				Reference
Hispanic/Latinx ethnicity	.02	.51	<.001	.005	.15				.83	.02				<.001				<.001
Male gender	.82	.04	<.001	<.001	.86				.41	.05				.02				.009
English language ^d	<.001	.06	.52	.21	.009				.11	.005				<.001				<.001
Location	<.001			<.001			<.001			.03								<.001
City		.44	.84		.001				.001					.46				.007
Suburban/town		Reference			Reference				Reference					Reference				Reference
Rural		.20	.02		.46				.46					.50				.28
Health status																		
Requested or accepted support	<.001	.94	+	.005	.82	+	<.001	<.001	<.001	+	<.001	<.001	<.001	<.001	<.001	<.001	<.001	+
Number of symptoms	<.001	<.001	+	<.001	<.001	+	<.001	<.001	.003	+	<.001	<.001	<.001	<.001	<.001	<.001	<.001	+
Time interval, h																		
Diagnostic test to completed interview	<.001	<.001	–	<.001	.21	–	.22	.009	.47	–	.009	.003	.40	.40	–	.003	.003	<.001

^a Respondents younger than 60 years only.

^b Sign of β estimate, provided for health status and time interval variables only. +, more likely to provide a response; –, less likely to provide a response.

^c Unadjusted models used the full categorical form of the age, language, and location variables. Individual dichotomized versions were used in the adjusted models.

^d Three-level variable (English, Spanish, Other) in the unadjusted model; dichotomous (English, All other) in the adjusted model.

Discussion

The main goals of COVID-19 CIs are to provide support to infected persons and limit the spread of the disease. However, these goals are dependent on the ability to reach the infected individuals and obtain an interview. Rainisch et al¹⁴ analyzed data for 64 jurisdictions reporting metrics to the CDC, finding a median interview rate of 58% (November 2020 to January 2021; range = 39%-74%). Lash et al¹⁵ reported a 59% interview rate (June-October 2020) from combined data for 11 states and 1 tribal nation, while early data from New Haven, Connecticut, showed a 48% interview rate.¹⁶ Our interview rate of 65.6% compares favorably with these results, although it is lower than that achieved in King County, Washington (82%; July 2020 to June 2021).¹⁷ Although racial differences in the likelihood of obtaining an interview have been documented, our race data were too incomplete to accurately address this.^{16,18,19} Importantly, however, our data clearly show that the likelihood of a completed interview varied significantly by respondents' age, language, and residential location (Table 5).

Notably, the percentage of completed interviews in our data declined over time, while the percentage of failed outreach increased in the final months (see Supplemental Digital Content Figure 3, available at <http://links.lww.com/JPHMP/B44>, showing outreach outcomes over time). External factors such as large-scale interventions and temporal changes in public support have been reported to affect CI outcomes.^{4,20,21} More than 50% of California's population older than 11 years had been vaccinated for COVID-19 by May 1, 2021, which may have affected motivation to be interviewed.²²

Timeliness is widely used as a metric of the effectiveness and efficiency of CI/CT programs, and delayed testing and receipt of results clearly affect the ability to reduce the spread of the disease.²³⁻²⁵ Spencer et al²⁶ have reported that delays in outreach reduce the likelihood of an accepted interview. Our data, however, did not show a significant difference in median times from diagnostic test to first call attempt for completed versus refused interviews (31.0 hours and 34.7 hours, respectively; $P > .05$). The longer intervals for failed outreach (35.0 hours; $P < .05$ for comparison with completed interviews) likely include passive refusals through call screening.

Literature is sparse on predictors of willingness to provide key information during a case interview. Lash et al¹⁵ reported that 56% of interviewed persons named contacts, while Rainisch et al¹⁴ reported a median of only 27% (range = 15%-74%). In contrast to an early report from Washington State, we found racial differences in whether information was

provided for contacts.²⁷ As expected, concerns about privacy and misuse of information were important reasons for declining to share contact information. Interestingly, in January 2021, one-half of our respondents (52.2%) provided information on contacts; the percentage subsequently dropped and then remained steady through the end of the program (36.1%-40.7% for February-July 2021). Finally, respondents who requested or accepted support services, or reported higher numbers of symptoms, were more likely to provide information. This greater cooperation may reflect unmet needs for social as well as resource support and an opportunity to link the availability of resources with community support of CI/CT programs.¹⁷

Overall, we found significant variation by respondents' demographics and other characteristics in their willingness to be interviewed and to provide information (Table 5). In early 2022, the CDC and the national public health agencies modified their recommendations from universal CI/CT to prioritizing outbreaks and high-risk settings.^{28,29} This reinforces the importance of designing outreach programs that are perceived as worthwhile by targeted groups, incorporating a focus on meeting the social and medical needs of infected persons, and using careful messaging and multiple outreach modes.^{6,30} For example, the effectiveness of face-to-face outreach has been shown in congregate settings and providers' offices, and with home-based contact in smaller communities.³¹⁻³⁴ Identifying outreach as being associated with health plans may also have a favorable impact in some communities.¹¹

Limitations

Difficulties in designing and implementing COVID-19 CI/CT programs on a rapid time frame are well documented.^{16,35,36} The CCTSI project was not designed as a formal research study but rather focused on the immediate need of reaching as many infected persons and their contacts as possible. This was manifested in, for example, missing data for key study variables, extreme outlying values for the call intervals, and 12% of records ending in failed outreach having only had 1 call (data not shown). Such factors may have introduced bias into the results. However, closer attention was paid to the completeness of data directly tied to the goals of the project, for example, respondents' answers around symptoms and contacts, and findings around these general outcomes are considered robust. Because of the MARI structure, we were also unable to account for bias related to multiple respondents from the same household, which may have inflated the significance of some results. Finally, our study population cannot be considered a representative random sample of persons infected

Implications for Policy & Practice

- “One size does not fit all” when designing COVID-19 CI/CT programs; multiple outreach methods and community messages that appeal to different segments of the target population will enhance the probability of successful outreach.
- Achieving an interview is only part of successful outreach; actually obtaining key information is affected by whether the format and content of interviews are responsive to respondents’ concerns about privacy and the use of their data.
- The ability to offer relevant resources to affected persons and communities should be considered an important function of CI/CT programs.
- Although the actual design of CI/CT programs necessarily varies across jurisdictions, incorporating standardized core questions, formal quality control measures, and comprehensive evaluation capacity will enable meta-analyses of their impact.

with COVID-19 and we do not assume that our demographic findings would be replicated in other populations. Therefore, although unconventional, we report regression results in terms of variability rather than traditional measures of association and present the study as an exploratory analysis of variability in the relationships of population characteristics and programmatic factors with outcomes of COVID-19 case outreach.

Conclusions

Although labor- and resource-intensive, manual CI and CT can help minimize the spread of infectious diseases. However, the effectiveness of CI/CT programs depends on their ability to reach their intended audience. We found that subject characteristics and program process measures predicted significant variation in the outcomes of outreach attempts and in respondents’ willingness to provide key interview information. An important addition to future research would be a focus on understanding the impact of social determinants such as income and employment, both for improving outreach outcomes and for addressing the needs of affected communities. Future CI/CT programs would also benefit from incorporating, to the extent possible, a formal research structure with a minimum set of standardized core questions and programmatic measures that allow comprehensive monitoring, evaluation, and comparison of results across projects and studies.¹¹ These measures would also enable ongoing marketing research for effective messaging. Whether the overall

scope is universal or targeted, carefully designed and monitored CI/CT programs that understand and are focused on the characteristics and needs of specific communities are likely to have the greatest impact on the spread of COVID-19 and other communicable diseases.

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