Project Report
ACTA-7

Toward Improving EN Adoption: Bridging the Gap between Stated Intention and Actual Use

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3 June 2022

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1. INTRODUCTION

As the COVID-19 pandemic swept the globe in the spring of 2020, technologists looked to enlist technology to assist public health authorities (PHAs) and help stem the tide of infections. As part of this technology push, experts in health care, cryptography, and other related fields developed the Private Automated Contact Tracing (PACT) protocol and related projects to assist the public health objective of slowing the spread of SARS-CoV-2 through digital contact tracing. The joint Google and Apple deployed protocol (Google-Apple Exposure Notifications, also known as GAEN or EN), which became the *de facto* standard in the U.S., employs the same features as detailed by PACT. The protocol leverages smartphone Bluetooth communications to alert users of potential contact with those carrying the COVID-19 virus in a way that preserves the privacy of both the known-infected individual, and the users receiving the alert. Contact tracing and subsequent personal precautions are more effective at reducing disease spread when more of the population participates, but there are known difficulties with the adoption of novel technology. In order to help the U.S. Centers for Disease Control and Prevention (CDC) and U.S. state-level public health teams address these difficulties, a team of staff from MIT's Lincoln Laboratory (MIT LL) and Computer Science and Artificial Intelligence Laboratory (MIT CSAIL) focused on studying user perception and information needs.

Initial work included ethnographically informed assessments of the Ireland and Pennsylvania (PA) mobile apps for exposure notification, the in-app and traditional contact tracing workflows, and information presentation compared to user information requirements. We also conducted a literature review of COVID-19 exposure notification technologies and related research efforts. These early efforts led to the development of a pilot empirical research study focused on investigating engagement factors that public health authorities and others in health care professions may be able to affect. Results of the pilot study were promising, leading to the conduct of a nationally representative survey (n=2157) sampling the AmeriSpeak recruited probability panel from April 30–May 24, 2021.

As a result of our research, we are able to make recommendations to public health and primary care physicians for communications and outreach that are expected to improve adoption of Exposure Notification applications, and which have broader implications for similar digital contact tracing systems.

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2. INITIAL INVESTIGATION

Our first effort focused on understanding the context around service deployment. We looked at the practical implications of the technology structure, or how the technology functions would require users to interact with the service. This ethnographically informed activity is akin to a heuristic review, wherein the reviewer imagines themselves as a novice user trying to complete the intended workflow. This would allow us to situate existing perception-and-use literature in context, and identify where human factors efforts could yield the most benefit for EN acceptance, thereby increasing the public health benefits of EN. We then evaluated the workflow and information provided within the deployed Ireland app and related PA smartphone app deployment, to provide immediate practical feedback on PA's deployment. Primary questions included:

- What actions do people need to take to enable exposure notification processes?
- What other factors exist that may prevent people from engaging?

2.1 PRACTICAL FUNCTION WORKFLOW ANALYSIS RESULTS

Initial user perception research started with understanding how EN functions in the context of required user actions. As shown in Figure 1, the typical technology explanation focuses on two actors: an index case (initial infection), and a contact. Each actor's phone would periodically issue Bluetooth "chirps" that the other's phone would "hear" and store locally on the phone. This would allow the service to determine approximate distance between actors, as well as the amount of time those actors were within Bluetooth range. If one actor were to test positive for COVID-19, they could enable their phone to share its daily cryptographic "keys" with the service, which would allow any phones with a record of the index phone's chirps to "unlock" them, estimate the "dosage" based on signal strength and duration, and issue an alert to contacts that were "too close for too long" (defined as within 6 feet for 15 minutes or more).

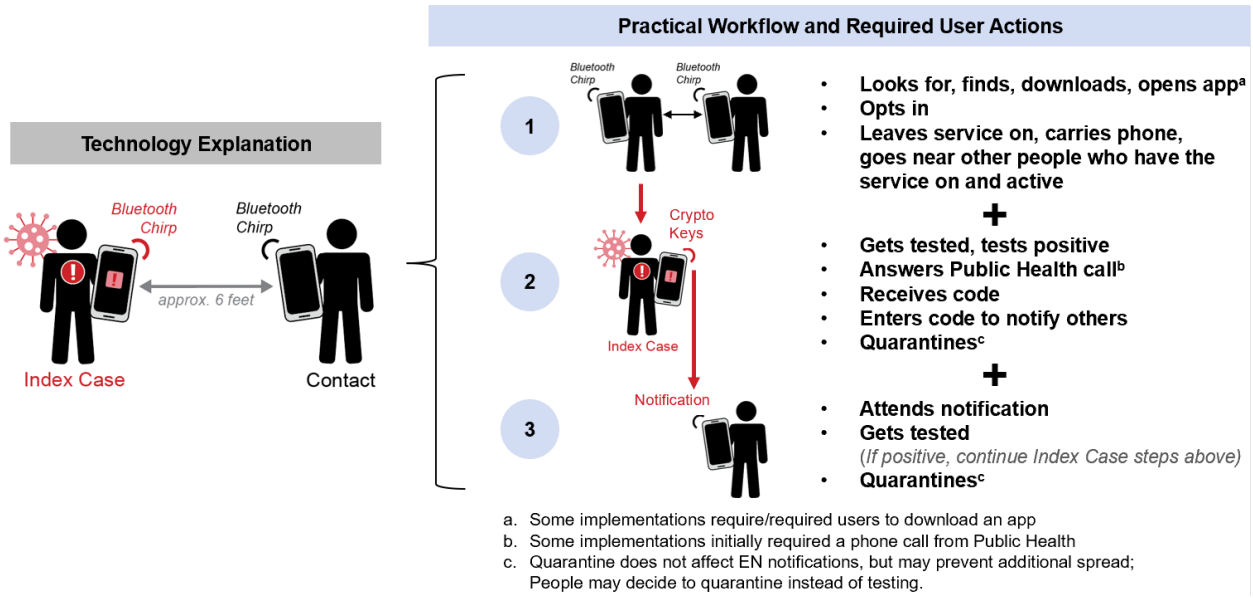

Figure 1. Overview of EN technology (left) showing communication between an index case and contact, exploded into practical workflow and user actions (right) required for the technology to function as intended.

By considering the practical user actions required to enable the technology in the wild (Figure 1, in blue at right), we detailed a number of different user engagement steps to allow the service to function as intended:

1. **First, there must be two actors 18 years or older that have downloaded an app and/or opted into the service.**
    a. Both actors need to know that the service/app is available through advertising, word-of-mouth, messages sent to phones, etc.
    b. Each actor then needs to locate the service/app. With the app, the actor needs to go to an app store or similar, find the app, and download it. For services that can be enabled in Apple or Google phone settings, the actor needs to access the correct settings screen on their phone.
    c. Each actor needs to enable EN either through the app or in their phone settings. A number of apps have a requirement that their users be 18 or older, limiting uptake with younger demographics.
    d. Each actor then needs to leave EN on, leave Bluetooth on, carry their phone on them without blocking Bluetooth signals (e.g., leaving the phone buried in a backpack), and be near other people who also have the service on and active.

2. **Second, one of the actors needs to test positive for COVID-19 and choose to notify others.**
    a. Someone who has followed all the steps in 1 needs to test for COVID-19 and receive a positive test result. If the person carrying the phone does not have symptoms, does not participate in surveillance testing, cannot obtain a test, or chooses not to, they would not test positive. Voluntary quarantining may prevent future spread, but will not enable the notification chain further for contacts who were exposed prior to the test results of the index case.
    b. At the time of assessment, many jurisdictions required individuals who tested positive to answer a call from local public health in order to receive the one-time code needed to enable notifications. This phone call could appear as an unknown number on the positive individual's phone. If the positive individual answers or returns the call, they are first told they have COVID-19, and then asked to share their known contacts and contact information. The code is offered at the end of the call. If they are very ill or stressed at the time of the call, or become stressed by having to remember and share information about their contacts, they may decline to receive the code.
    c. Once the positive individual has the one-time code, they need to then enter it into EN. If they cannot easily figure out how to enter the code at the time it is given to them, they misplace the code, or they are feeling too sick or stressed to enter it, they may neglect to do so.
    d. Finally, the positive individual needs to consent to share their keys, which will enable notifications. If the individual is uneasy about what information will be shared, or is not aware of this step, they may neglect to provide the necessary consent.
3. **Third, the actor receiving a notification needs to attend to the notification.** Once keys are shared, the "close contact" needs to see the notification, actually read it, understand that it is a valid communication from a service they opted into, and decide to adhere to the recommendations provided to them. If they quarantine instead of getting a test, the notification chain stops. If they do get a test and test positive, they would need to follow the steps in step 2 in order to get a code, enter it, and continue the notification chain.

Contextual considerations included which communications would target populations that were both out in public and willing to activate EN, how to deploy EN to groups of people that would likely be in proximity to each other, and what metrics could be collected to gauge the efficacy of deployments and advertising effort. Detailing the workflow and required user steps allowed us to identify key communication points between PHAs and EN users which could be studied and leveraged to improve user perception and experiences, such as marketing campaigns to increase awareness of the service, app store pages where downloads are required, informational screens within the apps/settings, smartphone notifications/alerts, and contact tracing call scripts [1]. It also allowed us to identify more detailed investigative questions, which helped to direct subsequent efforts:

- How available is this service across the United States? Who is it available to?

- Within the jurisdictions that enabled the service, how many people know it is available?
- What populations are going out in public and in what situations? How can those situations and populations be targeted?
- What is the perception of communications (in EN screens, and externally)? How effective are these communications?
- What is the current perception of EN functions, and how does this affect willingness to engage?
- Of those who choose to download, how many have functional understanding of how it works? Does this affect their choice to download/access EN/enable the service/notify others?
- How much attrition is there between each required step (download/access on phone, enable, notify others)?
- Could willingness to engage be affected by who is perceived as asking for the action?

2.2 INITIAL RECOMMENDATIONS

Identify key populations to target with communications. States should identify which populations are consistently going out in public (where they will be around many people they do not personally know), and target communications to reach those populations.

Evaluate the perception of within-EN and external-to-EN (e.g., press releases and ad buys) messages and communications. Test messaging with target populations to ensure the reception of the communication matches the sender intent.

Investigate implementation specifics to identify and mitigate friction points. Have states considered how easy or difficult it is to get from, for instance, a digital advertisement to the EN app or settings? Do the EN screens tell users what next steps are, when they need to do them, and what to expect? Do users understand whether an action taken in EN (e.g., enabling service, sharing keys) has succeeded or failed?

Investigate how to leverage communication points between public health teams and prospective EN users to improve user outreach and perception.

3. LITERATURE OVERVIEW

An initial literature search was conducted in October 2021, with supplemental searches conducted intermittently between October 2021 and April 2022 to address newer research efforts. Our literature review focused on understanding the state of deployments and public perception:

- What is known about various state deployments? Who has deployed EN, and what has the reception been?
- What is the current state of EN research? Has perception been studied, and if so under what circumstances? What populations?

EN deployment in the U.S. is decentralized, and relies on individual states to put effort and funds into issuing the service for their jurisdiction. As reported by The MIT Technology Review, roughly half of the states in the U.S. adopted some exposure notification smartphone service by June 2021 [2]. A modeling effort by the University of Oxford in April 2020 concluded that if 56% of a given population were to use the NHS app, it could potentially stop the spread of the virus [3]. Considering that a national poll from April 2020 reported 59% of the population to be comfortable using a contact tracing app to anonymously report a positive diagnosis [4], with research efforts reporting similar numbers for U.S. participants [5] [6], it appeared as though EN services could significantly impact or even stop the spread of COVID-19. However, the percentage of the population recorded as downloading or enabling the service in various states ranged from 1.2% (Arizona) to 45.7% (Hawaii) as of June 2021 [2]. Even though a later modeling effort conducted in the State of Washington indicated a 6-8% drop in infections if 15% of a given population were to adopt and use the app [7], many state deployments fell well below that mark [2].

A number of research efforts have examined what may affect willingness to install an app in the U.S. Li et al. [5] found that concerns with use of the data beyond the app (secondary data use) reduced intention to use EN. Hassandoust et al. [8] agreed, finding that participants rated information privacy protections as being the most important factor affecting their willingness to engage. Complementing the information privacy concerns were concerns about the agents that may be involved in each app. Lu et al. [9] found that people trusted the involvement of healthcare agencies, but were skeptical of other government agencies and technology companies, which matched with the findings from Maytin et al. [10] Additional clues were found according to individual differences in potential app users. While Hargittai et al. [11] reported variation according to age, medical condition (low vs. high-risk), and variation in internet skills ranging from mid-50s to 70%+ in some cases, complementary research by some of the authors found much lower reported willingness when they asked about various distributors of the apps as a proxy for information flow. This ranged from 37% willingness to use an app that was distributed by an organization such as the CDC, to 11% for an international organization, with apps issued by a technology company (17%) and public universities (12%) falling in the middle. [12] The authors additionally found that general trust in health agencies and government agencies correlated with willingness to use an app distributed by those agencies.

This was supported by a multi-country survey that found the U.S. (as well as Germany) to be less supportive of apps; this study also found a correlation between willingness to install and trust in the government. [6]

There were also a number of inconsistencies in the existing literature. Lu et al. [9] found no significant difference in comfort between participating in contact tracing efforts than engaging with EN smartphone apps, while Maytin et al. [10] found that people were more comfortable sharing their COVID results (which would be done through an app) than their personal contacts (which are requested during the manual contact tracing case investigation process). Li et al. [5] found both their younger and older groups less inclined to install apps; this finding is partially supported by Maytin et al. [10], who looked at 18-24 year olds and found low willingness to download apps, as well as Hassandoust et al. [8] who found older people more inclined to participate. However, this was contradicted by Kostka and Habich-Sobiegalla [13], who did not find any significance due to age. Li et al. [5] found women less inclined to install apps, while Hassandoust et al. [8], Maytin et al. [10], and Kostka and Habich-Sobiegalla [13] did not find gender to be significant. In addition, Li et al. [5] found that people were more likely to allow the app to notify others than would install the app in the first place. On the surface, this appears to be a mistake; however, some research indicates that people misunderstand how the apps function [13] [14]. We hypothesize that participants may not have a mental model of needing to download an app in order to share information, and may instead be telling the researchers that sharing information using their phone is more palatable than the act of finding and downloading an app. Therefore, services requiring people to seek out and download an app may be excluding a portion of their willing population.

Our workflow analysis, literature review, and discussion with CDC representatives raised several outstanding questions:

- If one were to strip out implementation details and workflow specifics, what actions are people most willing to do (e.g., share contacts over a contact tracing phone call, downloading/enabling an app, notifying others using EN, quarantine)?
- Would requests from different agents affect willingness to engage in different actions? For instance, if the CDC or personal doctors were to request engagement, would that affect people's willingness to do so?

We developed a survey instrument to conduct empirical research to answer these questions.

4. EMPIRICAL RESEARCH

4.1 STUDY OBJECTIVES

Our primary objective was to investigate how to leverage communication points between public health teams and prospective app users to improve user outreach and perception. We aimed to situate research identified in our literature review, particularly where there was disagreement, and identify concrete actions public health and healthcare providers could take to improve acceptance and use of EN smartphone services/apps.

4.2 SURVEY METHODOLOGY

We developed a survey instrument intended to take 10-15 minutes to complete. After indicating that they were above 18 years old, owned a smartphone, and consented to participate, participants were directed to the survey questions, split into four sections:

1. **Familiarity with contact tracing and exposure notification:** Whether they heard of the term (yes, no, unsure), if so, what they thought it was (short description), and where they heard it (multiselect from 7 options). This section would be used to understand how well known the terms were.
2. **Interactions with health authorities and COVID-19:** Four questions, 5-point Likert scale. These questions would be used to determine if there were significant differences according to existing relationships with health authorities, or perceptions of COVID-19.
3. **Willingness based on the action required, as well as the agent that may request this action** (main body of the survey). 16 questions: 11 - 5-point Likert scale, 2 - yes/no/unsure, 1 - yes/no, 2 - open ended.
    a. Actions: traditional contact tracing, downloading or enabling EN, notifying others with EN, notifying others with EN when agents could see the information, quarantine.
    b. Agents: your doctor or healthcare provider; any doctor or nurse; your employer or school; city, county, or state public health department; federal public health authorities; smartphone notification (EN and quarantine questions); on your own (EN and quarantine questions); your state's governor's office (quarantine question only).
4. **General demographic information:** Three questions.

We leveraged the broad range of agents used by [5] and, where appropriate, compared requests with an "on your own" condition. While some researchers detailed deployment specifics [5], or focused on the specific information shared [10], we focused on a general description of the action required to understand which general actions were most palatable to participants and to minimize effects of specific deployment strategies on study results.

We tested the survey instrument twice with a small sample of people from various backgrounds (11 individuals) to ensure the questions were understood as written, and to test the survey function. From this feedback, we made several improvements to the study format and wording to improve perception of question intent. We then issued a pilot study through the authors' social media channels (Twitter, Facebook, Reddit) from January 21-27, 2021. During the pilot, we used response time to discard any responses that were completed too quickly based on clustered response times (under four minutes), and removed incomplete survey responses (those that did not continue to the end of the survey). Participants were not compensated. We analyzed the remaining 218 responses to determine that although our sample was generally homogenous, skewing White (77%), female (65%), educated (equivalent of college graduate or above, 91%), and from the Northeastern U.S. (72%), there were significant differences in willingness to engage both by action and by the agent requesting the action. Adjustments were made to investigate additional details of downloading EN further, including the deployment of EN Express, which allows Apple phone users and some Android users in participating jurisdictions to enable the service through their phone settings.

We then conducted a U.S.-census-representative, national-scale study from April 20-May 24, 2021. NORC at the University of Chicago, a nonpartisan and established research organization, was contracted to sample a baseline of 1000 members of their AmeriSpeak panel[1] aged 18 years and above to match U.S. census demographics for age, gender, race/ethnicity, and income, with oversamples for Black/African American and Hispanic panel members to ensure that we would be able to properly assess demographics traditionally under-served in medical analysis. We issued a soft launch to a limited number of panel members on April 20, and after ensuring everything was working properly, we expanded the survey to the remaining panel member sample. Participants could choose to take the online survey in English or Spanish on any device. We tracked participant ID numbers as participants were passed from NORC's survey system to ours to check on NORC's sampling efforts and enable compensation, and leveraged additional participant-specific demographic information provided by NORC.

[1] Funded and operated by NORC at the University of Chicago, AmeriSpeak® is a probability-based panel designed to be representative of the U.S. household population. Randomly selected U.S. households are sampled using area probability and address-based sampling, with a known non-zero probability of selection from the NORC National Sample Frame. These sampled households are then contacted by U.S. mail, telephone, and field interviewers (face-to-face). The panel provides sample coverage of approximately 97% of the U.S. household population. Those excluded from the sample include people with P.O. Box-only addresses, some addresses not listed in the United States Postal Service (USPS) Delivery Sequence File, and some newly constructed dwellings. While most AmeriSpeak® households participate in surveys by web, non-internet households can participate in AmeriSpeak® surveys by telephone. Households without conventional internet access, but having web access via smartphones, are allowed to participate in AmeriSpeak® surveys by web. AmeriSpeak® panelists participate in NORC studies or studies conducted by NORC on behalf of governmental agencies, academic researchers, and media and commercial organizations. [21]

A total of 9,941 panel members were invited to participate; 2157 (21.7%) completed the survey and were included in the analysis. We excluded 36 persons who indicated not owning smartphones, and 163 persons who failed the established quality control checks for insufficient time taken (defined as less than ⅓ of the median time for all collected responses—214 seconds for our survey) and/or skipping 10 or more single choice questions. The survey took a median of 13 minutes to complete. Participants received the cash equivalent of USD 3 in AmeriSpeak panel points for completing the survey.

We report descriptive statistics by number and percentages by race/ethnicity. We focused regression analysis on White, Black/African American, and Hispanic race/ethnicity groups, as those were the groups where we had sufficient numbers to power the analysis. We calculated mean, median, and standard error for each agent/action pairing, and report results by our main race/ethnicity groups with gender (as reported in census/AmeriSpeak panel demographics), income, and age.

4.3 DESCRIPTIVE STATISTICS

We reached demographic recruitment goals for our analysis, resulting in 885 participants identifying as White (41%), 567 as Black/African American (26.3%), and 601 as Hispanic (27.9%). An additional 104 participants (4.8%) identified as Asian, another race/ethnicity, or multiple race/ethnicity. Participant age ranged from 18-93, with the median age being 45. Slightly more than half of our participants (1102, 51.1%) identified as female, 1055 (48.8%) identified as male, and 40 (1.8%) of our participants selected another option. Participants were equitably split among U.S. regions, income, and education levels excepting only those indicating having less than a high school education (43, or 2%). The full demographics are listed in the appendix.

Our participants were generally familiar with the terms “contact tracing” (1598, 74.1%) and “exposure notification” (1455, 67.5%), with 1182 (54.8%) indicating familiarity with both. Only 158 of our participants (7.3%) indicated not hearing of either term. Of the participants with a state service as of March 2021[2] (1077, 49.9%), 608 (56.5%) indicated that they were not aware of a service being available; 219 (20.3%) indicated using the available state service. Familiarity of the terms, awareness of service, availability of service, and indicated use were equitably split across race/ethnicity.

4.4 OVERALL WILLINGNESS BY ACTION AND FOCUS RACE/ETHNICITY GROUPS

We calculated the median overall reported likelihood to participate in a given action, looked at reported likelihood by our three focus race/ethnicity groups (White, Black/African American, and Hispanic participants), and compared the trend by race/ethnicity to the overall median to identify different trends by race/ethnicity. Table 1 details the overall median reported likelihood by action, then broken out by

[2] States were coded according to whether they were reported as having a state-issued app as of March 2021 [22], and compared to participant-reported location.

race/ethnicity and compared to the median. Where scores are lower than 3, a higher percentage of participants indicated low likelihood to participate; where scores are higher, a higher percentage of participants indicated high likelihood to participate. Cells are marked "++" where the trend by race/ethnicity is higher than the overall trend. Participants indicated the highest willingness to engage with contact tracing and quarantine overall, which is consistent with reports from another national survey [15]. Willingness to notify other EN users was higher than willingness to download an EN app in the first place, echoing Li et al. [5] However, when others can see the information, willingness to notify was similar to willingness to download. These results suggest that information visibility is less desirable than the act of notifying others, and that the notification action rather than information visibility aspects may have been highlighted in [5] where the question was asked.

We found a number of differences by race/ethnicity. Black/African American participants indicated high likelihood to engage with each step overall, and were the most likely to indicate engagement with contact tracing, downloading/enabling EN, notification with visible information, and quarantine. They were also the only demographic not to drop in willingness to notify others when the information was visible to different agents. Hispanic participants tended to report higher likelihood than White participants for EN actions (download/enable an app, notify other users) consistent with Li et al. [5], though their willingness to notify others dropped when others could see the information. This drop was echoed by White participants, who overall reported the least likelihood to engage with each EN action.

Table 1

Likelihood to Engage with Each Action Investigated Overall, and by Race/Ethnicity

Action	Median Reported Likelihood*	Median by Race/Ethnicity, Trend Compared to Overall Median**		
		White	Black/African American	Hispanic
Traditional Contact Tracing	4	4	5 ++	4
Download/Enable EN	3	3	4 ++	3 ++
Notify Other EN Users	4	4	4 ++	4
Notify with Visible Info	3	3	4 ++	3 ++
Quarantine	4	4	5 ++	4

* Willingness across all agents. 3 = neither likely nor unlikely; >3 = likely, <3 = unlikely. Higher number = higher overall reported likelihood.

** Overall willingness by race/ethnicity. Cells are noted where there was a higher trend compared to overall willingness (++).

Examining results by sub-demographic provides more detailed insight. The following results focus on White, Black/African American, and Hispanic participants by gender and age, gender and income, and gender and education.

4.4.1 Contact Tracing by Sub-Demographic[3]

Table 2 shows the breakdown of participant responses by race/ethnicity + gender + age (median reported likelihood), then details median and trends by requesting agent. The focus is on detailing which agents had either a positive or negative effect on participant reported likelihood. Cells are marked green and appended with "++" where the trend for that sub-demographic group and agent pairing was higher than the overall sub-demographic median, meaning that the agent had a positive effect on participant willingness; they are marked red and appended with "--" where the trend is lower. In some instances, there were no discernible trends due to numbers being too low to make a determination, trends in both directions, or too equal a spread of scores between participants.

All race/ethnicity and age sub-demographics reported high willingness overall to engage with traditional contact tracing (median response of 4 or above). Notable lower trends are the youngest cohort (18-24) of White and Black/African American males, as well as Black/African American females, where the median response dropped to 3 with some agent requests. Notable higher trends include Black/African American men and women 45+, Hispanic men and women 60+, and White women 60+. A number of sub-demographics show consistently high willingness to engage in contact tracing regardless of who is asking (e.g., White male 30-44), with requests by personal doctors having the most consistent positive effect above the median. Other demographics, such as White males 18-29, show a higher or lower likelihood to engage depending on the agent asking. For some sub-demographics such as Black/African American women 60+, requests from local public health and federal public health also had a positive effect, while any doctor had a positive effect on others such as Black/African American males aged 18-29.

Table 3 shows that all race/ethnicity + income sub-demographics also indicated overall high willingness to engage with traditional contact tracing (median response of 4 or above), with many female and many Black/African American demographics showing comparatively little variation. However, as with race/ethnicity + gender + age, there are still a number of effects both positive and negative depending on which agent is asking. Again, the only consistently positive effect came with a request from their doctor, with local public health and federal public health requests having a positive effect for some sub-demographics, such as White males making more than USD 100K/yr.

Detailed in Table 4, all race/ethnicity + education sub-demographics also indicated overall high willingness to engage with traditional contact tracing (median response of 4 or above). One notable exception is for Hispanic women with a post-grad degree when local public health is asking, who overall indicated being neither likely nor unlikely to engage. A number of sub-demographics reported higher or

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[3] Actual question text*: "If you were to test positive for COVID-19, you may be asked to provide the names and phone numbers or addresses of the people you have been physically close to in the last two weeks so those people can be informed of their risk. Please indicate how likely you are to share that information if one of the below people or organizations calls you on the phone and asks you to."*

lower likelihood to engage depending on the agent asking, again with the most consistent positive effect coming from their doctor. All other agents had some positive and negative effect on certain sub-demographics.

Table 2

Likelihood to Engage with Traditional Contact Tracing by Race/Ethnicity + Gender + Age Sub-Demographics, Overall and Compared to Requests by Individual Agents

Traditional Contact Tracing		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**				
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School
White Male	18-29	4	4	4 --	4 --	4 --	4 --
	30-44	4	5 ++	4	4	4	4 --
	45-59	4	5 ++	4	4	4	4
	60+	5	5 ++	4 --	5 ++	5 ++	4 --
White Female	18-29	4	5 ++	4	4	4	5 ++
	30-44	5	5	4 --	4 --	4 --	5 --
	45-59	4	5 ++	4	4	4	5 ++
	60+	4	5 ++	4 --	5 ++	4 --	4
Black/AA Male	18-29	4	5 ++	5 ++	4	4 --	4 --
	30-44	5	5	5 --	5	5	5 --
	45-59	5	5 ++	5	4 --	4 --	4 --
	60+	5	***	4 --	4 --	5	5
Black/AA Female	18-29	4	5 ++	4	4	4	4
	30-44	5	5	5	5	5	5
	45-59	5	5	5 --	5	5	4 --
	60+	5	5	5	5 --	5 --	5
Hispanic Male	18-29	4	4	4 --	4	4	4 --
	30-44	4	5 ++	4 ++	4	4	4
	45-59	4	5 ++	4	4	4 ++	4
	60+	4	5 ++	4	4 ++	4 ++	4
Hispanic Female	18-29	4	5 ++	4	4	4	4
	30-44	4	5 ++	4	4	4	4
	45-59	4	5 ++	4	4 --	4	4
	60+	4	4	4	3 --	4	4

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 3

Likelihood to Engage with Traditional Contact Tracing by Race/Ethnicity + Gender + Income Sub-Demographics, Overall and Compared to Requests by Individual Agents

Traditional Contact Tracing		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**				
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School
White Male	< USD 30K/yr	4	5 ++	4	4	4	4 --
	USD 30-59K	4	4	4	4	4	3 --
	USD 60-99K	4	5 ++	4	4	4	4
	USD 100K+	4	5 ++	4	5 ++	5 ++	4
White Female	< USD 30K/yr	4	5 ++	4	5 ++	5 ++	4
	USD 30-59K	4	5 ++	4 --	4 --	4 --	4 --
	USD 60-99K	4	5 ++	4	4	4	4
	USD 100K+	5	5	4 --	5 --	4 --	5
Black/AA Male	< USD 30K/yr	5	5	5	5 --	5	5 --
	USD 30-59K	5	5	5	4 --	4 --	5 --
	USD 60-99K	4	5 ++	4	4	4	4
	USD 100K+	5	5	5	5 --	5	5
Black/AA Female	< USD 30K/yr	5	5 ++	5	4 --	4 --	4 --
	USD 30-59K	5	5	5	5	5	5
	USD 60-99K	5	***	5	5	5	5
	USD 100K+	5	5	5	5 --	5	5
Hispanic Male	< USD 30K/yr	4	4	4	4	4	4
	USD 30-59K	4	5 ++	4	4	4	4
	USD 60-99K	4	4	4	4	4	4
	USD 100K+	4	5 ++	4	4	4 --	4
Hispanic Female	< USD 30K/yr	4	5 ++	4	4	4	4
	USD 30-59K	4	5 ++	4	4 --	4 --	4
	USD 60-99K	5	5	4 --	5	5 --	4 --
	USD 100K+	4	4 ++	4 --	4 --	4 --	4 ++

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 4

Likelihood to Engage with Traditional Contact Tracing by Race/Ethnicity + Gender + Education Sub-Demographics, Overall and Compared to Requests by Individual Agents

Traditional Contact Tracing		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**				
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School
White Male	HS grad	4	4	4 --	4 --	4 --	4 --
	Voc/Tech/Assoc	4	5 ++	4	4	4	4 --
	Bachelor's	4	5 ++	4	4	4	4
	Post-grad/Prof	5	5 ++	4 --	5 ++	5 ++	4 --
White Female	HS grad	4	5 ++	4	4	4	5 ++
	Voc/Tech/Assoc	5	5	4 --	4 --	4 --	5 --
	Bachelor's	4	5 ++	4	4	4	5 ++
	Post-grad/Prof	4	5 ++	4 --	5 ++	4 --	4
Black/AA Male	HS grad	4	5 ++	5 ++	4	4 --	4 --
	Voc/Tech/Assoc	5	5	5 --	5	5	5 --
	Bachelor's	5	5 ++	5	4 --	4 --	4 --
	Post-grad/Prof	5	***	4 --	4 --	5	5
Black/AA Female	HS grad	4	5 ++	4	4	4	4
	Voc/Tech/Assoc	5	5	5	5	5	5
	Bachelor's	5	5	5 --	5	5	4 --
	Post-grad/Prof	5	5	5	5 --	5 --	5
Hispanic Male	HS grad	4	4	4 --	4	4	4 --
	Voc/Tech/Assoc	4	5 ++	4 ++	4	4	4
	Bachelor's	4	5 ++	4	4	4 ++	4
	Post-grad/Prof	4	5 ++	4	4 ++	4 ++	4
Hispanic Female	HS grad	4	5 ++	4	4	4	4
	Voc/Tech/Assoc	4	5 ++	4	4	4	4
	Bachelor's	4	5 ++	4	4 --	4	4
	Post-grad/Prof	4	4	4	3 --	4	4

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

4.4.2 Downloading/Enabling EN by Sub-Demographic[4]

Table 5 shows that race/ethnicity + gender + age sub-demographics were split on whether they would be willing to download an exposure notification app. Notable unwilling sub-demographics were the youngest cohort (18-24) of White males and females (median reported likelihood = 2). Notable willing demographics include Black/African American men and women 45+, Hispanic men and White women 60+, and Hispanic women. A number of sub-demographics show higher or lower likelihood to engage depending on the agent asking, with the most consistent positive effect coming yet again from their doctor. Notable exceptions are Black/African American males 18-29 where requests by personal doctors trended lower, and White males 18-29 who remained unlikely to participate when their doctor asked. For some sub-demographics such as White males and females 45+, requests from local public health and federal public health also had a positive effect. Requests from smartphone providers or relying on people to download or enable an app on their own consistently trended lower, while guided in-phone notifications walking users through enabling the service improved likelihood for some demographics.

Table 6 shows that when split by race/ethnicity + gender + income, sub-demographics were neutral-to-willing overall. Notable neutral sub-demographics spanned all White income levels and both genders, as well as Hispanic men of all income levels. Notable willing sub-demographics overall were the Black/African American males making up to USD 59K/year, and Black/African American women of all incomes. Again, a number of sub-demographics show higher or lower likelihood to engage depending on the agent asking, with the most consistent positive effect coming yet again from their doctor. In a number of cases, requests from personal doctors moved the median to "likely" from "neutral" indicating that these requests may be enough for some demographics to decide to download the app or enable the service. For some sub-demographics such as White females of all income levels and Hispanic males making less than USD 30K/year, requests from local public health and federal public health also had a positive effect. As with race/ethnicity + gender + age, requests from smartphone providers or relying on people to download or enable an app on their own consistently trended lower, while guided in-phone notifications walking users through enabling the service improved likelihood for some demographics.

Table 7 shows that when split by race/ethnicity + gender + education, sub-demographics were again neutral-to-willing overall. Notable neutral sub-demographics were consistent with breakdowns by income, spanning all White education levels and both genders, as well as Hispanic men of all education levels. Notable willing sub-demographics overall were all Black/African American male and females of all education levels, and Hispanic women of all education levels. Again, a number of sub-demographics show

[4] Actual question text*: "COVID-19 exposure notifications can alert you if you have been in close proximity to a potentially infectious person in the last two weeks. Imagine you are asked to download a COVID-19 exposure notification app. This request may come as a phone call, text, or smartphone notification. Please indicate how likely you are to do so if one of the below asks you to?"; "Please indicate how likely you are to download a COVID-19 exposure notification app on your own, without anyone asking you to do so."; "Please indicate how likely you are to enable COVID-19 exposure notifications in your settings if you got a notification on your smartphone that walked you through that process."*

higher or lower likelihood to engage depending on the agent asking, with the most consistent positive effect coming yet again from their doctor. In a number of cases, requests from personal doctors moved the median to "likely" from "neutral" indicating that these requests may be enough for some demographics to decide to download the app or enable the service. For some sub-demographics such as White females with a Bachelor's degree or higher, and Hispanic males except for those with a Bachelor's degree, requests from local public health and federal public health also had a positive effect. As with sub-demographic breakdowns by age and income, requests from smartphone providers or relying on people to download or enable an app on their own consistently trended lower, while guided in-phone notifications walking users through enabling the service improved likelihood for some demographics.

Table 5

Likelihood to Engage with Downloading or Enabling EN by Race/Ethnicity + Gender + Age Sub-Demographics, Overall and Compared to Requests by Individual Agents

Download or Enable EN		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**							
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	On Own	Guided
White Male	18-29	2	2	2	2	2	2	2 - -	2 - -	2
	30-44	3	4 + +	3	3 + +	3 + +	3	2 - -	2 - -	3 + +
	45-59	3	4 + +	3 - -	3 + +	3 + +	3 + +	2 - -	2 - -	3 + +
	60+	3	4 + +	3 + +	4 + +	4 + +	3	2 - -	2 - -	3
White Female	18-29	2	3 + +	2 - -	2 + +	2	2	2 - -	2	2
	30-44	3	3	3	3	3	3	2 - -	2 - -	3
	45-59	3	4 + +	3 + +	3 + +	3 + +	3 + +	2 - -	2 - -	3
	60+	3	5 + +	3 + +	4 + +	4 + +	3 + +	2 - -	3 - -	3 - -
Black/AA Male	18-29	4	3 - -	4 - -	3 - -	3 - -	4 + +	3 - -	4	4 + +
	30-44	3	4 + +	4 + +	4 + +	4 + +	4 + +	3	3	3
	45-59	4	5 + +	4	4	4	4	3 - -	4 - -	4
	60+	4	5 + +	4	4	5 + +	4	3 - -	3 - -	4 + +
Black/AA Female	18-29	3	4 + +	3	3 - -	3	3 + +	3 - -	3 - -	4 + +
	30-44	3	4 + +	3 - -	3	4 + +	4 + +	3 - -	3 - -	4 + +
	45-59	4	4	4	4	4	4	3 - -	3 - -	4
	60+	4	5 + +	5 + +	5 + +	5 + +	4	3 - -	4	4
Hispanic Male	18-29	3	4 + +	3 + +	3	4 + +	3 + +	4	4	4 + +
	30-44	3	4 + +	3	3	3	3	3 - -	3 - -	4 + +
	45-59	3	4 + +	3	3 + +	4 + +	3 + +	3 - -	3 - -	3
	60+	4	5 + +	4	4 + +	4 + +	4	3 - -	3 - -	3
Hispanic Female	18-29	4	4 + +	4	4	4 + +	4 + +	3 - -	3 - -	4
	30-44	4	4 + +	4 + +	4 + +	4 + +	3 - -	3 - -	3 - -	4
	45-59	4	4	4	4	4	4	3 - -	3 - -	3 - -
	60+	4	4 + +	4 + +	4 + +	4 + +	4 - -	3 - -	3 - -	4

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 6

Likelihood to Engage with Downloading or Enabling EN by Race/Ethnicity + Gender + Income Sub-Demographics, Overall and Compared to Requests by Individual Agents

Download or Enable EN		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**							
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	On Own	Guided
White Male	< USD 30K/yr	3	4 ++	3	3	3 ++	3	2 --	3 --	3 ++
	USD 30-59K	3	4 ++	3	3	3	3	2 --	3 --	3
	USD 60-99K	3	4 ++	3	3	3 ++	3	2 --	2 --	3 --
	USD 100K+	3	4 ++	3 --	4 ++	4 ++	3	3 --	2 --	4 ++
White Female	< USD 30K/yr	3	4 ++	3 ++	4 ++	3 ++	3 ++	3 --	3 --	4 ++
	USD 30-59K	3	4 ++	3	4 ++	3 ++	3	2 --	2 --	2 --
	USD 60-99K	3	4 ++	3	4 ++	3 ++	3	2 --	2 --	3
	USD 100K+	3	4 ++	3	4 ++	4 ++	4 ++	2 --	3 --	3 --
Black/AA Male	< USD 30K/yr	4	4	4	4	4	4	3 --	3 --	4
	USD 30-59K	4	4	4	4	4	4	3 --	4	4
	USD 60-99K	3	4 ++	3 --	3 --	3 --	3 --	3 --	3 --	3 ++
	USD 100K+	4	5 ++	4	4	4	4	4 --	4 --	4 --
Black/AA Female	< USD 30K/yr	4	4	4	4	4	4	3 --	4 --	4 --
	USD 30-59K	4	4 ++	4 --	4 ++	4 ++	4 ++	3 --	3 --	4 ++
	USD 60-99K	4	4	4	4	4	4	3 --	3 --	4 --
	USD 100K+	4	4	4	4 --	4	3 --	3 --	3 --	4
Hispanic Male	< USD 30K/yr	3	4 ++	4 ++	4 ++	4 ++	3 ++	3 --	3 --	4 ++
	USD 30-59K	3	4 ++	3	3	4 ++	3	3 --	3 --	4 ++
	USD 60-99K	3	4 ++	3	3	4 ++	3	3 --	3	3
	USD 100K+	3	4 ++	3	4 ++	4 ++	4 ++	3	3 ++	3 ++
Hispanic Female	< USD 30K/yr	4	4 ++	4	4 ++	4 ++	4 --	3 --	4	4
	USD 30-59K	4	4 ++	4	4	4	4	3 --	3 --	4
	USD 60-99K	4	4 ++	4 ++	4 ++	4 ++	4	3 --	3 --	4 ++
	USD 100K+	3	4 ++	4 ++	3	3	4 ++	2 --	3	2 --

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 7

Likelihood to Engage with Downloading or Enabling EN by Race/Ethnicity + Gender + Education Sub-Demographics, Overall and Compared to Requests by Individual Agents

Download or Enable EN		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**							
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	On Own	Guided
White Male	HS grad	3	3	3	3	3	3	2 --	3 --	3
	Voc/Tech/Assoc	3	4 ++	3	3 ++	3	3	2 --	3 --	3
	Bachelor's	3	4 ++	3	3	3	3 --	2 --	2 --	3
	Post-grad/Prof	3	4 ++	3 --	4 ++	4 ++	3	3 --	2 --	4 ++
White Female	HS grad	3	3 ++	3 ++	3	3 ++	3 ++	3	2 --	3
	Voc/Tech/Assoc	3	4 ++	3	3 ++	3 ++	3	2 --	2 --	3
	Bachelor's	3	4 ++	3	3 ++	3 ++	3 ++	2 --	2 --	3
	Post-grad/Prof	3	4 ++	3	4 ++	4 ++	3 ++	2 --	3 --	3
Black/AA Male	HS grad	4	4	4	4	4	4	3 --	3 --	3 --
	Voc/Tech/Assoc	4	4	4	4	4	4	3 --	3 --	4
	Bachelor's	4	4 ++	4 ++	4	4	4	3 --	3 --	4
	Post-grad/Prof	4	4 ++	4 ++	4 ++	4 ++	4 ++	3 --	4 --	4 --
Black/AA Female	HS grad	4	4	4	4	4	3 --	3 --	3 --	4 --
	Voc/Tech/Assoc	4	4	4	4	4	4	3 --	3 --	4
	Bachelor's	4	4 ++	***	4 ++	4 ++	4 ++	3 --	4 --	4
	Post-grad/Prof	4	4	4	4	4	4	3 --	3 --	4
Hispanic Male	HS grad	3	4 ++	3	3 ++	4 ++	3 ++	3	3	3
	Voc/Tech/Assoc	3	4 ++	4 ++	4 ++	4 ++	3 ++	3 --	3 --	4 ++
	Bachelor's	3	4 ++	3	3	3	3 --	3 --	3 --	3
	Post-grad/Prof	3	4 ++	3 --	3 ++	4 ++	3 ++	3	3	4 ++
Hispanic Female	HS grad	4	4 ++	4	4 ++	4	4	3 --	3 --	4
	Voc/Tech/Assoc	4	4	4	4	4	3 --	3 --	3 --	4
	Bachelor's	4	4	4	4 ++	4 ++	4 ++	3 --	3 --	3 --
	Post-grad/Prof	4	4 ++	4	4 ++	4 ++	3 --	3 --	3 --	***

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

4.4.3 Notifying Others Using EN by Sub-Demographic[5]

Table 8 shows that most race/ethnicity + gender + age sub-demographics indicated they would be likely overall to allow EN to notify others. Similar to downloading/enabling EN, notably less willing sub-demographics overall were the youngest cohort (18-24) of White males and females; this time, the youngest cohort (18-24) of Black/African American and Hispanic men also indicated lower overall willingness. However, each of the young male cohorts 18-29 indicated being likely to notify others depending on different agents; all indicated higher likelihood when their doctor asks. Notable higher trends include Black/African American men and women 60+, with a median of 5. The most consistent positive effect came from their doctor, with a number of sub-demographics also being positively affected by local and federal public health workers, as well as employer/school. Requests from smartphone providers consistently trended lower, while many sub-demographics indicated less likelihood to participate without prompting.

All race/ethnicity + gender + income sub-demographics indicated they would be likely overall to allow EN to notify others, as shown in Table 9, with the notable exception of White males making USD 30-59K/year who indicated overall being unlikely, but affected positively by requests from their doctor, any doctor, and local or federal public health workers. Black/African American males making up to USD 59K/year and USD 100K or able, as well as Black/African American females making below USD 30K, and about USD 60K a year indicated the highest overall likelihood (median of 5). Again, the most consistent positive effect came from their doctor, with a number of sub-demographics also being positively affected by any doctor, local or federal public health workers, and employer/school. Requests from smartphone providers consistently trended lower. Many sub-demographics additionally indicated less likelihood to participate without prompting.

Most race/ethnicity + gender + education sub-demographics indicated they would be likely overall to allow EN to notify others, as shown in Table 10, with the notable exception of White and Hispanic male high school graduates. Both were affected positively by requests from their doctor, federal public health workers, and their employer/school. White male high school graduates were additionally affected positively by requests from local public health workers or on their own, while Hispanic male high school graduates were affected by requests from any doctor. Black/African American males with a post-graduate degree indicated the highest overall likelihood (median of 5). Again, the most consistent positive effect came from

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[5] Actual question text*: "COVID-19 exposure notifications can alert other users of those exposure notification services that they have been physically close to a potentially infectious person in the last two weeks without sharing identifying information, but only if the potentially infectious person lets the service notify them. This request may come as a phone call, text, or smartphone notification. If you were to test positive for COVID-19 today, how likely are you to let an exposure notification service notify other service users if one of the below asks you to?"; "If you were to test positive for COVID-19 today, how likely are you to let a COVID-19 exposure notification service notify other service users without anyone asking you to notify others?"*

their doctor, with a number of sub-demographics also being positively affected by all other agents with the exception of smartphone providers.

Table 8

Participant-Reported Likelihood to Notify Others Using EN by Race/Ethnicity + Gender + Age Sub-Demographics, Overall and Compared to Requests by Individual Agents

Notifying Others Using EN		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**						
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	On Own
White Male	18-29	3	4 ++	3 --	3 --	3 ++	4 ++	3 --	3 ++
	30-44	4	4 ++	4 ++	4 ++	4	4 ++	3 --	4
	45-59	4	4 ++	4	4	4	4	3 --	4
	60+	4	5 ++	4	4 ++	4	4 --	3 --	4
White Female	18-29	3	3 ++	3	3	3 ++	3 ++	2 --	3
	30-44	4	4	4	4	4	4 ++	3 --	3 --
	45-59	4	4	4	4	4	4	2 --	4
	60+	4	5 ++	4	5 ++	4	4	3 --	4
Black/AA Male	18-29	3	4 ++	4 ++	4 ++	4 ++	4 ++	***	3 ++
	30-44	4	4	4	4	4	4	4 --	4
	45-59	5	5 ++	5 ++	5 ++	5 ++	5 ++	4 --	4 --
	60+	5	5 ++	5 ++	5 ++	5 ++	4 --	3 --	4 --
Black/AA Female	18-29	4	4	4	4	4	4	4	4
	30-44	4	4	4	4	4	4	3 --	4 --
	45-59	4	5 ++	5 ++	5 ++	5 ++	4	3 --	4
	60+	5	5	5	5	5	5 --	4 --	4 --
Hispanic Male	18-29	3	4 ++	4 ++	4 ++	4 ++	4 --	3 --	3 --
	30-44	4	4 ++	4	4 ++	4	4 ++	3 --	4
	45-59	4	4	4	4	4	4	3 --	4
	60+	4	5 ++	5 ++	5 ++	5 ++	4	4 --	4
Hispanic Female	18-29	4	4	4	4	4	4	4 --	4
	30-44	4	4	4	4	4	4	3 --	3 --
	45-59	4	4	4	4	4	4 --	3 --	3 --
	60+	4	5 ++	4 ++	4 ++	5 ++	4	4 --	4 --

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 9

Likelihood to Engage with Notifying Others Using EN by Race/Ethnicity + Gender + Income Sub-Demographics, Overall and Compared to Requests by Individual Agents

Notifying Others Using EN		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**						
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	On Own
White Male	< USD 30K/yr	4	5 ++	4	4 ++	4 ++	3 --	3 --	4
	USD 30-59K	3	4 ++	4 ++	4 ++	3 ++	3	3 --	4 ++
	USD 60-99K	4	4 ++	4 ++	4 ++	4	4 ++	3 --	3 --
	USD 100K+	4	5 ++	4	4 ++	4	4	3 --	4
White Female	< USD 30K/yr	4	5 ++	4	4 ++	4	4	3 --	3
	USD 30-59K	4	5 ++	4	4	4	4	3 --	3 --
	USD 60-99K	4	5 ++	4 ++	4 ++	4	4 ++	2 --	3 --
	USD 100K+	4	5 ++	4	5 ++	4	5 ++	3 --	4
Black/AA Male	< USD 30K/yr	4	5 ++	5 ++	5 ++	5 ++	5 ++	3 --	4
	USD 30-59K	5	5 ++	5 ++	5 ++	5 ++	5 ++	4 --	4 --
	USD 60-99K	4	4	4	4	4	4	3 --	4 --
	USD 100K+	5	5 ++	4 --	5 ++	5 ++	5	4 --	4 --
Black/AA Female	< USD 30K/yr	4	5 ++	4	4	4	4	3 --	4
	USD 30-59K	4	4 ++	4	4	4	4	4 --	4 --
	USD 60-99K	5	5 ++	5 ++	5 ++	5	5 ++	3 --	4 --
	USD 100K+	4	5 ++	4 ++	4	5 ++	4	3 --	4 --
Hispanic Male	< USD 30K/yr	4	4	4	4	4	4	3 --	4
	USD 30-59K	4	4	4 --	4 --	4 --	4 --	3 --	4 --
	USD 60-99K	4	4 ++	4	4	4	4 ++	3 --	3 --
	USD 100K+	4	5 ++	4 ++	4 ++	4	4 ++	3 --	4
Hispanic Female	< USD 30K/yr	4	4	4	4	4	4	4 --	4
	USD 30-59K	4	4	4	4	4	4	3 --	4
	USD 60-99K	4	4 ++	4	4	4	4	4 --	3 --
	USD 100K+	4	4 ++	***	***	4 ++	4 ++	3 --	3 --

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 10

Likelihood to Engage with Notifying Others Using EN by Race/Ethnicity + Gender + Education Sub-Demographics, Overall and Compared to Requests by Individual Agents

Notifying Others Using EN		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**						
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	On Own
White Male	HS grad	3	4 ++	3 --	4 ++	4 ++	4 ++	3 --	4 ++
	Voc/Tech/Assoc	4	5 ++	4 ++	4 ++	4	4	3 --	4
	Bachelor's	4	4 ++	4	4	4 --	4 --	3 --	4 --
	Post-grad/Prof	4	5 ++	4 ++	4	5 ++	4	3 --	4
White Female	HS grad	4	4 ++	4	4	4	4	3 --	4 --
	Voc/Tech/Assoc	4	5 ++	4	4	4	4 ++	3 --	4
	Bachelor's	4	4 ++	4	4	4	4	3 --	3 --
	Post-grad/Prof	4	5 ++	4 ++	4 ++	4 ++	4 ++	2 --	4
Black/AA Male	HS grad	4	5 ++	4	4	4	4 --	3 --	4
	Voc/Tech/Assoc	4	5 ++	4	5 ++	5 ++	4	4	4
	Bachelor's	4	5 ++	5 ++	5 ++	5 ++	5 ++	4 --	4
	Post-grad/Prof	5	5 ++	4	5 ++	5 ++	5 ++	4 --	4 --
Black/AA Female	HS grad	4	4	4	4	4	4	3 --	4
	Voc/Tech/Assoc	4	5 ++	4	5 ++	5 ++	5 ++	4 --	4
	Bachelor's	4	5 ++	4	4	4	4	3 --	4 --
	Post-grad/Prof	4	5 ++	4 ++	4 ++	4	4	3 --	4
Hispanic Male	HS grad	3	4 ++	4 ++	3	4 ++	4 ++	3 --	3 --
	Voc/Tech/Assoc	4	5 ++	4	4	4	4	3 --	4
	Bachelor's	4	4 ++	4	4 --	4	4	3 --	4
	Post-grad/Prof	4	4 --	4 --	4	4 --	4 --	4 --	4
Hispanic Female	HS grad	4	4	4	4	4	4	4 --	4 --
	Voc/Tech/Assoc	4	4	4	4	4	4 --	3 --	3 --
	Bachelor's	4	4	4	4	4	4	3 --	4 --
	Post-grad/Prof	4	4	4	4	4	4	3 --	4

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

4.4.5 Notifying Others Using EN When Information is Visible by Sub-Demographic[6]

We additionally asked participants about their willingness to notify others when different agents could see data or information about notifications or contacts. Overall participants indicated less willingness to notify others when the information would be visible, with many willing sub-demographics becoming overall unlikely to participate. Looking at the race/ethnicity + gender + age breakdowns shown in Table 11 and comparing reports to likelihood to notify others without mention of information visibility, some sub-demographics reported a large shift, with White females 18-30 changing their overall reports from neutral (median of 3) to unlikely (median of 2), while White females 30-44 went from likely (median of 4) to unlikely (median of 2). Other sub-demographics remained consistent overall, such as Black/African American males 45+, Black/African American females 60+, Hispanic males 60+, and Hispanic females 30-44 and 60+ continuing to indicate being likely to participate overall (median of 4). Similar patterns for agent preference showed here as well; there were consistently higher trends with their doctor being able to see data, though with many more reports of being neutral (median of 3) to unlikely (median of 2). The most consistent negative trend was reported with data being visible by smartphone providers.

Looking at race/ethnicity + gender + income shown in Table 12, White females making between USD 30K- 59K/year also indicated less likelihood overall (median of 2), with no agent raising that higher than no one being able to see the information. Black/African American sub-demographics continued to report the most resilience to information visibility, with many reporting being likely to participate overall (median of 4). Similar patterns for agent preference showed here as well; there were consistently higher trends with their doctor being able to see data, and some demographics reported higher willingness when local or federal public health workers can see the information. The most consistent negative trend was reported with data being visible by smartphone providers.

Table 13 shows that breakdowns by race/ethnicity + gender + education did not follow similar patterns to other sub-demographics, action, and agent comparisons. While overall median reports by sub-demographics ranged from neutral to positive, most sub-demographics showed a negative trend with most agents. This can be explained by variation within the sub-demographic, where many respondents indicated being likely (score of 4 or 5) resulting in a high overall median, while many other respondents within that demographic reported much lower scores. While personal doctors were the least likely to trend negative from the median, they also did not increase scores for most sub-demographics.

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[6] Actual question text*: "Please indicate how likely you are to let a COVID-19 exposure notification service notify other service users if one of the below providers can see data or information about those notifications or contacts."; "Please indicate how likely you are to let a COVID-19 exposure notification service notify other service users if data or information about those notifications or contacts is not viewable by anyone."*

Table 11

Likelihood to Notify Others Using EN By Race/Ethnicity + Gender + Age Sub-Demographics, Overall and Compared to When Data or Information about Notifications is Visible to Individual Agents

Notifying Others Using EN When Information is Visible		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**						
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	No One
White Male	18-29	3	3 ++	3	3	3	3	2 --	3
	30-44	3	3 ++	3 ++	3 ++	3 ++	3	2 --	4 ++
	45-59	3	3 ++	3	3	3	3	2 --	3 ++
	60+	3	4 ++	4 ++	4 ++	4 ++	3 --	2 --	3
White Female	18-29	2	2	2 --	2	2	2	2 --	3 ++
	30-44	2	3 ++	3 ++	2	2	3 ++	2	3 ++
	45-59	3	3 ++	3	3 ++	3	3	2 --	3 ++
	60+	3	4 ++	3	3 ++	3 ++	3	2 --	4 ++
Black/AA Male	18-29	3	4 ++	3 --	3 --	***	***	3 --	4 ++
	30-44	3	4 ++	3	3	3	3	3 --	3
	45-59	4	4	4	4	4	4	3 --	4
	60+	4	5 ++	4	4 ++	5 ++	4	3 --	4
Black/AA Female	18-29	3	3 ++	3	3	3 ++	3	3	4 ++
	30-44	3	4 ++	3	3	3	3	3 --	3 --
	45-59	3	4 ++	4 ++	4 ++	4 ++	***	3 --	4 ++
	60+	4	5 ++	4	4	5 ++	4	3 --	4
Hispanic Male	18-29	3	3	3	3	3	3	3 --	4
	30-44	3	4 ++	3 ++	3 ++	3 ++	3	3 --	4 ++
	45-59	3	4 ++	4 ++	4 ++	4 ++	3	3 --	3 ++
	60+	4	4 ++	4	4	4 ++	3 --	3 --	4 ++
Hispanic Female	18-29	3	4 ++	3 ++	3 ++	3 ++	3	3 --	4 ++
	30-44	4	4 ++	4 ++	4 ++	4 ++	4	3 --	3 --
	45-59	3	3	3	3	3	3	3 --	3
	60+	4	4 --	4	4	4	4	3 --	4 --

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 12

Likelihood to Notify Others Using EN By Race/Ethnicity + Gender + Income Sub-Demographics, Overall and Compared to When Data or Information about Notifications is Visible to Individual Agents

Notifying Others Using EN When Information is Visible		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**						
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	No One
White Male	< USD 30K/yr	3	4 ++	3	3	3	3	2 --	3 ++
	USD 30-59K	3	4 ++	3	3	3	3	2 --	4 ++
	USD 60-99K	3	4 ++	3	3	3 ++	3	2 --	4 ++
	USD 100K+	3	4 ++	3 --	4 ++	3	3 --	2 --	4 ++
White Female	< USD 30K/yr	3	4 ++	3 ++	3 ++	3 ++	3	3 --	3 ++
	USD 30-59K	2	3 ++	3 ++	3 ++	2 ++	3 ++	2	3 ++
	USD 60-99K	3	3 ++	3	3	3	3	2 --	3 ++
	USD 100K+	3	3	3 --	3	3	2 --	2 --	4 ++
Black/AA Male	< USD 30K/yr	4	4	4	4	4	4	3 --	4
	USD 30-59K	4	5 ++	4	4	4	4	3 --	4
	USD 60-99K	3	3 ++	3	3	3 ++	3	3 --	3
	USD 100K+	4	5 ++	4	4	4	4	4 --	4
Black/AA Female	< USD 30K/yr	4	4	3 --	4	4	3 --	3 --	4
	USD 30-59K	4	4 ++	4	4 ++	4 ++	3 --	3 --	4
	USD 60-99K	4	4 ++	4	4	4	4	3 --	4 ++
	USD 100K+	3	4 ++	3	4 ++	4 ++	3 --	3 --	4 ++
Hispanic Male	< USD 30K/yr	3	4 ++	3	3	4 ++	3	3	4 ++
	USD 30-59K	3	4 ++	3 ++	3	3 ++	3	3 --	4 ++
	USD 60-99K	4	4 ++	4 --	4	4	3 --	3 --	***
	USD 100K+	3	4 ++	3 ++	3 ++	3	3 ++	2 --	4 ++
Hispanic Female	< USD 30K/yr	4	4	4	4	4	4 --	3 --	3 --
	USD 30-59K	3	3	3	3	3	3	3 --	3 ++
	USD 60-99K	4	4 ++	4	4 ++	4 ++	4	3 --	4 ++
	USD 100K+	3	3	3	3	3 ++	3	3	3 ++

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

Table 13

Likelihood to Notify Others Using EN by Race/Ethnicity + Gender + Education Sub-Demographics, Overall and Compared to When Data or Information about Notifications is Visible to Individual Agents

Notifying Others Using EN When Information is Visible		Median Likelihood*	Median by Requesting Agent, Trend Compared to Median Likelihood**						
			Their Doctor	Any Doctor	Local Public Health	Federal Public Health	Employer/ School	Phone Provider	No One
White Male	HS grad	3	3	3 --	3 --	3 --	3 --	3 --	3 --
	Voc/Tech/Assoc	4	4	3 --	3 --	3 --	3 --	2 --	3 --
	Bachelor's	4	4	3 --	3 --	3 --	3 --	2 --	4
	Post-grad/Prof	4	4	3 --	4	4	3 --	2 --	4 ++
White Female	HS grad	4	3 --	3 --	3 --	3 --	3 --	2 --	3 --
	Voc/Tech/Assoc	4	3 --	3 --	3 --	3 --	3 --	2 --	4 --
	Bachelor's	4	3 --	3 --	3 --	3 --	3 --	2 --	3 --
	Post-grad/Prof	4	3 --	2 --	3--	3 --	2 --	2 --	4 --
Black/AA Male	HS grad	4	4	3 --	4	4	3 --	3 --	4
	Voc/Tech/Assoc	4	4	4	4	4	4	3 --	4
	Bachelor's	4	4 ++	4 ++	4	4	4	3 --	3 --
	Post-grad/Prof	4	4	4 --	4 --	4 --	3 --	3 --	4 --
Black/AA Female	HS grad	4	4 --	3 --	3 --	3 --	3 --	3 --	3 --
	Voc/Tech/Assoc	4	4	4	4	4	4	3 --	4
	Bachelor's	4	4	4 --	4 --	4 --	3 --	3 --	4
	Post-grad/Prof	4	4 ++	3 --	4	4	3 --	3 --	4 --
Hispanic Male	HS grad	3	4 ++	3 --	3 --	3 --	3 --	3 --	3 --
	Voc/Tech/Assoc	4	4	4 --	4 --	4 --	3 --	3 --	4
	Bachelor's	4	4	3 --	3 --	3 --	3 --	2 --	4
	Post-grad/Prof	4	4	4 --	4 --	4 --	4 --	3 --	4
Hispanic Female	HS grad	4	4	3 --	4	4	3 --	3 --	3 --
	Voc/Tech/Assoc	4	4 --	4 --	4 --	4 --	3 --	3 --	3 --
	Bachelor's	4	4 --	3 --	3 --	4 --	3 --	3 --	4 --
	Post-grad/Prof	4	4 --	3 --	3 --	4 --	3 --	3 --	4 --

* Reported likelihood across all agents. >3 = consistently + reported likelihood; <3 = Higher number = higher reported likelihood.

** Cells are coded according to whether there is a significantly higher trend attributed to agent involvement compared to overall willingness (green + +), as well as significantly lower trend (red - -).

*** Indicates difference from median but no discernible trend (due to movement in both directions or insufficient data)

5. DISCUSSION

Our survey instrument was developed in order to investigate a few core questions:

- If one were to strip out implementation details and workflow specifics, what actions are people most willing to do (e.g., share contacts over a contact tracing phone call, downloading/enabling an app, notifying others using an app, quarantine)?
- Would requests from different agents affect willingness to engage in different actions? For instance, if the CDC or personal doctors were to request engagement, would that affect people's willingness to do so?

By investigating public perception of the high-level actions, we were able to determine that most participants were more willing to engage in traditional contact tracing and quarantine actions. We also determined that many participants were willing to let a smartphone app notify others of potential pathogen exposure, which is the primary use case for EN smartphone applications and similar technologies. While the majority of our participants indicated being willing to use the core function of EN, only 20.3% of those with an available service indicated using it.[7] These reports combined with our literature review point to a disconnect between stated intention and actual EN use. We found a similar disconnect with traditional contact tracing, where many survey participants expressed willingness to share information about their contacts with contact tracers (72%) [15], though actual participation was reported to be far lower, with some jurisdictions reporting up to 48% of people not being reached, with an additional 35% reporting no contacts [16]. Additionally, though a vast majority of those surveyed reported that they would quarantine if advised to do so (93%), 32% of people indicated that it would be at least somewhat difficult to quarantine [15], which raises questions about how well reported willingness translates to actual behavior.

Some of this can be explained by a disconnect between words on a page people read quickly before offering an opinion, and the reality surrounding actual use. As our initial workflow investigation sought to

[7] There are a number of confounding factors when trying to gauge EN usage. Reports indicated that in areas with high visitation from people in other states (e.g., Hawaii and Washington, D.C.), usage percentage is still calculated based on raw usage numbers vs. population. Usage by visitors would inflate those numbers. Our results additionally indicate that at least some people believe there is an app available when there is not, or do not know one is available when there is. Part of this likely stems from discrepancies in communication strategies from state-to-state, as well as the word of mouth that spreads between states on social media. It is also likely that a number of people would not accurately recall whether the app they are downloading is issued by Virginia or Maryland, or their state or their school, confusing interpretation of numbers collected in our survey. Though nationwide availability of the EN service would alleviate some confusion, so would interoperability between state deployments, clear and easily accessible usage guidelines, and familiarity gained by usage over time.

understand, there are a number of small decisions and actions built into EN apps and services, which require a number of steps to be taken by individuals. There are also are a number of actions required from public health personnel in order to ensure the technology works as intended, such as calling positive cases to provide the information needed for the service to notify others. While this does likely protect against malicious reporting, it introduces delay that is detrimental to containment efforts for a rapidly spreading virus. At the height of the pandemic, states were trying to work out how to stretch their finite contact tracing capabilities to cover the explosion of COVID cases [17]; but states that also required public health calls to positive individuals were adding small amounts of workflow friction to an already stressed system. In 2022, moves by states to allow self-reports by individuals outside of the traditional public health contact system will likely result in increased use. In examples where the full technology-and-public-health workflow has been designed and implemented to work smoothly together, there have been robust numbers reported, such as the 91% usage of Ottawa's symptom-check system that was integrated into their traditional contact tracing processes [18]. Workflow friction reduction has also been shown to help engagement in states such as Hawaii, which saw its engagement numbers double once EN Express was enabled, allowing people to enable the service in their smartphone settings rather than having to download an app [2]. Considering our survey results, where the action of downloading an app was less palatable to our participants than notifying others, this can be read as reducing a less desirable action (downloading an app) to present potential users with a lower bar to entry for the more desirable action (notifying others).

Perception also plays a large part in user willingness. EN services are relatively new and untested; public health as well as the general public do not have a strong understanding of what to expect from use, so rely on what they know (with a healthy dose of bias). Perception of what the apps do is just as (if not more) important than what they actually do, just as who people perceive as being involved is just as (if not more) important than who actually is involved. Our results show that for many people, recommendations or requests from their personal doctor would make them more likely to engage with EN. Though there is a separation between public health and personal health services in practice, the general public has had much more opportunity to develop a trust relationship with the doctors they engage with consistently over time. For some sub-demographics, requests from other agents such as local or federal public health, employers, or schools would help. Targeting requests to demographics by agents they trust will likely help improve willingness to engage. However, if these requests are perceived as coming from smartphone providers, most of our participants indicated being less likely to engage. Care should be taken to ensure communications are perceived as coming from a trusted source, wherever these official communications are occurring. For instance, there are efforts to brand messages to smartphones about the state deployments to ensure they are perceived as official public health communications, and not spam, to address anecdotal evidence of people dismissing messages out of hand. Though managing perception is always important, it becomes more important during pandemic situations where deployments need to gain the attention of a stressed population trying to handle daily needs with reduced attentional resources. While perception of smartphone messages may be considered a small aspect, it is the primary method of communicating directly with smartphone users who are the target of EN deployments.

Perception of involvement also extends beyond messaging and requests; our results complement prior research indicating that health departments are more trusted than app providers [9], as well as research indicating that people were more comfortable sharing information with a physician than public health authorities and others [10]. It also sheds some light on why only 32% of respondents from a national survey would indicate probably using an EN app from Apple and Google [4], while closer to 60% indicate willingness when the question does not mention specific app developers [6] [5] [4]. Who people think has developed the app, as well as whom they think the information is being shared with and what they think is being shared, contribute to their willingness to engage. Research has shown that sharing too much detail about privacy information can be sometimes more detrimental than sharing nothing [19]. Care needs to be taken with each deployment to ensure that privacy protections are explained simply and succinctly within the app itself, and that it is clearly an effort stemming from public health authorities with support from other trusted entities.

Longstanding tools of public health such as traditional contact tracing should also be thought of as "new technology" to the general population, as most people do not have experience with the process outside of pandemic situations. Similar concerns with perception apply here; a Pew poll from October 2020 found that 80% of people do not answer the phone from unknown numbers, and 91% thought that people pretend to be someone else to try to steal personal information over the phone at least some of the time [15]. Though most of our respondents indicated being willing to share information about their contacts with public health, this assumes they know the call is from public health. Ensuring the call comes through in a manner that is easily and immediately recognizable to the general public as an official communication will help establish trust and remove some of the burden from contact tracing personnel. Additional assistance could come from partnering with health care providers, testing sites, and pharmacies to educate the public about what to expect, as well as investing in technology improvements to reduce workflow friction on both the general public and the public health side.

One existing issue highlighted in our empirical research is the awareness of an app deployment; more than half of the participants with an available state service indicated not being aware of one (56.5%). Our research identifies sub-demographics that were open to using EN apps and services regardless of who was perceived to be involved. Targeting communications to those populations to ensure awareness is likely to help increase adoption numbers.

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6. SUMMARY

In support of EN deployments and in an effort to improve public adoption, we analyzed the implied technology usage workflow to identify controllable communication points with the general public, as well as the required user and public health actions to enable to service. We delivered an initial set of recommendations to the CDC and other interested parties in an effort to improve user adoption of ongoing deployments in Pennsylvania and Massachusetts. This work, along with a review of literature surrounding EN deployments and related technologies, led to the development and conduct of a national survey. The process to develop our survey allowed us to identify key investigative questions, and situate our findings in the broader research community.

Our participants indicated willingness to participate in contact tracing, quarantine, and notifying others through an EN app or service. They were less willing to download an app or notify others when the information being shared was visible. This allowed us to determine that the core action inherent in EN services—notifying others—was one that our participants were generally willing to do. Reducing the need for less palatable actions, such as downloading an app, would therefore be expected to improve adoption, as would addressing information visibility concerns. Investigating responses by demographic, then sub-demographic, allowed us to explain some seeming inconsistencies in prior research; we can hypothesize that researchers who looked at the larger demographic group but came to different conclusions were looking at different aspects of the action in some situations, and sampling different concentrations of sub-demographics in others. We were also able to identify a number of groups who indicated willingness to use EN regardless of agent involvement, while confirming that most participants were unaware of currently available deployments. We also identified groups where requests by trusted agents such as personal doctors, local public health, or federal public health would improve their likelihood of engagement. Our results tables detail which agents were likely to have overall positive or negative effects on the likelihood of each sub-demographic to engage in the action investigated. These tables should help organizations identify which sub-demographic groups to target for which communications, as well as what to avoid, as perceived involvement by certain agents may help or hinder communication efforts.

Though these findings are specific to EN deployments, the process of investigating the human system, communications, and user actions surrounding technology use to identify friction points and controllable communication points is expected to be broadly applicable. Understanding which actions users are willing to take and which are less palatable will help future technology development and deployment considerations, particularly for future EN use or related technologies. Investigating impacts of agent involvement on sub-demographic groups is also expected to help improve user outreach and shape messaging for ongoing EN efforts as well as future related technologies.

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GLOSSARY

AA	African American
CDC	Centers for Disease Control and Prevention (United States)
COVID-19	Coronavirus disease caused by the SARS-CoV-2 virus
CSAIL	MIT's Computer Science and Artificial Intelligence Laboratory
EN	Exposure Notification
GAEN	Google-Apple Exposure Notification
HS	High school
ID	Identifier, implicitly unique
Key	A cryptographic token generated on the smartphone once per day, used to generate pseudo-identifiers transmitted in Bluetooth messages by EN
MIT	Massachusetts Institute of Technology
MIT LL	Massachusetts Institute of Technology Lincoln Laboratory
NHS	National Health Service (U.K.)
NORC	An independent research organization at the University of Chicago (founded under the name "National Opinion Research Center"; renamed NORC)
PA	Pennsylvania
PACT	Private Automated Contact Tracing
PHA	Public Health Authority (or Agency)
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
USD	United States dollar(s)

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APPENDIX

Demographic details of participants in national survey conducted April 20–May 24, 2021, showing overall sample (n=2157), as well as race/ethnicity break-downs by age, binary gender (aligning with census reporting), education, household income, and U.S. region [20].

Table 14

Unweighted Distribution of Participants Across Demographics Presented According to Race/Ethnicity (Surveyed April 10–May 24, 2021)

Characteristic	Total (n = 2,157) n (100%)		Non-Hispanic White (n = 885) n (41%)		Non-Hispanic Black (n = 567) n (26.3%)		Hispanic (n = 601) n (27.9%)		Other[a] (n = 104) n (4.8%)	
Age group, y										
18-24	109	(5.1)	39	(4.4)	21	(3.7)	42	(7.0)	7	(6.7)
25-34	575	(26.7)	212	(24.0)	117	(20.6)	197	(32.8)	49	(47.1)
35-44	372	(17.2)	127	(14.4)	101	(17.8)	130	(21.6)	14	(13.5)
45-54	313	(14.5)	117	(13.2)	88	(15.5)	94	(15.6)	14	(13.5)
55-64	395	(18.3)	184	(20.8)	123	(21.7)	75	(12.5)	13	(12.5)
65-74	321	(14.9)	166	(18.8)	100	(17.6)	49	(8.2)	6	(5.8)
75+	72	(3.3)	40	(4.5)	17	(3.0)	14	(2.3)	1	(1.0)
Gender										
Male	1,055	(48.9)	483	(54.6)	222	(39.2)	292	(48.6)	58	(55.8)
Female	1,102	(51.1)	402	(45.4)	345	(60.8)	309	(51.4)	46	(44.2)
Education										
Less than high school	43	(2.0)	13	(1.5)	5	(0.9)	24	(4.0)	1	(1.0)
High school/equivalent	406	(18.8)	143	(16.2)	103	(18.2)	147	(24.5)	13	(12.5)
Vocational/some college	786	(36.4)	298	(33.7)	229	(40.4)	235	(39.1)	24	(23.1)
Bachelor's degree	602	(27.9)	277	(31.3)	140	(24.7)	148	(24.6)	37	(35.6)
Post graduate study	320	(14.8)	154	(17.4)	90	(15.9)	47	(7.8)	29	(27.9)
Household Income, USD										
<10,000	127	(5.9)	27	(3.1)	55	(9.7)	38	(6.3)	7	(6.7)
10,000-20,000	177	(8.2)	49	(5.5)	58	(10.2)	65	(10.8)	5	(4.8)
20,000-30,000	273	(12.7)	84	(9.5)	90	(15.9)	90	(15.0)	9	(8.7)
30,000-40,000	221	(10.2)	76	(8.6)	67	(11.8)	68	(11.3)	10	(9.6)
40,000-50,000	195	(9.0)	81	(9.2)	55	(9.7)	53	(8.8)	6	(5.8)
50,000-75,000	449	(20.8)	195	(22.0)	103	(18.2)	134	(22.3)	17	(16.3)
75,000-100,000	311	(14.4)	153	(17.3)	66	(11.6)	76	(12.6)	16	(15.4)
100,000-150,000	269	(12.5)	142	(16.0)	51	(9.0)	56	(9.3)	20	(19.2)
>150,000	135	(6.3)	78	(8.8)	22	(3.9)	21	(3.5)	14	(13.5)
Region										
Northeast	288	(13.4)	140	(15.8)	68	(12.0)	67	(11.1)	13	(12.5)
Midwest	515	(23.9)	268	(30.3)	137	(24.2)	90	(15.0)	20	(19.2)
South	864	(40.1)	294	(33.2)	310	(54.7)	228	(37.9)	32	(30.8)
West	490	(22.7)	183	(20.7)	52	(9.2)	216	(35.9)	39	(37.5)

[a] Other race/ethnicity includes participants who self-identified as non-Hispanic Asian, another race/ethnicity, or marked 2 or more race/ethnicity selections.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

As the COVID-19 pandemic swept the globe in the spring of 2020, technologists looked to enlist technology to assist public health authorities (PHAs) and help stem the tide of infections. As part of this technology push, experts in health care, cryptography, and other related fields developed the Private Automated Contact Tracing (PACT) protocol and related projects to assist the public health objective of slowing the spread of SARS-CoV-2 through digital contact tracing. The joint Google and Apple deployed protocol (Google-Apple Exposure Notifications, also known as GAEN or EN), which became the de facto standard in the U.S., employs the same features as detailed by PACT. The protocol leverages smartphone Bluetooth communications to alert users of potential contact with those carrying the COVID-19 virus in a way that preserves the privacy of both the known-infected individual, and the users receiving the alert. Contact tracing and subsequent personal precautions are more effective at reducing disease spread when more of the population participates, but there are known difficulties with the adoption of novel technology. In order to help the U.S. Centers for Disease Control and Prevention (CDC) and U.S. state-level public health teams address these difficulties, a team of staff from MIT's Lincoln Laboratory (MIT LL) and Computer Science and Artificial Intelligence Laboratory (MIT CSAIL) focused on studying user perception and information needs.

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