Quantifying meaningful adoption of a SARS-CoV-2 exposure notification app on the campus of the University of Arizona

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Abstract

Digital exposure notification requires both the primary and secondary cases to have previously installed a smartphone application, and the primary case to rapidly report their positive diagnosis. These conditions were met for an estimated 12% of transmission pairs during a SARS-CoV-2 outbreak on the campus of the University of Arizona.

Main Text

Smartphone applications (apps) for exposure notification have the potential, given sufficient uptake, to significantly reduce the spread of SARS-CoV-2, by making contact tracing faster, more scalable, and potentially more acceptable due to greater privacy and ease of use (1). The University of Arizona community piloted the Covid Watch app, which through the Google/Apple Exposure Notification API (GAEN), uses Bluetooth to measure date, distance, and duration of contact, and assess infection risk (2). App users who tested positive for SARS-CoV-2 were able to anonymously trigger notifications, including testing and quarantine recommendations, for other Covid Watch users with whom they had been in contact.

Here we quantify meaningful uptake. App download numbers are readily accessible, but overstate active app usage (3). Effective uptake requires not just app installation in both a primary and a secondary case, but also that the primary case report a positive diagnosis by obtaining and entering a secure verification code.

The effectiveness of exposure notification depends not on total population usage, but on usage among individuals who go on to be infected by SARS-CoV-2. One concern is that individuals who tend to comply with public health guidelines might be both more likely to download an exposure notification app and less likely to contract SARS-CoV-2, leading to the overestimation of effective usage. With the help of a third party, the University of Arizona used social marketing tools to promote app usage. Identified influencers proved successful with quick download rates among students.

Evaluation of GAEN apps is challenging because of their strict privacy protections. We therefore partnered with case investigation of primarily university students to ask three questions, with consent of the local health department. The questions were (i) ‘Have you downloaded the Covid Watch app?’; (ii) ‘If yes, did you already enter the verification code following your positive test?’; and (iii) ‘If yes, have you received an exposure notification yourself?’ Interviews were conducted by a university team (SAFER) contracted to conduct case investigations and contact tracing (4) of faculty, staff and students who tested positive through the on-campus testing program. We also compared the numbers of positive tests to the numbers of requests for a verification code, tabulated through our on-campus testing program. We do not report here on question (iii) because early in the pilot, smartphone operating systems (not the app) issued exposure notifications even for insignificant exposures, creating user confusion, and rendering notification data unreliable. This issue affected all GAEN version 1 apps that implemented their own risk scoring calculations, but has been resolved in later versions.

Our data span August 23 to November 28, during which there was a significant outbreak of SARS-CoV-2 in the student population. Verification code issuance peaked in the same week as confirmed cases (Figure 1).

Among the 1,113 faculty, staff, and students with a COVID-19 diagnosis interviewed, 524 (47%) told campus contact tracers that they had previously downloaded the app. Among these 524, 289 (55%) had already entered a positive diagnosis code into their app, enabling contact notification to occur even before the case interview. This rate of code entry is similar to that of Germany (5), where there has been extensive investment in integrating verification code delivery with the delivery of SARS-CoV-2 test results.

Combining these numbers, 26% of all infected individuals interviewed by manual contact tracers reported having previously entered a verification code into their app to anonymously notify their contacts. One caveat is that the cases that contact tracers succeed in interviewing (response rate is ~70% of assigned cases) may have higher app use than the general campus population. However, we get the same estimate of 26% by dividing the total number of verification codes issued by the total number of positive tests from our campus testing facilities. We count verification codes (613 in total) at point of issue rather than upon usage, but because obtaining a code requires some action from an infected individual (either a phone call or clicking on a request link), we expect this to be only a slight overestimate. There are also factors that might cause this number to be an underestimate; specifically, we count positive tests not cases, and some individuals tested positive on multiple test platforms (PCR and antigen) for the same illness. These two independent approaches both yield the same estimate that 26% of cases notified their contacts using the Covid Watch app.

Because the three questions regarding app usage were asked during the case investigation interview, our results demonstrate that notification via the Covid Watch app was more rapid not only than traditional contact tracing at the University of Arizona, but also more rapid than other digital exposure notification workflows where traditional contact tracers provide verification codes over the phone. Our automated code delivery via an end-user test results portal is now adopted by commercial test providers in Arizona.

We propose and estimate a metric of meaningful usage among cases. Because the app's purpose is to isolate the infected, focusing on cases is more epidemiologically meaningful than usage among the general population. We consider the scenario where a primary case infects a secondary case within a tightly interconnected community such as a college campus, and estimate the probability that both cases have used the app to the minimum necessary level to potentially impact transmission. The estimated probability for the primary case is 26% (where verification code entry is required) and 47% for the secondary case (where only app activation is required). Combining these by assuming a well-mixed population, and neglecting transmission from outside campus given low community prevalence at the time this pilot study was conducted, app usage is estimated to affect 12% of transmission pairs. In a structured population where individuals in the same transmission pair have more similar app usage rates, this value will be higher than 12%.

Our app usage metric can be used to estimate the expected reduction in R(t) due to the direct impact on the behavior of secondary cases. This reduction could be ~12% if 1) all cases carried their phones with them at the time transmission occurred, 2) primary cases are tested sufficiently rapidly, 3) the app detects exposures that led to transmission, and 4) notifications following infection eliminated forward disease transmission by sufficiently changing the behavior of secondary cases. The direct reduction in R(t) will be smaller, because of violations in these assumptions, especially the fourth given reports of low quarantine compliance (6, 7). However, R(t) is also indirectly reduced when the far larger number of exposure events that do not lead to transmission also lead to behavior change, which either prevents infection in the notification recipient, or elicits first quarantine and then isolation after they have been infected by a different exposure within the same social network (8).

Here we have proposed a new metric for assessing app usage within a tightly interconnected community that does its own testing and tracing. We show that usage on the University of Arizona campus is high enough to make it a useful tool that complements and augments traditional contact tracing.

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Author Bio

Joanna Masel is a Professor of Ecology & Evolutionary Biology at the University of Arizona and a consultant at WeHealth PBC (distributors of the Covid Watch Arizona app). She is a mathematical biologist and data scientist who has published in diverse fields including infectious disease, biochemistry, evolutionary biology, economics, and education.

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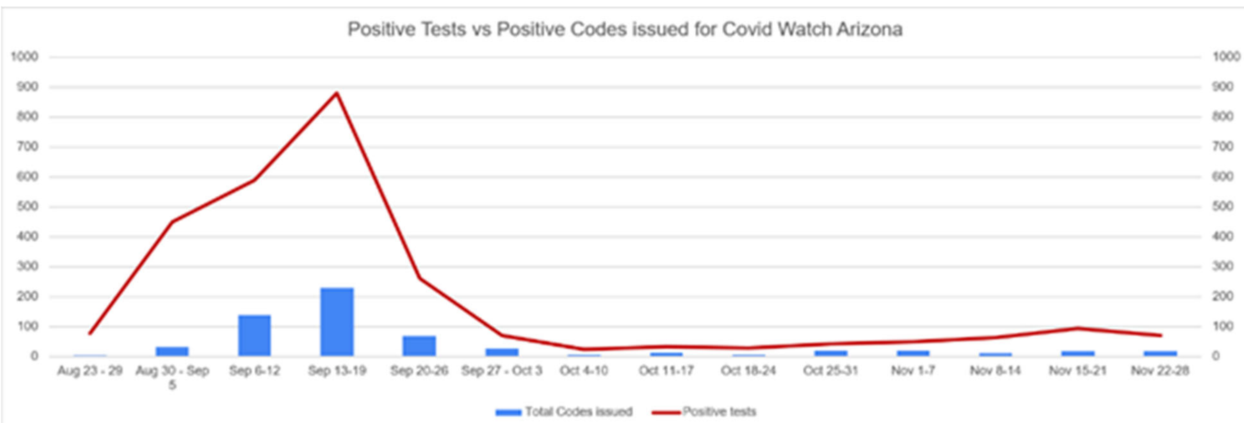

Figure 1. The number of verification codes issued tracks the number of positive tests during an outbreak among students on the campus of the University of Arizona. The total number of codes issued represents 26% of the number of positive tests.