

# **Elimination of Shame, Embarrassment, and Fear Associated with COVID-19 Contact Tracing**

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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# Elimination of Shame, Embarrassment, and Fear Associated with COVID-19 Contact Tracing

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## ABSTRACT

Shame, embarrassment, and fear are the main emotions people feel when notifying others they have contracted COVID-19. The challenge of contact tracing is overcoming those negative emotions, so how do we solve that challenge? The key to the solution is anonymity. The object of the proposed solution is to create a website where COVID-19 patients can anonymously notify those close contacts. To do so, the patient would provide the phone numbers or email addresses of those they want to notify and the website would handle sending them the message. This solution reduces the shame, embarrassment, and fear of directly contacting the person. The technical aspects of the website are a front-end framework, the proposed framework is Django, React, or Angular, and Amazon Web Services (AWS) to handle the notification system using the Simple Queue Service (SQS) or Simple Notification Service (SNS). If the solution is successfully implemented, the issue of shame, embarrassment, and fear would be reduced and individuals would be more likely to contact trace.

## INTRODUCTION

As stated in the previous section, shame, embarrassment, and fear have prevented individuals from contact tracing. Before we propose the solution, what exactly is contact tracing? Contact tracing involves notifying close contacts, people who have been within six feet of the patient for 15 minutes or more, that the patient has tested positive [1]. Contact tracing is an important aspect of reducing the growth of cases. Notifying close contacts is the moral and responsible action to take when confirmed positive for COVID-19, however, it is not being done often because of the problem of feeling shame and embarrassment. With the spread of COVID-19 not slowing down, more research can be done to analyze the current pain points of patients sharing their close contacts and the solutions others have proposed. However, with COVID-19 still spreading rapidly and variants arising, it is critical for

individuals with COVID-19 to contact trace. Individuals do not contact trace due to shame and embarrassment of contracting COVID-19 and fear of losing their jobs, housing, or relationships. Individuals are also reluctant to participate due to distrust in the government, as they are fearful that the information they share may not truly be confidential. Furthermore, individuals are fearful to notify about exposure in their jobs due to risk of unpaid time off and discouragement and inactiveness of COVID-19 precautions from their employer. Due to this, other employees and individuals are not aware of COVID-19 exposure in public places. In California, people are reluctant to contact trace due to fear and embarrassment caused by various factors [2]. Furthermore, if the individual decides to participate in contact tracing they may not share an accurate list of close contacts. California found that almost half of the patients who tested positive would not share their close contacts. Currently, people are able to contact trace through direct notification to the contact, official contact tracers, and recently anonymously contact tracing through apps and websites. In the first solution, direct contact tracing depends on the infected individual to communicate to the contact, which may take days, weeks, or it may never occur. In the second solution, official contact tracers will notify those contacts given by the infected individual within 24 hours [3]. Lastly, in the third solution, the infected individual is able to anonymously notify their contacts in an average of two minutes. Although the anonymous contact tracing allows users to easily and quickly notify their contacts while reducing shame and embarrassment, there is still fear of government officials or their contacts finding out the personal information of the COVID-19 positive individual due to the requirement of signing into Healthvana's system [4].

Additionally, there is still the issue of COVID-19 exposure in public establishments as even effective contact tracing may not help others avoid exposure in those places. Public establishments could be a breeding ground for COVID-19 if the employees and customers

are not following COVID-19 precautions. Currently, there are no online resources that display COVID-19 exposures in public establishments. An individual is only able to view exposures through COVID-19 exposure maps; however, they are only county, state, or country specific and do not highlight specific establishments.

## RELATED WORK

A proposed solution to a similar problem is anonymous notification, as implemented by STDcheck.com. On their website, people are able to anonymously notify their sexual partners of their sexually transmitted disease (STD) by text or email for free and without requiring any personal information from the infected individual [5]. In the same way people feel negative emotions with having COVID-19, people with STDs are also reluctant to share their test results. However, both boast the same benefits of anonymous notifications. Those benefits being the moral and responsible action to take, allowing the person in contact to be self-aware and take precautions such as getting tested, self-quarantining, and receiving medical attention and treatment, letting the person know as soon as possible to take preventative action, and possibly saving a life or many lives. STDcheck.com gives a system framework for how anonymous notification could be done, but is only used for STDs.

Another solution to a similar problem was implemented by Healthvana's Digital Contact Tracing Feature. Once an individual tests positive for COVID-19, they are able to use this system to anonymously notify their close contacts in an average time of two minutes. Their system is similar to STDcheck.com, as they display helpful information and capture relevant contact information to send the close contact an informative exposure notification. The helpful information in the directions and notification message educate the user on who to notify and what the close contact should do once they discover they have been exposed [4]. The issue with this solution is the need to sign into a Healthvana account before a user can use this feature. This can limit and prevent users from contact tracing, as they only can contact trace if they received their COVID-19 test result from Healthvana or they may not want to share any personal information. Additionally, this increases the number of steps needed to anonymously contact trace, reducing the efficiency and ease of use.

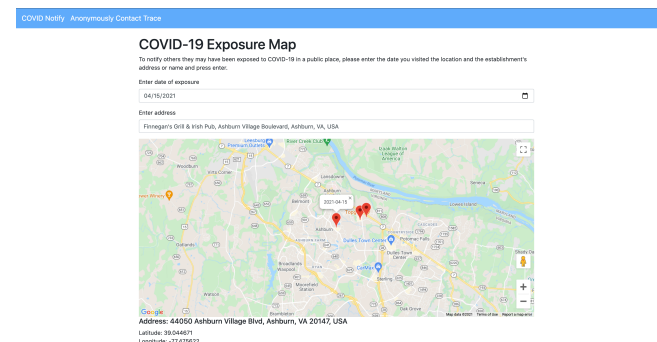
## SYSTEM DESIGN

A contact tracing system, COVID Notify, was built using Angular and deployed on Google Cloud Platform (GCP). The deployment of the Angular app was implemented using GCP bucket storage and GCP App

Engine. The front-end was also built using HTML, CSS, Bootstrap, and JavaScript. Bootstrap was mainly used to create the navigation bar, layout of the forms, and support responsive design/layout. The website has two pages and features: the COVID-19 Exposure Map, which is also the home page, and the Anonymous Contact Tracing.

## 1 COVID-19 Exposure Map

The COVID-19 Exposure Map and corresponding form were built using the Angular Google Maps (AGM) API, JavaScript, HTML, CSS, and Bootstrap. The AGM API was utilized to take the user's input public establishment name or address and find the coordinates to create a marker. Each marker is placed on the map using the coordinates and is labeled by the date of exposure entered by the user. Additionally, the AGM API creates a marker for the user's current location to allow the user to see COVID-19 exposure markers near them. To protect a user's privacy, the current location is only set after approval from the user from their web browser. After the user enters the date of exposure and address and presses enter, TypeScript and the AGM API finds the longitude and latitude and create a new marker with the date of exposure as a label. The date of exposure input is a standard HTML date input, but was improved using JavaScript to ensure a future date is not chosen and displays an error message if chosen. The address input is able to autocomplete using an event listener and the AGM API. The layout of the form is simple and easy to use as there are only two inputs and directions at the top of the page.



**Figure 1: COVID-19 Exposure Map Page with Example Markers**

## 2 Anonymous Contact Tracing

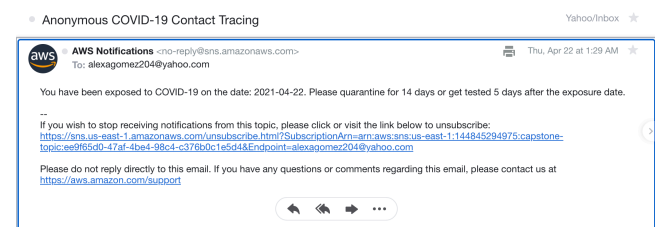
The Anonymous Contact Tracing was built using JavaScript, Amazon Web Services (AWS) Lambda, AWS Simple Queue Service (SQS), and AWS Simple Notification System (SNS), JavaScript, HTML, and

CSS. The form was built using HTML and JavaScript. The form is formatted as a table and takes the date of exposure, email address, and phone number as input. The user is required to enter a date of exposure and email address or phone number. HTML was utilized to ensure a date was chosen, a valid email was entered, and a valid phone number was entered in the correct format. Additionally, error validation was implemented by JavaScript. It ensured the date of exposure was not in the future and either an email address or phone number were entered. If there were any errors in the form, an error message would display. JavaScript was also utilized to aid Document Object Model manipulation. Specifically, it enables the user to enter more than one contact by adding more rows to the table. As the user adds more rows, all the rows are checked for errors. The layout of the form is simple and easy to read and use. Additionally, to aid the user through the process, directions are displayed at the top of the page along with the message that is sent to their contact.

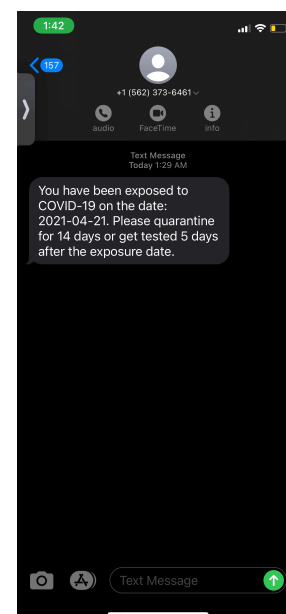
**Figure 2: Example Anonymous Contact Tracing Scenario**

The notification system was built using JavaScript, AWS Lambda, AWS SQS, and AWS SNS. After the user enters the contact information and clicks the button, an email and/or text message is sent to their contact(s). After the button is clicked and if the information is valid, for each contact a message is added to the AWS SQS queue, which is written in JavaScript. The message contains the type of information entered (e.g. email address, phone number, or both), date of exposure, email address, phone number, and the notification message. Once the message is added to the queue, an AWS Lambda function utilizes the information in the SQS message to create a specific notification message and sends an email, text, or both. The specific notification message is: “You have been exposed to COVID-19 on the date YYYY-MM-DD. Please quarantine for 14 days or get tested 5 days after the exposure date.” Both the email and text messaging services are handled by AWS SNS. For the text messages, an AWS SNS client is used to publish the text

message to the contact’s phone number. Similarly, an AWS SNS client is used to publish the email to the contact’s email address, which is currently hardcoded to a placeholder test email address due to AWS complications. AWS SNS only allows messages to be published to email addresses subscribed to an SNS Topic, therefore, to receive a message the email address must be subscribed before the message is published. Subscribing the email addresses causes an issue of privacy, which is discussed in the Future Work section. In the email notification system specifically, the AWS Lambda function uses an AWS SNS client to publish the notification to the SNS Topic. Once the message is published, the SNS Topic sends an email to the email addresses subscribed, which is currently only the test email address.



**Figure 3: Example Anonymous Email Notification**



**Figure 4: Example Anonymous Text Notification**

### 3 Major Design Decisions

One of the main requirements of the design was ease of use, which drove the simplicity of the website. The website contains only two pages that contain the two

main features. To increase contact tracing to individuals and for public establishments, the process needed to be simple. For both the COVID-19 Exposure Map and Anonymous Contact Tracing, there are only essential inputs for the form so that the user could quickly and easily create a marker or anonymously notify their contacts. Additionally, to reduce shame, fear, and embarrassment, users are never asked to enter their own information or make an account. Users do not need to hesitate using the website due to shame, embarrassment, and fear their personal information may be shared with others or the government.

After research into multiple map APIs, the AGM API was chosen due to its seamless connection with Angular. It was the easiest to incorporate with the current front-end framework. Additionally, the AGM API had the simplest tutorials of the features needed: setting current location, autocompleting an address, displaying a map, and creating a marker.

The anonymous contact tracing workflow was created based on previous experience and prior research. AWS Lambda and AWS SQS were chosen due to the context of the notification system. Messages published to the queue could be instantly processed by the lambda function and handled by their perspective services. It would allow for rapid handling of messages added to the queue and could handle multiple messages being sent for many contacts. Afterwards, the possible AWS services were refined by looking into those that were able to send text messages and emails. Instantly, it became apparent AWS SNS was the simplest and easiest to send text messages. AWS Simple Email Service (SES) was the top choice for sending emails, however, due to the AWS Educate account being used there were major barriers. In AWS SES, the only way to send an email to an email address without prior approval is through a production request. The AWS Educate account used did not allow for the verification of email addresses, furthermore, a regular AWS account would need approval from AWS to send emails to non-verified email addresses. Due to this, AWS SNS became the next best option for the COVID Notify prototype because it allowed for an email to be sent to a subscribed email. Although the email notification system was not built as expected, the subscribed test email address was able to receive an anonymous COVID-19 notification email.

## PROCEDURE

This section of the report explains how a user interacts with COVID Notify.

### 1 COVID-19 Exposure Map

The user is able to use the first feature by going to the home page or clicking the COVID Notify navigation tab. Once there, they are able to accept or decline if they would like to share their current location. If they accept, they will be able to see COVID-19 exposure markers around them, if not, they will be able to view markers by manually moving around the map. To add to the ease of use, the instructions are displayed at the top of the page. To add a marker to the map, the user is required to enter a date of exposure in the corresponding input box and can choose a public establishment by beginning to type the name or address of the establishment in the corresponding input box. If the user enters a future date, a red error message will appear at the top of the page. The autocomplete feature will be able to complete the address and will create a marker once the user presses the enter key. A marker will then appear on the map alongside the other markers with the date of exposure as the label. Whenever a user clicks on a marker, the date of exposure will appear.

### 2 Anonymous Contact Tracing

The user is able to use the second feature by clicking on the Anonymously Contact Trace navigation tab. To add to the ease of use, the instructions and notification message are displayed at the top of the page. To anonymously contact trace, the user is required to enter the date of exposure and an email address and/or phone number. To notify more than one contact, the user can click the “+” button and more rows will be added to the form. Furthermore, if they would like to remove a row, they can click on the “X” button corresponding to the specific row. If the user tries to submit the form without satisfying the requirements, specific error messages about the date or contact information will appear. Once all the required information is entered and the user clicks the “Anonymously Notify Contacts” button, a confirmation message is shown at the bottom of the form informing the users their contacts have been notified. If the user has more contacts to notify or forgot about some contacts, they are able to notify more contacts by clicking the link “Anonymously Notify More Contacts”.

## RESULTS

COVID Notify successfully allowed users to mark public COVID-19 exposures and anonymously contact trace. Whereas there was no previous solution and only county, state, or country specific COVID-19 exposure maps, the implemented prototype allowed for users to easily mark multiple location and view other exposure markers globally and locally in less than a minute. Additionally, with this feature, users could view heavily exposed public establishments and may possibly verify their COVID-19 exposure suspicions. Users were able

to easily use the anonymous contact tracing form to notify multiple contacts with a single click. After the form is submitted, the anonymous notification message is sent to the contact in less than a minute, where it took an average of two minutes or longer before through Healthvana's system and other previous solutions. Additionally, the issue of fear in government and others finding out is reduced as COVID Notify never requires a user to login and does not have a user account system. The only aspect of obtaining user information is asking for their current location, which the user can decline. The ease and simplicity of the prototype allowed users to efficiently and effectively complete the two main features presented.

## CONCLUSIONS

The COVID Notify prototype implemented met the need of the lack of public establishment COVID-19 exposure maps and an anonymous system that reduced fear of personal information exploitation and sharing. COVID Notify enabled users to mark public places and the date of exposure. It increased the specificity of COVID-19 exposure maps from county, state, or country to a single public establishment. Furthermore, the anonymous contact tracing allowed for users to genuinely anonymously contact trace. Compared to previous solutions, users would not have to provide any personal information or discuss their personal contacts with the direct close contact or an official contact tracer. With this prototype, there is no possible way of finding a user's personal information to exploit to others as it is completely anonymous and only captures a user's current location through prior approval.

## FUTURE WORK

The COVID Notify prototype could be improved in the future to successfully save and filter COVID-19 exposure markers into a database and progress the anonymous notification system to successfully send emails and provide extra COVID-19 resources for those sending and receiving the message.

Currently, the prototype does not save the COVID-19 exposure markers to a database, therefore, when the user refreshes the page or navigates to another tab, the markers disappear. The database would be in SQL and connected to the front-end using PHP. If the markers were saved to the database, the markers could be seen on by everyone visiting the website and not just the single user on their own web browser. Additionally, the database would allow for filtering of exposure dates. Since the exposure date would only be relevant for others for 14 days, any markers placed before then would not have to be displayed and could be deleted from the database. Furthermore, the current

implementation allows the user to place a marker at any location, which may cause issues if a user places a marker on a private location, such as an individual's house. To prevent this, the addresses allowed could be limited to only public establishments and addresses.

The prototype is not able to successfully send emails to non-subscribed emails, which takes away from the functionality of the anonymous notification system. In the future, AWS SES production approval could be received to enable the system to send an email to any email address. Additionally, to expand the functionality of the anonymous notification message, it could include a link to COVID-19 precautions, such as quarantining and social distancing, and locations to receive a COVID-19 test. The message could also redirect the close contact to COVID Notify to add their public exposures to the map and anonymously contact trace with their close contacts.

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