

Supporting Pandemic Response using GAEN and ENPA

CDC Health Data Innovation Summit

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**SOLVING PROBLEMS
FOR A SAFER WORLD®**

Exposure Notification (EN) apps

Contact tracing can help identify infected people before they spread COVID-19 to others, but **traditional contact tracing has limitations:**

- Relies on human memory
- Difficult to trace between strangers
- Requires significant manual effort
- Interviews and follow-up take time



Exposure notification apps have the potential to address these limitations, supplementing traditional contact tracing with alerts through a mobile phone

How do EN apps work?

Bluetooth low-energy beacons exchanged by nearby devices are used to estimate the distance and duration of an interaction in a **privacy-preserving** way



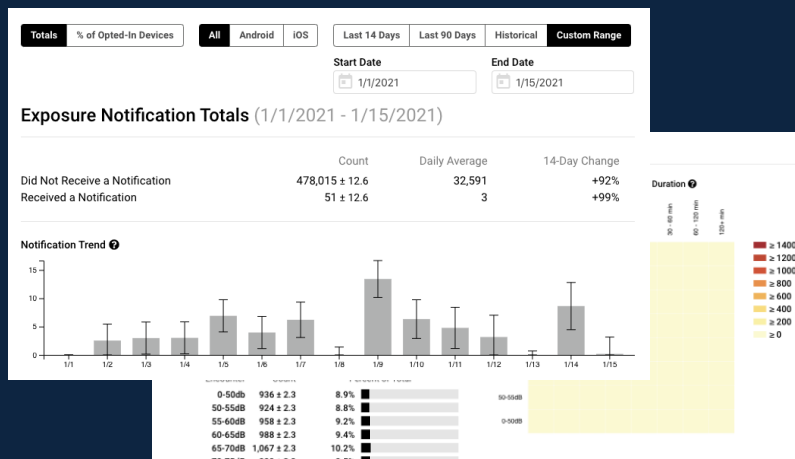
People who are later diagnosed can self-report through the app, which **anonymously notifies** other app users who were “too close for too long”, who are then **pointed to health resources**

EN Express (ENX) is a turnkey solution provided by Google and Apple that enables public health authorities to launch EN quickly and drives high user adoption via prominent mobile phone notifications

Exposure Notifications Private Analytics (ENPA)

EN Express provides a platform for guidance but **public health authorities (PHAs) need more:**

- Help onboarding to navigate overall EN process
- Feedback and insight on app user behavior
- Interpretation of public health rules into configuration and strategy



Exposure Notifications Private Analytics (ENPA) provides PHAs tools and visualizations of aggregated data to better understand COVID-19 transmission patterns and to optimize EN notifications against PHA resources

ENPA Privacy Considerations

Data Sharing

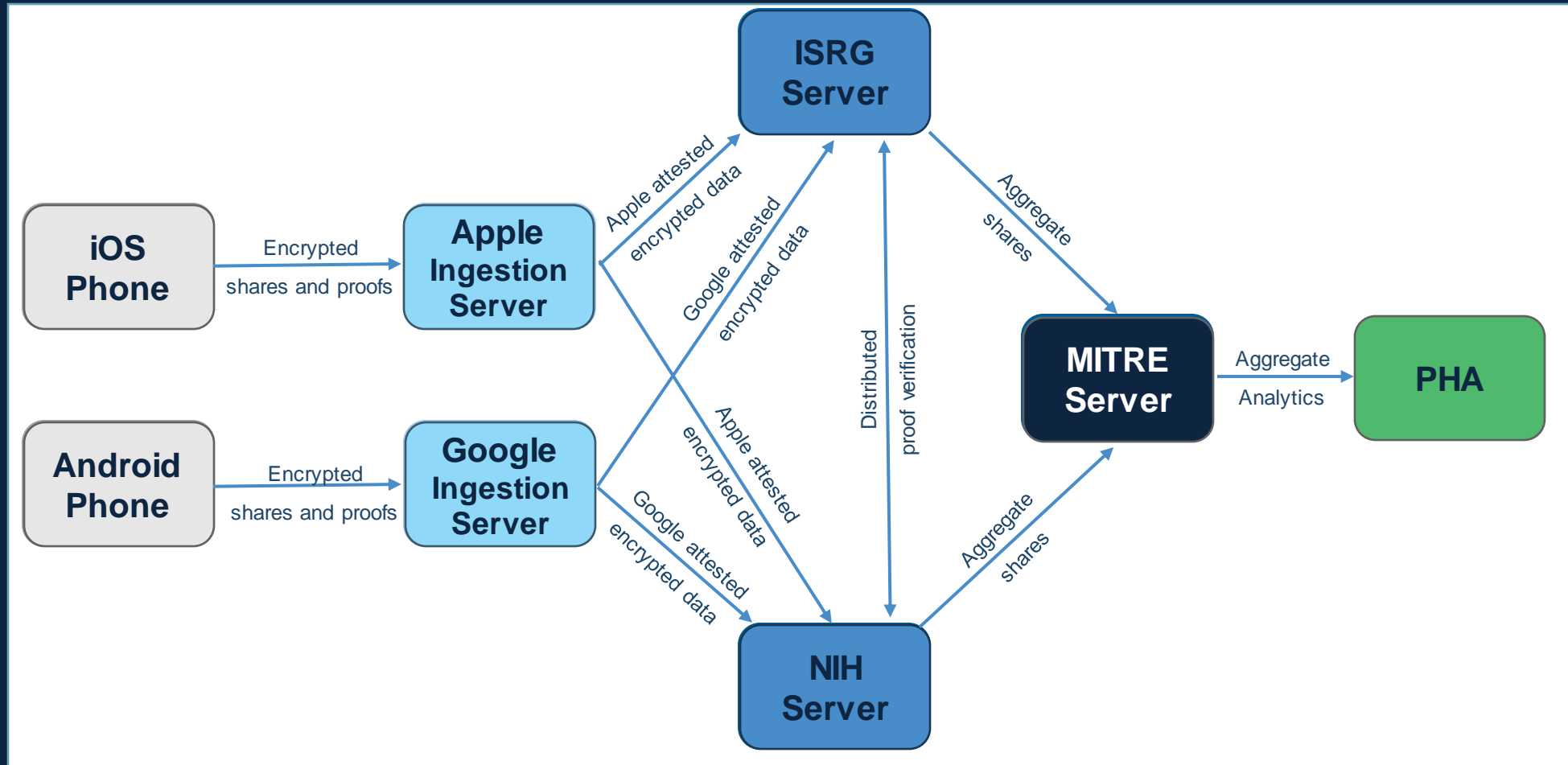
- Primary DUA between the PHA and the MITRE Corporation
- Additional sharing at the discretion of the PHA

Privacy-preserving techniques

- Users consent to share data (opt-in)
- **Prio**
 - Algorithm which allows private collection and computation of aggregated statistics about clients
- **Differential Privacy**
 - Injection of a small amount of statistical noise into the aggregate data to ensure individual records cannot be identified

ENX intended to be privacy-preserving method of notifying individuals about possible exposure to COVID-19 with several processes in place to ensure this extends to ENPA data

ENPA Privacy



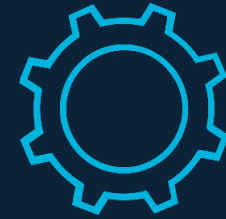
This Prio-based process ensures that individual user data is never accessible in an intelligible form once it leaves the user's device, yet useful aggregate metrics are provided to PHAs

ENPA Features



Analysis

- Summary
- Notifications
- User Engagement
- Codes Verified
- Keys Uploaded
- Beacon Counts (iOS)
- Encounters
- Derived Metrics
- Date Exposure
- Secondary Attack
- Integrations
- National Rollup



Access Management

- User Access
- Share Data

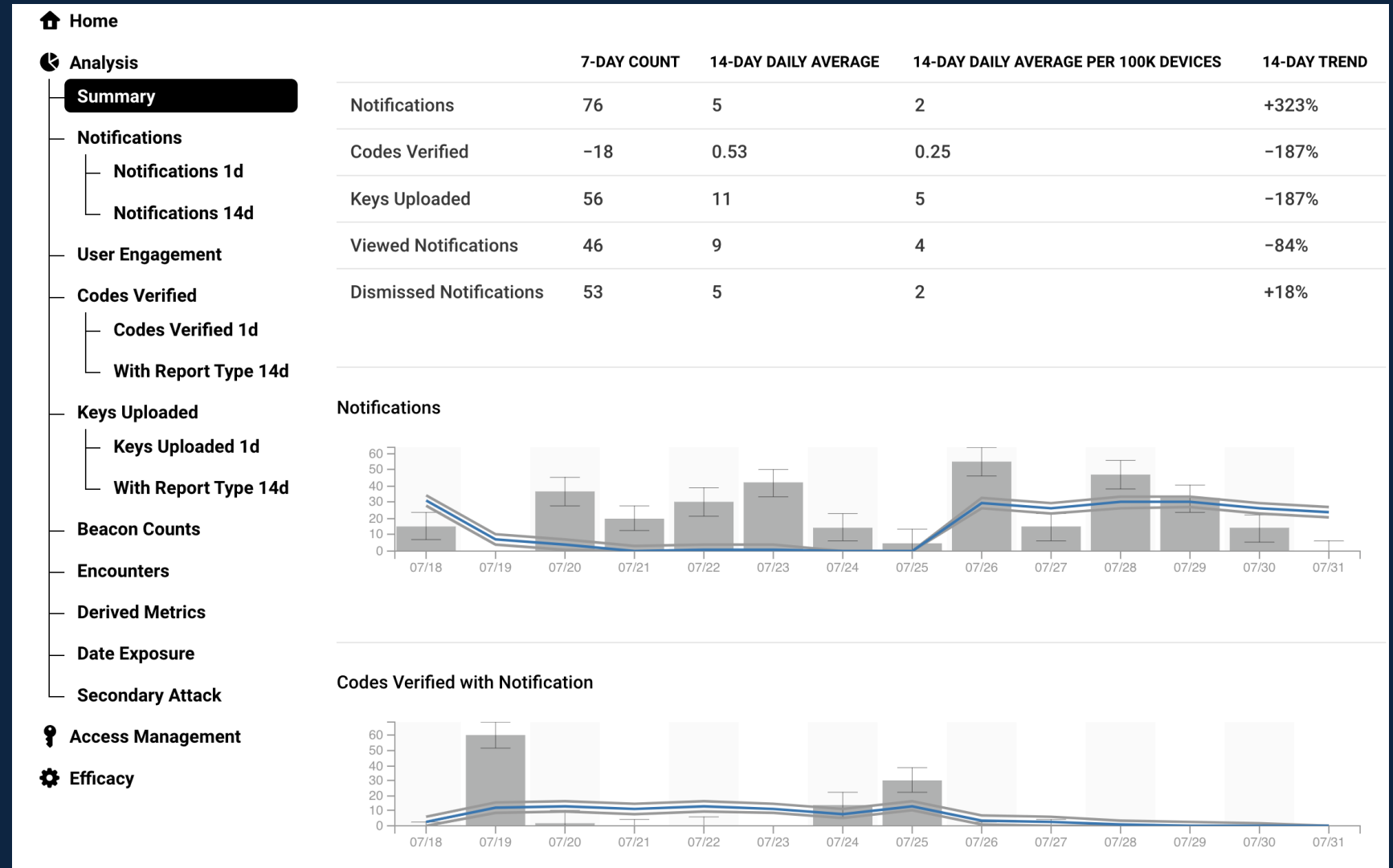


Efficacy

- Configuration Tuner & Efficacy Simulation Tool (CTEST)

ENPA Portal Summary View

- Mobile devices that received or did not receive an exposure notification
- Can be broken out by notification types



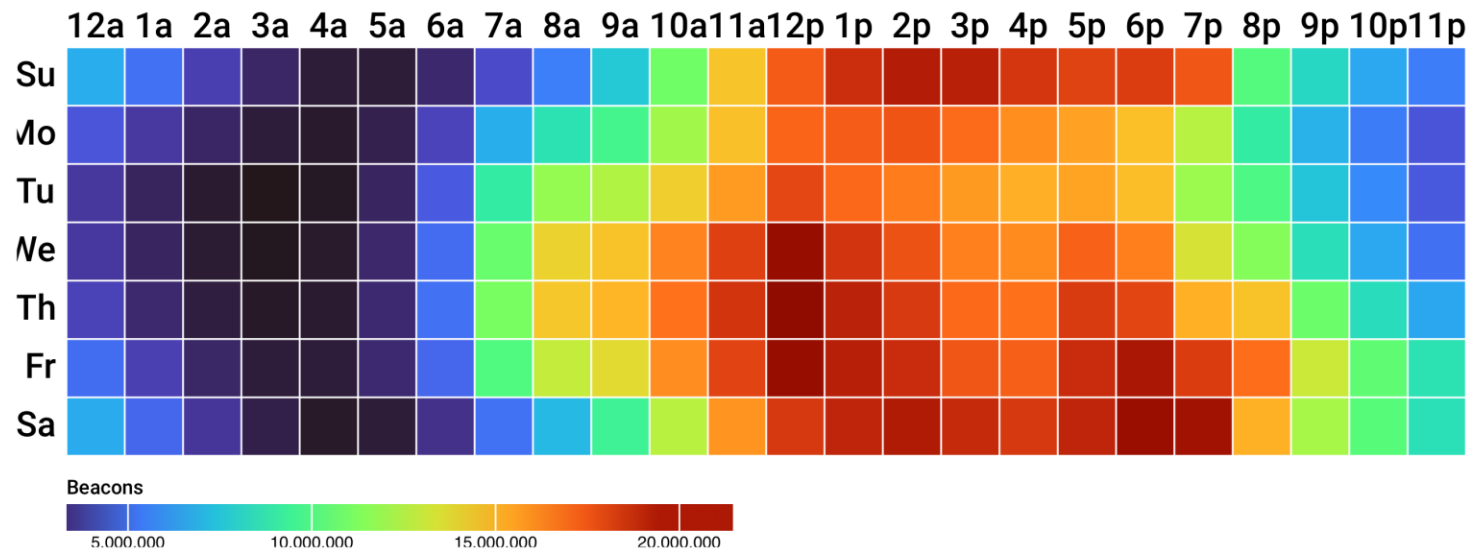
Beacon Counts describe Population trends (iOS only)

Beacon Counts (8/31/2022 - 9/13/2022)

📄 [JSON](#) [CSV](#)

Average Weighted Beacon Count Sums ?

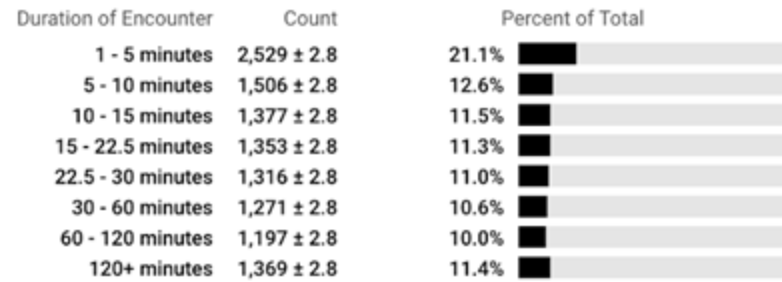
Since beacons are reported by device day totals for 9 ranges (1-3, 3-7, 7-15, 15-30, 30-50, 50-80, 80-120, 120-250, and 250+ beacons observed) the total number of beacon counts cannot be calculated by adding up the beacons for the corresponding day and hour. This calculation takes the lower value of each range (1 from 1-3, 3 from 3-5, 5 from 5-7, etc.) as a weight that is multiplied by the number of device days for the corresponding hour and day to approximate the beacons observed. Therefore this approximation is almost always lower than the actual number of beacons observed, but allows the data to be presented in a single visualization.



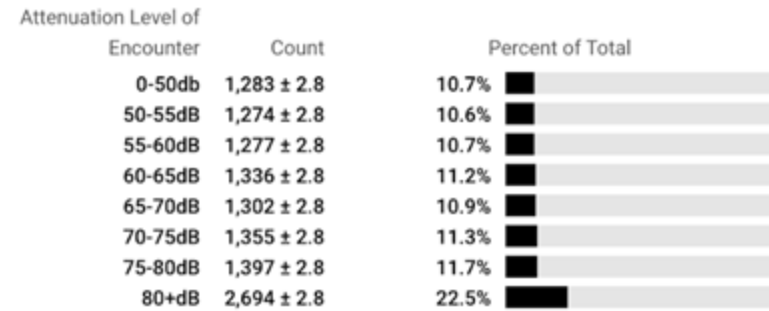
ENPA Encounters

- Details exposure events as a histogram of risk score inputs
- Inputs are:
 - Attenuation
 - Duration
 - Infectiousness
- These data can provide insight into what would happen if the risk score was configured differently

Distribution of Duration of Encounters ?



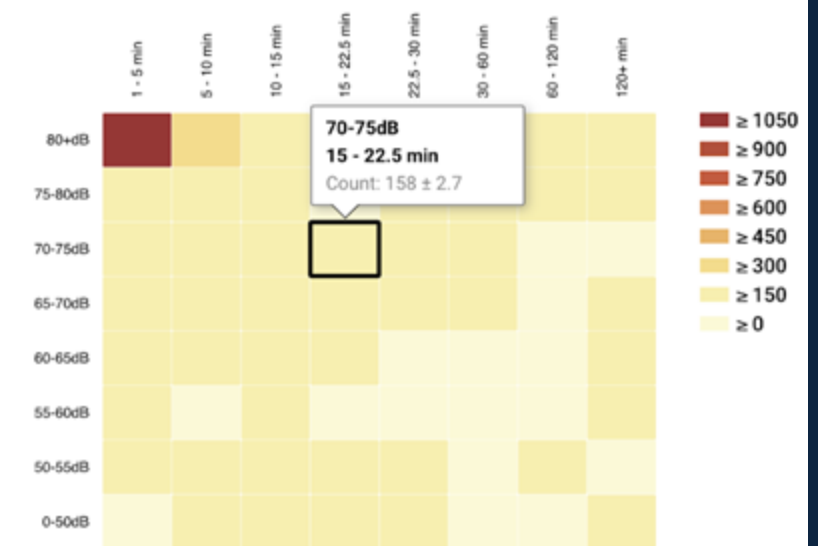
Distribution of Attenuation Levels ?



Distribution Among Infection Categories ?

Infectiousness of the Case When the Encounter Occurred	Count	Percent of Total
Occurred		

Number of Encounters by Attenuation and Duration ?



An event where two people participating ENX come in close enough proximity for their devices to exchange information and one of the users has reported being diagnosed with COVID-19.

Efficacy

Configuration Tuner & Efficacy Simulation Tool (CTEST)

- Helps PHAs estimate potential impact of changing configuration settings
- Statistics reapplied to real-world data can help inform decisions for PHAs

Exposure Notification Config

Preset: Ernieville

Notification Types

- Type 1**
Risk Score Threshold: seconds (15.00 minutes)
- Type 2**
Risk Score Threshold: seconds (0.00 minutes)
- Type 3**
Risk Score Threshold: seconds (0.00 minutes)
- Type 4**
Risk Score Threshold: seconds (0.00 minutes)

Simulation Parameters

Data Source for Exposure Risk Factors

Whether to randomly select the distance and duration of simulated encounters based on real data from this organization or uniformly across attenuation and duration bins

Real Data Uniform

Systemic Delays

Testing: days

Results: days

Reporting: days

Transmissibility

How easily the COVID-19 variant that the infected person has can be transmitted relative to the original

Estimated Real-world Impact

- 59,727** Total number of exposures recorded between EN app users in the last 14 days
- 29** Estimated number of such exposures that result in a new infection
- 16** Estimated number of such new infections for which a notification is sent
- 12** Estimated number of such notifications sent before symptom onset in the secondary case
- 474** Estimated number of notifications sent to app users who are not infected

Estimated Efficacy Metrics

Category	Recall	Precision	Percent
Notification Type 1	54.17%	3.27%	0.79%
All Notifications	54.17%	3.27%	0.79%

Risk Score vs Infection Likelihood for Simulated Data

National Rollup

US - National Rollup

Home

Analysis

Summary

Notifications

Notifications 1d

Notifications 14d

User Engagement

Codes Verified

Codes Verified 1d

With Report Type 14d

Keys Uploaded

Keys Uploaded 1d

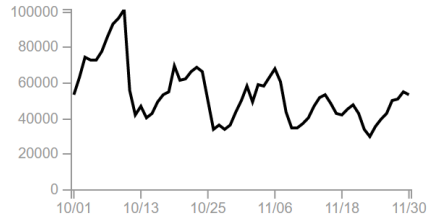
With Report Type 14d

Derived Metrics

Date Exposure

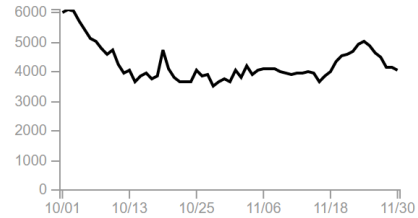
Secondary Attack

14-Day Notifications



7-Day Count	330,271
14-Day Daily Avg	41,415
14-Day Daily Avg/100k Devices	5,909
14-Day Trend	+59%

1-Day Notifications



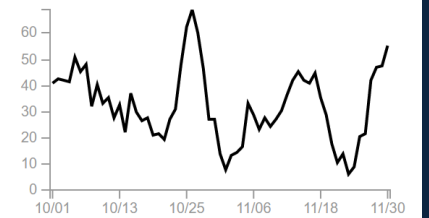
7-Day Count	29,203
14-Day Daily Avg	4,537
14-Day Daily Avg/100k Devices	45
14-Day Trend	-26%

1-Day Codes Verified with Notification



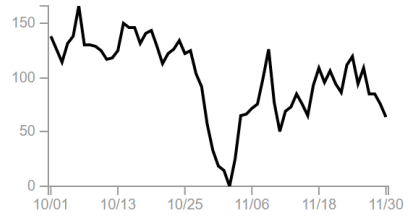
7-Day Count	196
14-Day Daily Avg	39
14-Day Daily Avg/100k Devices	0.39
14-Day Trend	-27%

1-Day Keys Uploaded with Notification



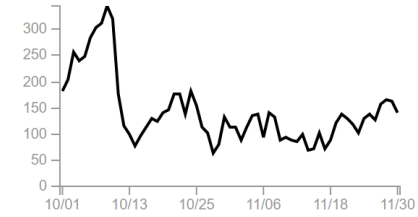
7-Day Count	395
14-Day Daily Avg	31
14-Day Daily Avg/100k Devices	0.31
14-Day Trend	+2,442%

Codes Verified:Keys Uploaded



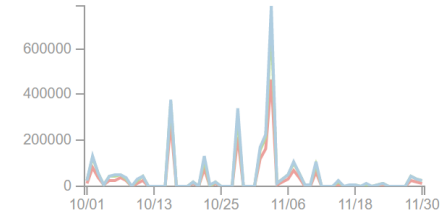
14-Day Daily Avg	87
14-Day Trend	-25%

Secondary Attack Rate

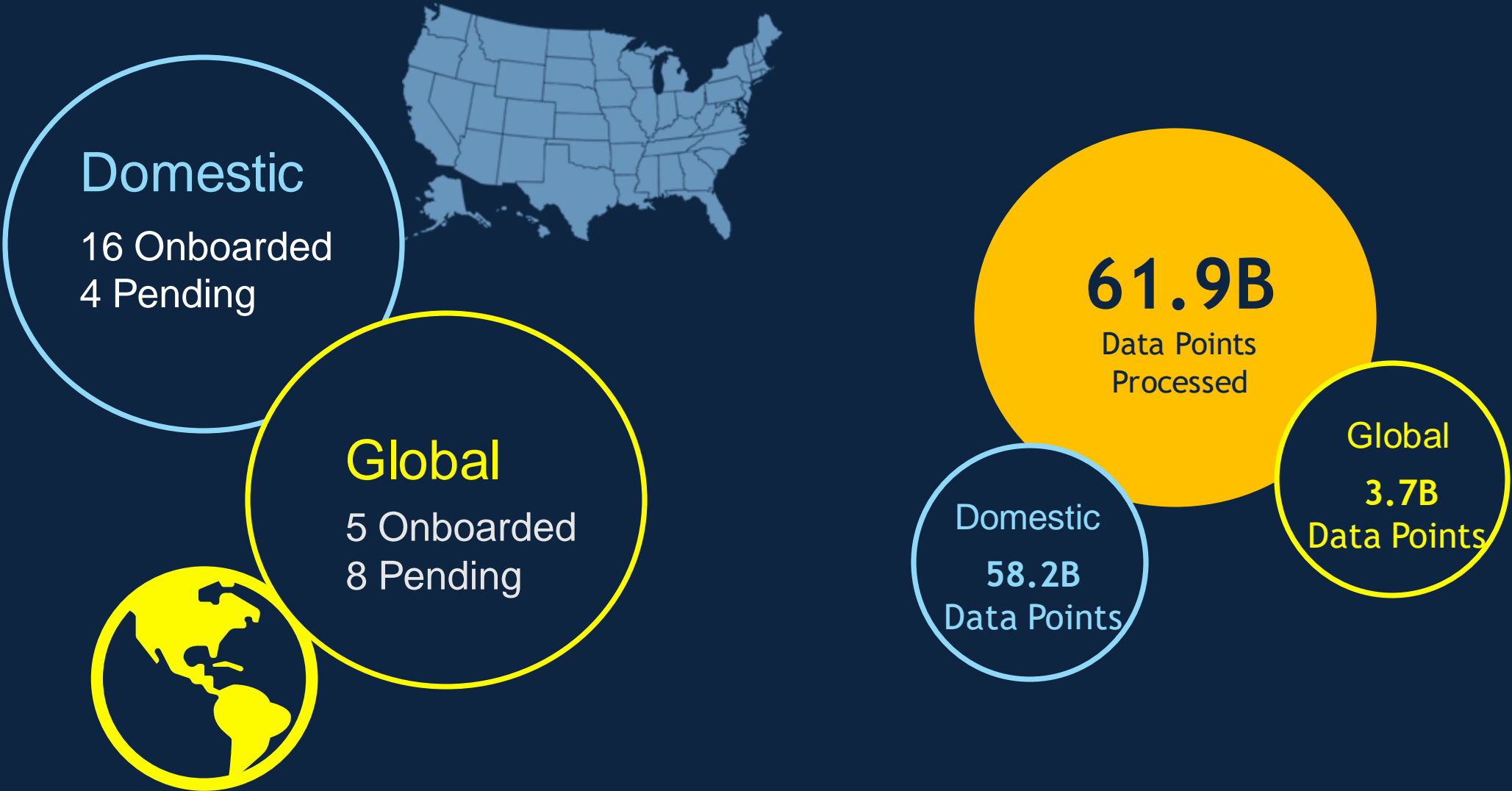


7-Day Count	895
14-Day Daily Avg	124
14-Day Daily Avg/100k Devices	18
14-Day Trend	+56%

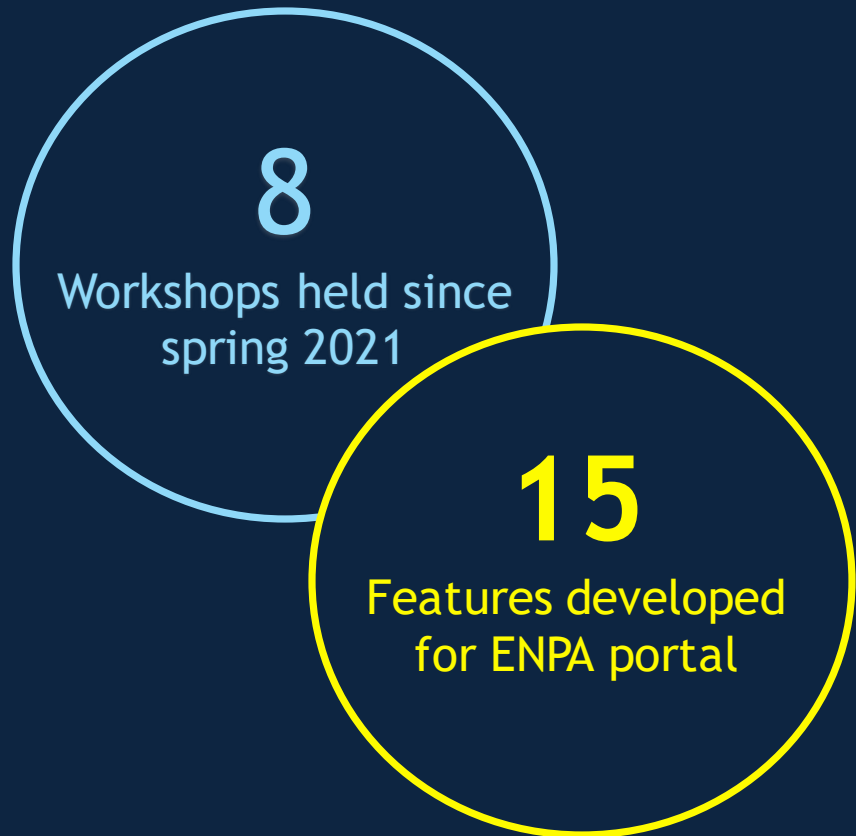
Date Exposure



Jurisdiction Enrollment Progress



MITRE Support to States



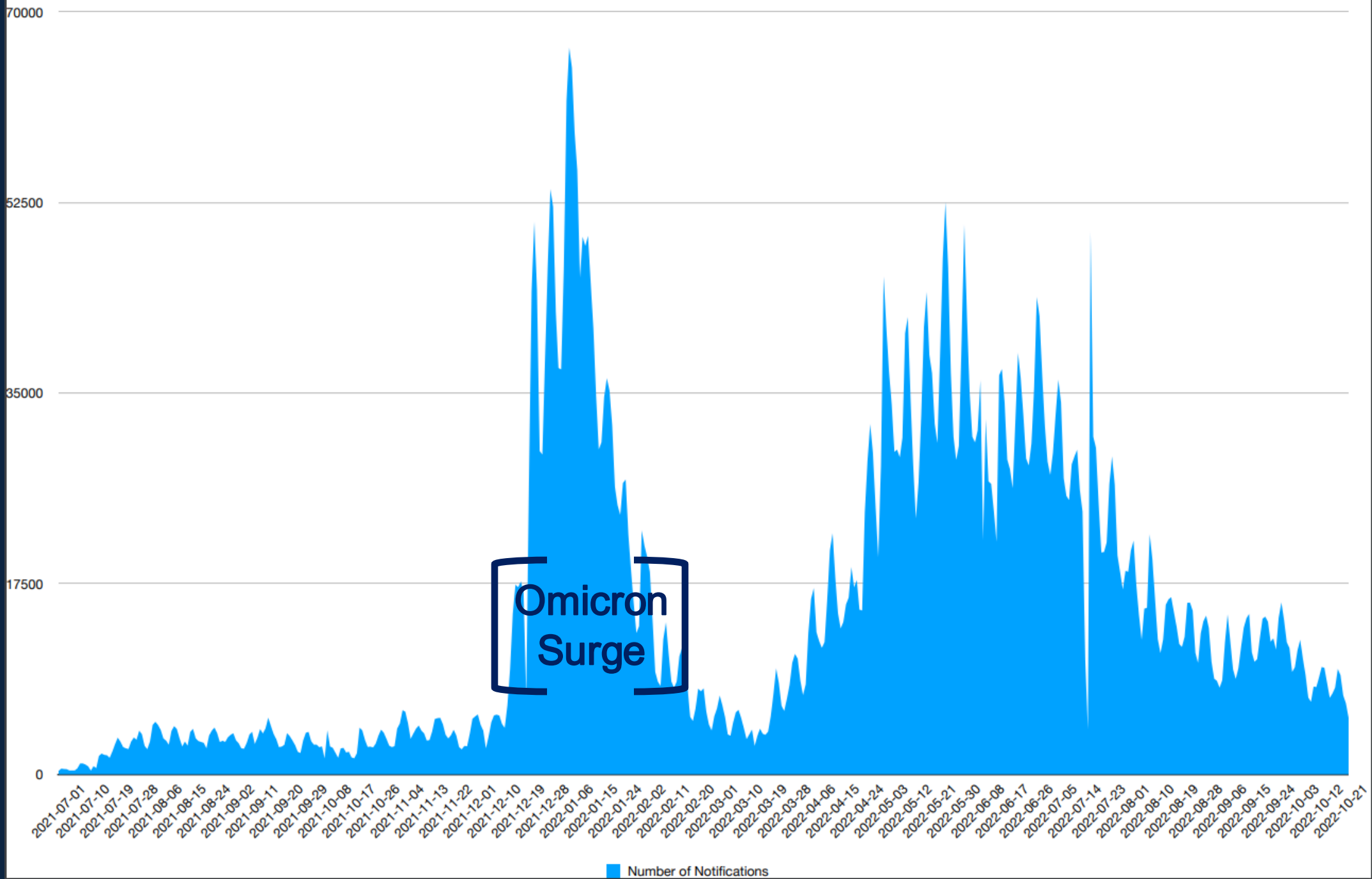
PHA Engagement

- Jurisdiction enrollment and PHA onboarding
- Workshops for PHAs
- New portal features that integrate PHA feedback

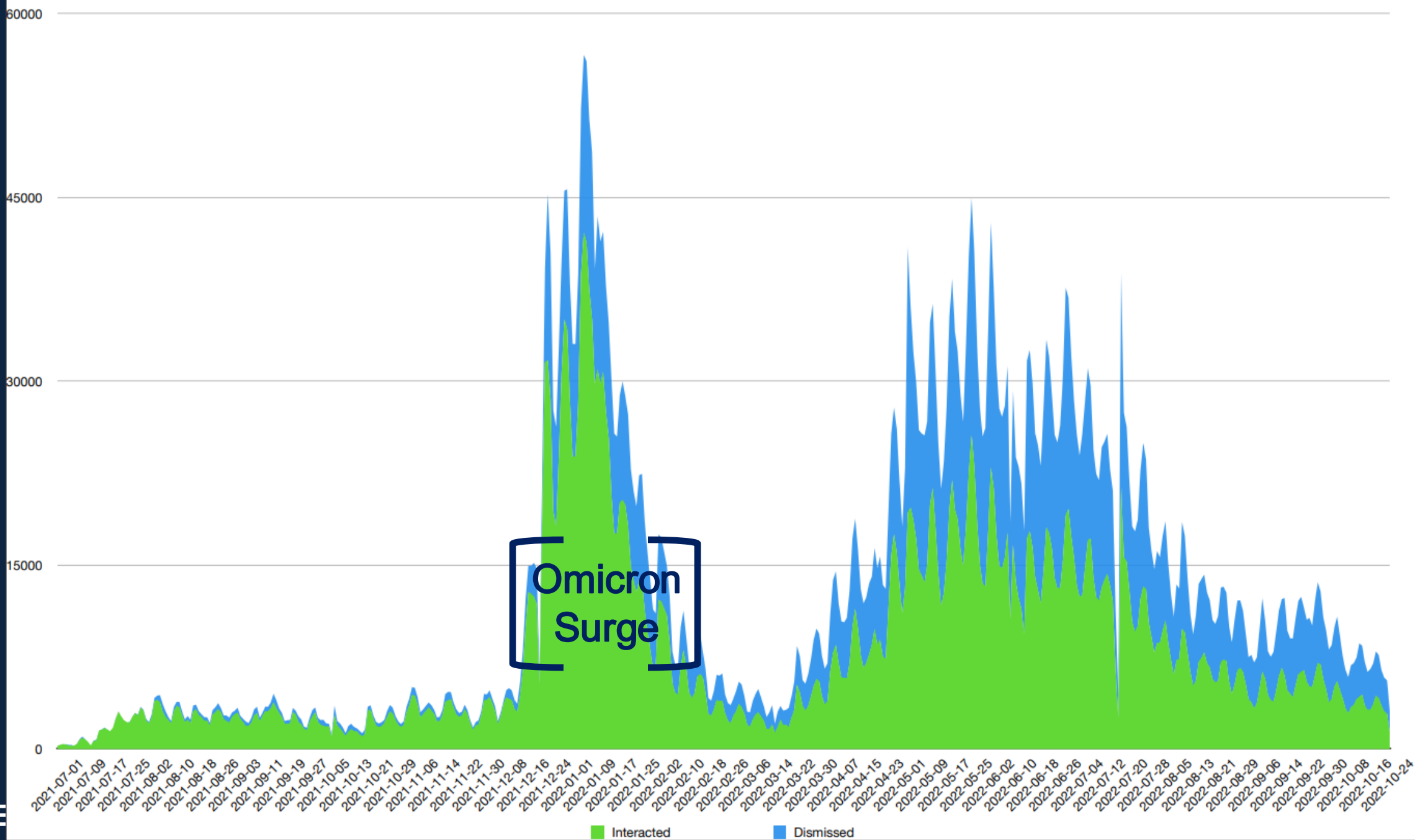
Analytics

- Web portal that provides analyses and visualizations of ENPA data
- REST APIs to provide access to data programmatically
- Custom Jupyter notebooks guiding PHAs to support customized analytics and visualizations
- State focused working sessions with PHAs
- Visualizations to communicate ENPA metric flow
- CTEST to model ENX configuration changes

Total Number of Notifications (US)



Total Interactions (US)



Omicron Surge

Preliminary Results from EN Evaluation

UW Preprint

Nationwide

Enabling self-report helps to reduce PHA burden

WA Notify







Over 4M* activations

*as of 5/11/2023

CA Notify

Review of configuration settings in progress

Early Epidemiological Evidence of Public Health Value of WA Notify, a Smartphone-based Exposure Notification Tool: Modeling COVID-19 Cases Averted in Washington State

 Courtney Segal,  Zhehao Zhang,  Bryant T Karras,  Debra Revere,  Gregory Zane,  Janet G Baseman

doi: <https://doi.org/10.1101/2021.06.04.21257951>

6240 cases averted statewide in first four months of ENX

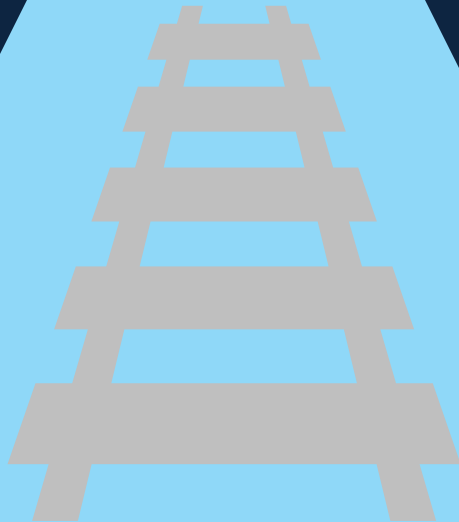
Based on estimated COVID-19 case fatality of 1.4%, WA Notify saved 30-120 lives during study period

ENPA dashboard data used in analysis

[Paper Link](#)

Future Opportunities

How can this technology be leveraged?



We see great potential in the technology and possible usage for future infectious diseases.

We are moving towards sunset, but I am very optimistic regarding the future for ENs for Public Health. We will have a robust public health system to possibly roll out during a new time of need.

Comments from PHAs

Serve the “little guys” who lack staffing capacity and capability to conduct analyses of these complex data so we can similarly benefit as the advanced jurisdictions to use data to modify settings and encourage full public participation.

ENPA Partners

MITRE

- Develops and manages the ENPA Portal

Google

- Operate ingestion servers, provide reference server code and integration

Apple

- Operate ingestion servers, provide reference server code and integration

Internet Security Research Group (ISRG)

- Owns and operates the Facilitating Server

National Cancer Institute (NCI)

- Owns and operates the PHA Server

Linux Foundation for Public Health (LFPH)

- Funds the facilitating server

Thank you!

enpa@mitre.org

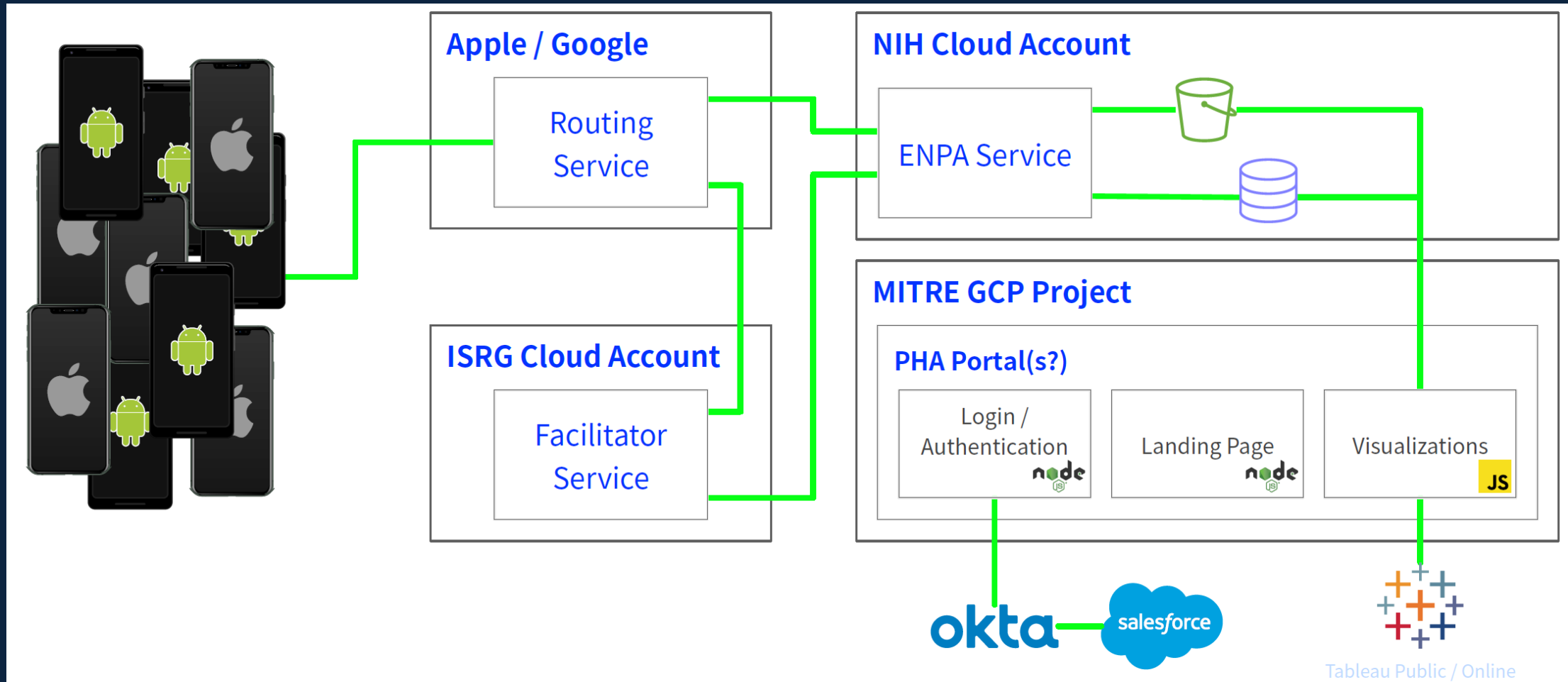
ahankus@mitre.org

MITRE |

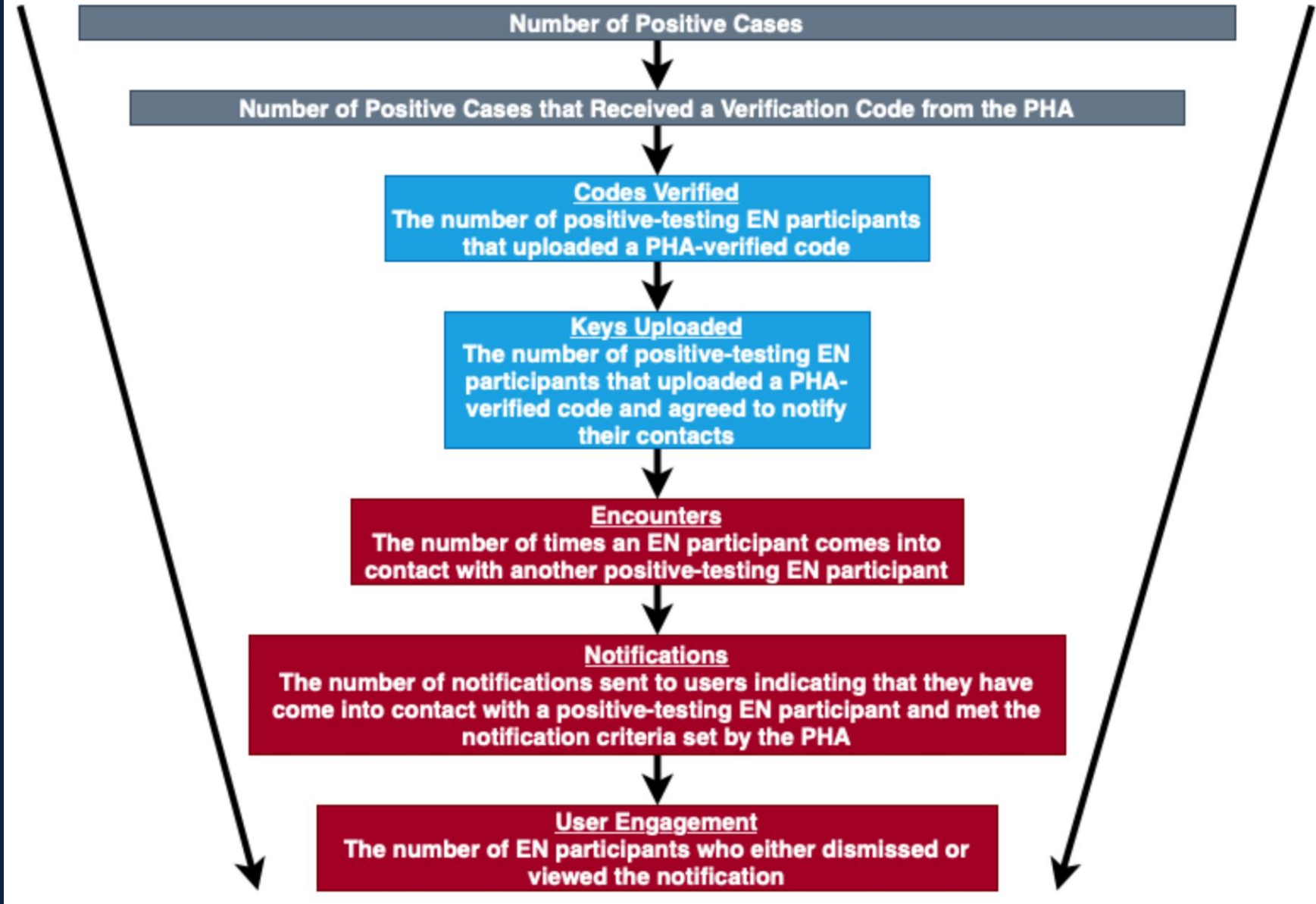
**SOLVING PROBLEMS
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MITRE on-boarded States & Provided Web Portal for PHAs to Visualize & Download Metric data

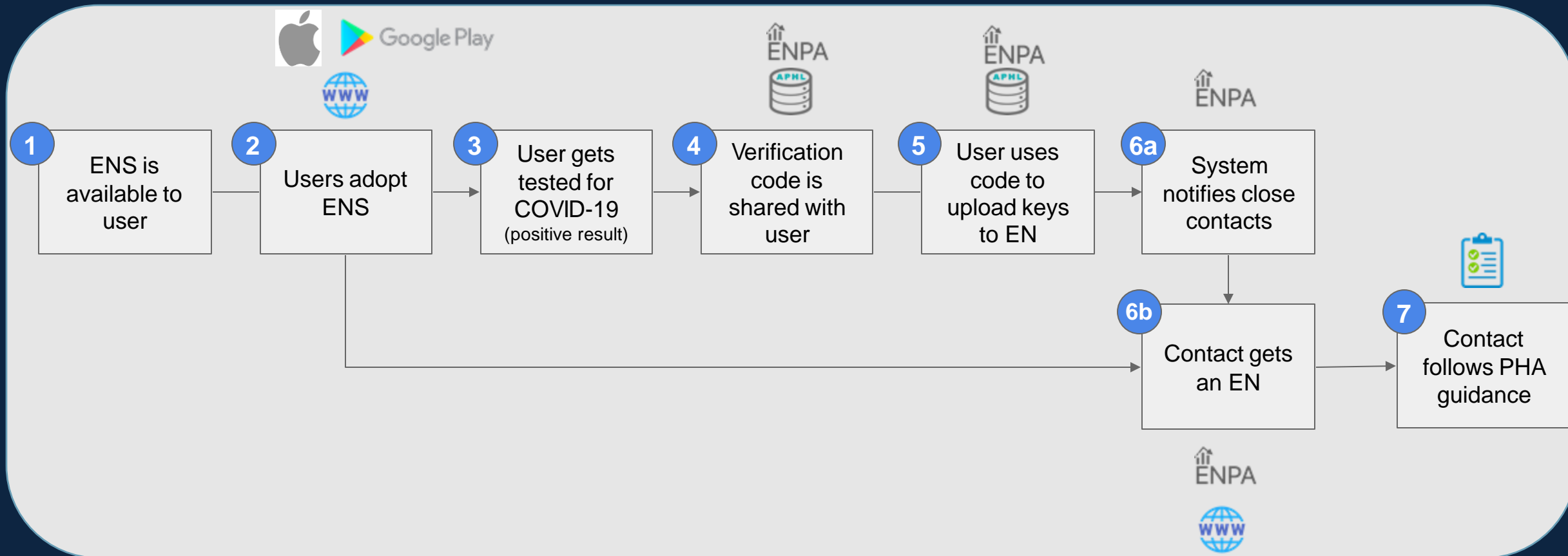
- Privacy-Preserving System to collect aggregated data from GAEN users



Exposure Notification Flow



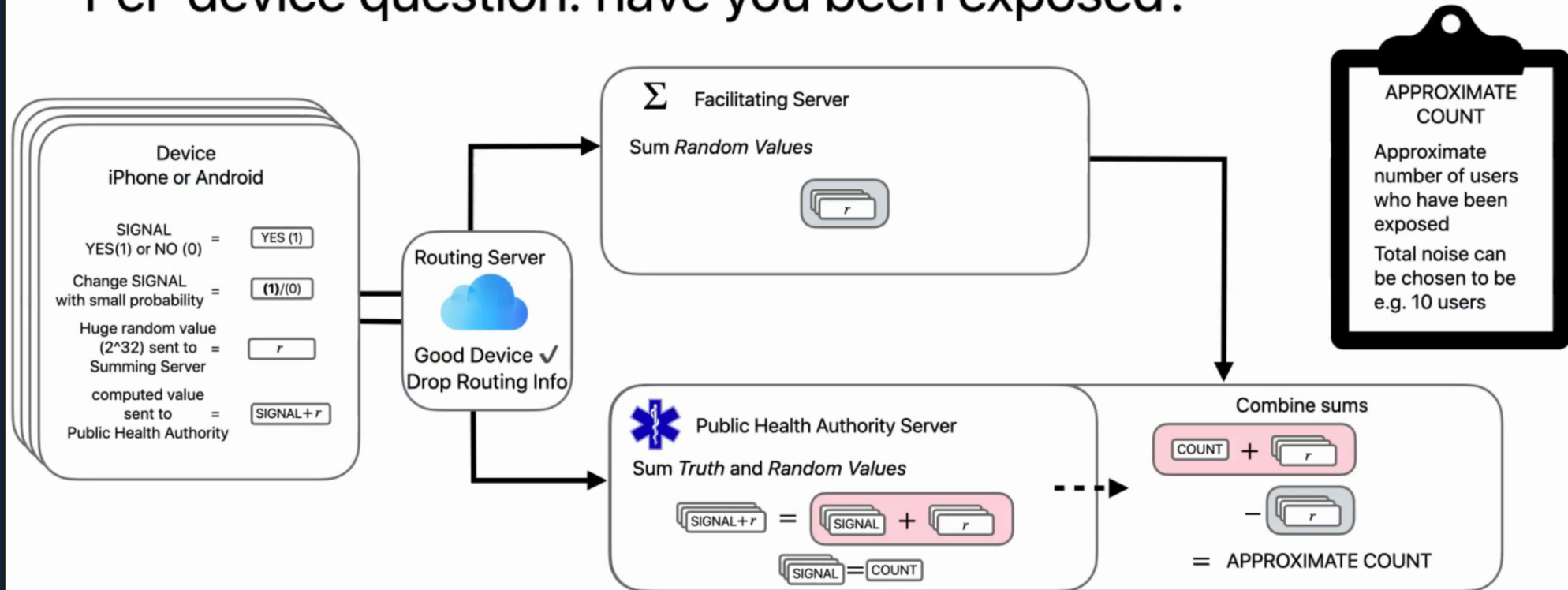
The EN User Journey



Viewing efficacy as a multi-step flow (i.e., not just risk score tuning or adoption) will help identify critical issues/gaps in EN's overall ability to help stop the spread

Prio Example

Prio aggregation: simple count example
How many users have had an Exposure Notification?
Per-device question: have you been exposed?

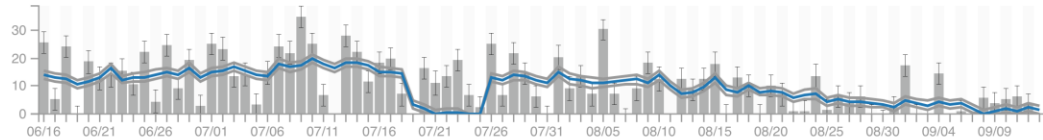


Secure Multi-Party Compute System
with Differential Privacy using
<https://crypto.stanford.edu/prio/>

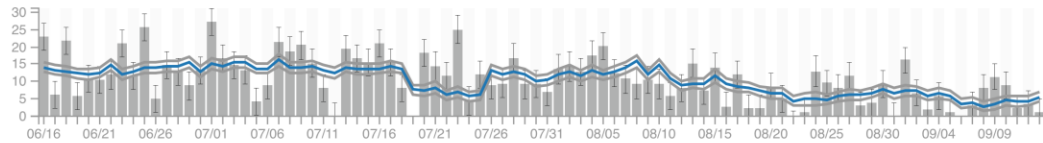
Apple Confidential—Internal Use Only

Notifications and User Engagement

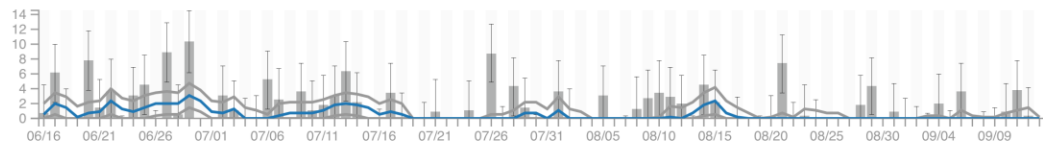
Notifications



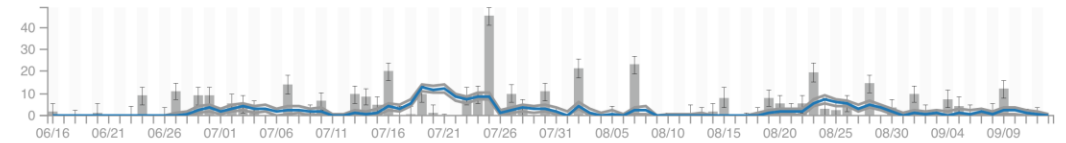
Notifications Type 1



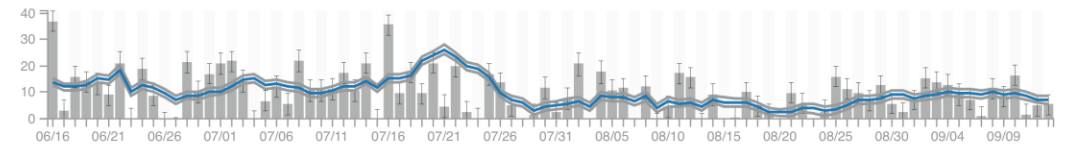
Notifications Type 2



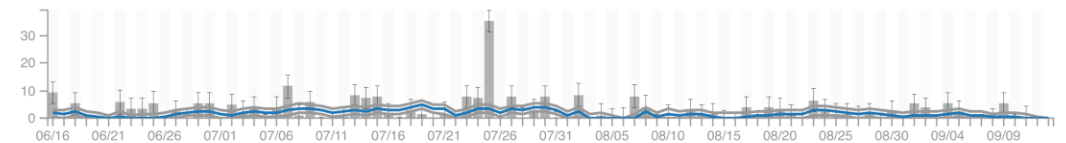
Dismissed Notifications



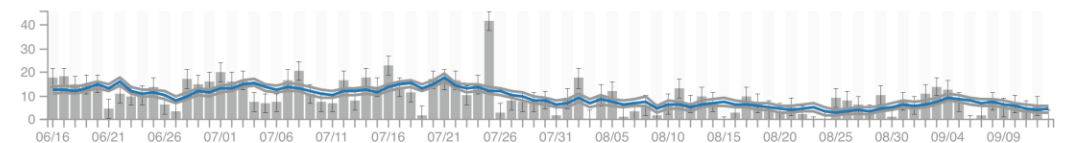
Viewed Notifications



Dismissed Notifications Type 1



Viewed Notifications Type 1

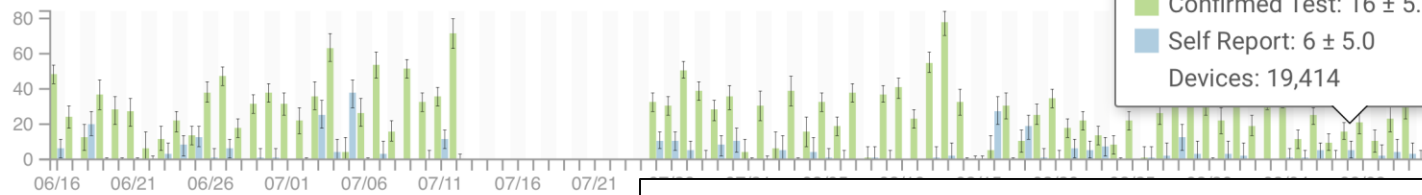


Codes Verified & Keys Uploaded: Reporting and Testing

Codes Verified with Report Type (6/16/2022 - 9/13/2022)

↓ [JSON](#) [CSV](#)

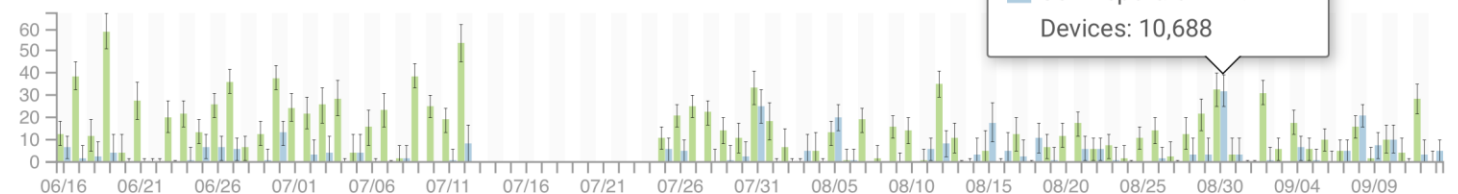
Total Codes Verified with Report Type



Keys Uploaded with Report Type (6/16/2022 - 9/13/2022)

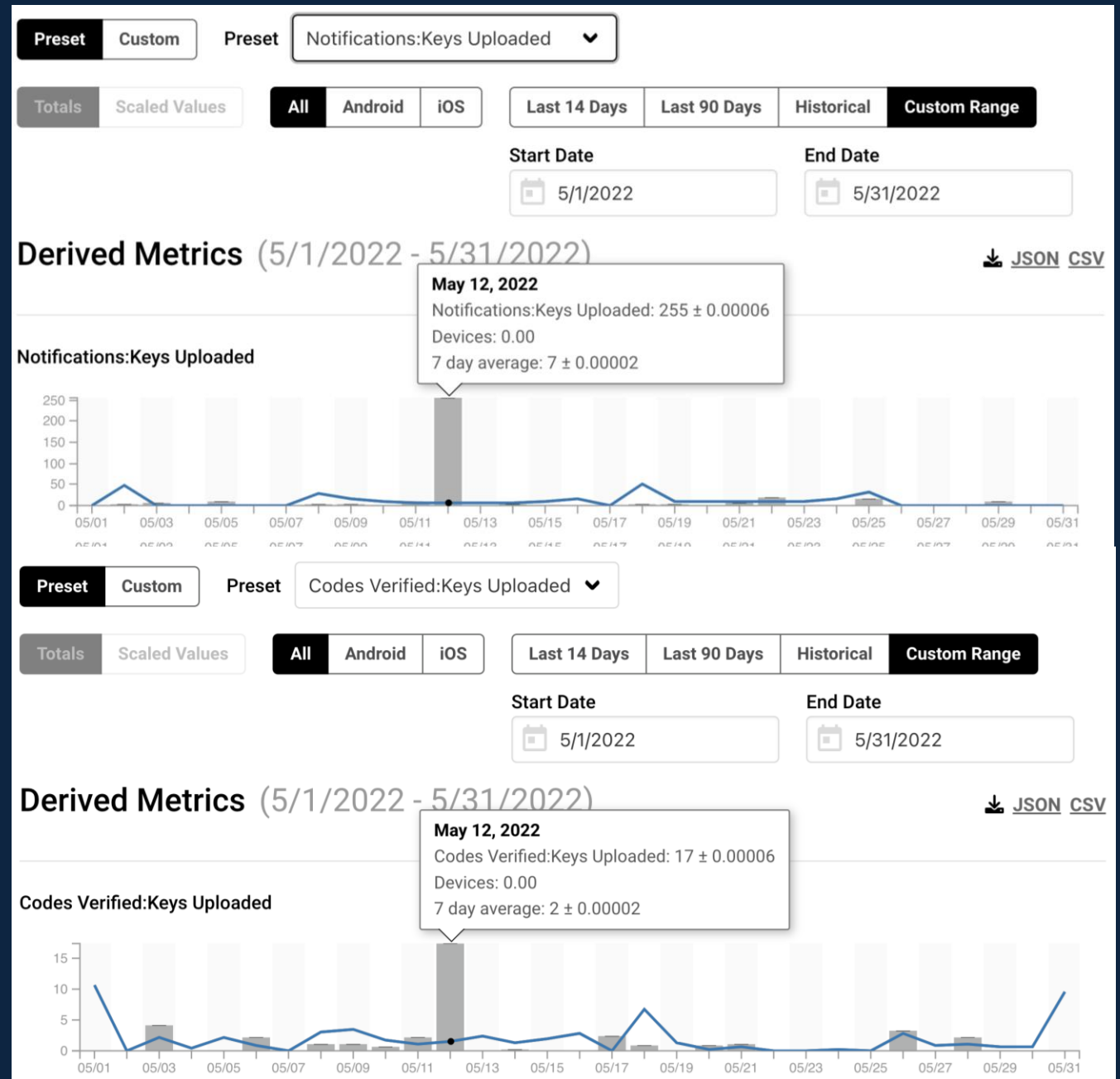
↓ [JSON](#) [CSV](#)

Total Keys Uploaded with Report Type



Derived Metrics

- View the ratio of one Exposure Notification metric to another
- Available calculations:
 - Codes Verified | Keys Uploaded
 - Notifications | Keys Uploaded



Date Exposure

- Amount of time between a user being exposed to COVID and when a notification is displayed for that exposure

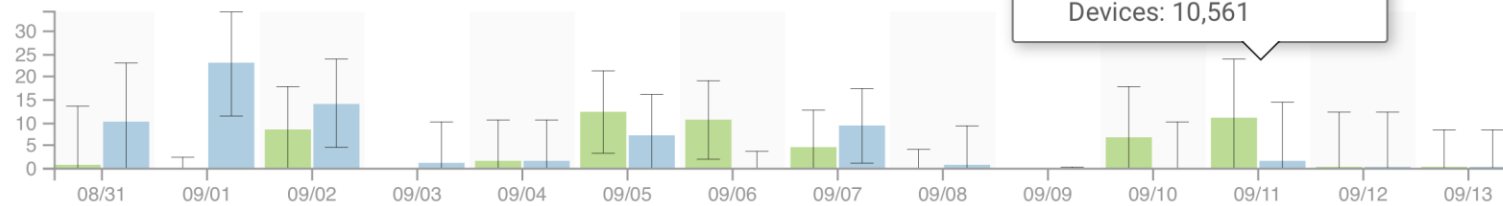


Secondary attack rate

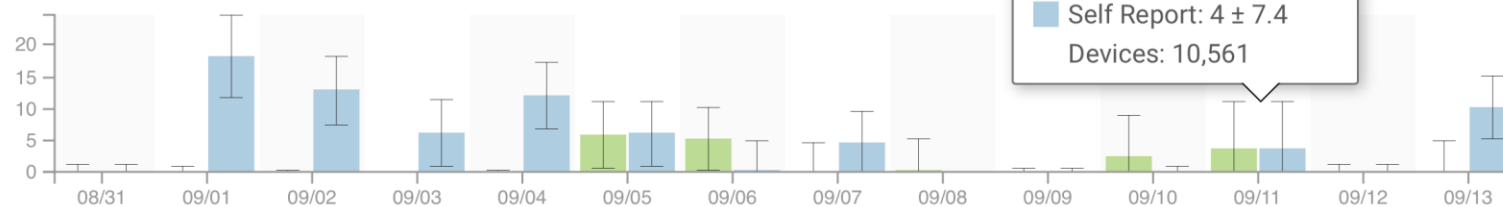
Secondary Attack Rate (8/31/2022 - 9/13/2022)

↓ [JSON](#) [CSV](#)

Total Secondary Attack



Secondary Attack with Type 1 Notification



CTEST

How do I use it?

1. Specify desired configuration settings
2. Select simulation parameters
3. Metrics and visualizations are displayed to help evaluate EN efficacy

1

Exposure Notification Config

Preset:

Notification Types

- Type 1**
Risk Score Threshold: seconds (15.00 minutes)
- Type 2**
Risk Score Threshold: seconds (0.00 minutes)
- Type 3**
Risk Score Threshold: seconds (0.00 minutes)
- Type 4**
Risk Score Threshold: seconds (0.00 minutes)

2

Simulation Parameters

Data Source for Exposure Risk Factors

Whether to randomly select the distance and duration of simulated encounters based on real data from this organization or uniformly across attenuation and duration bins

Real Data Uniform

Systemic Delays

Testing: days

Results: days

Reporting: days

Transmissibility

How easily the COVID-19 variant that the infected person has can be transmitted relative to the original

3

Estimated Real-world Impact

- 19,514** Total number of exposures recorded between EN app users in the last 14 days
- 13** Estimated number of such exposures that result in a new infection
- 6** Estimated number of such new infections for which a notification is sent
- 4** Estimated number of such notifications sent before symptom onset in the secondary case
- 121** Estimated number of notifications sent to app users who are not infected

Estimated Efficacy Metrics

Category	Recall	Precision	Percent
Notification Type 1	48.53%	5.33%	0.62%
All Notifications	48.53%	5.33%	0.62%

Risk Score vs Infection Likelihood for Simulated Data

Access Management

- Sharing data with other organizations
- User roles

Access Management

Users **Add User**

Name	Role	E-mail
Shawn	ADMIN	
Ernest	ADMIN	
Ari	ADMIN	
Chris	ADMIN	
Pietari	ADMIN	
Austin	USER	
Luke	USER	
Dev PHA	ADMIN	
Dev PHA	USER	
Dev PHA	OWNER	
MITRE InfoSec	ADMIN	

Organizations **Manage**

Name
Alabama PHA
Alaska PHA
MITRE
Ernieville University

Manage Organizations

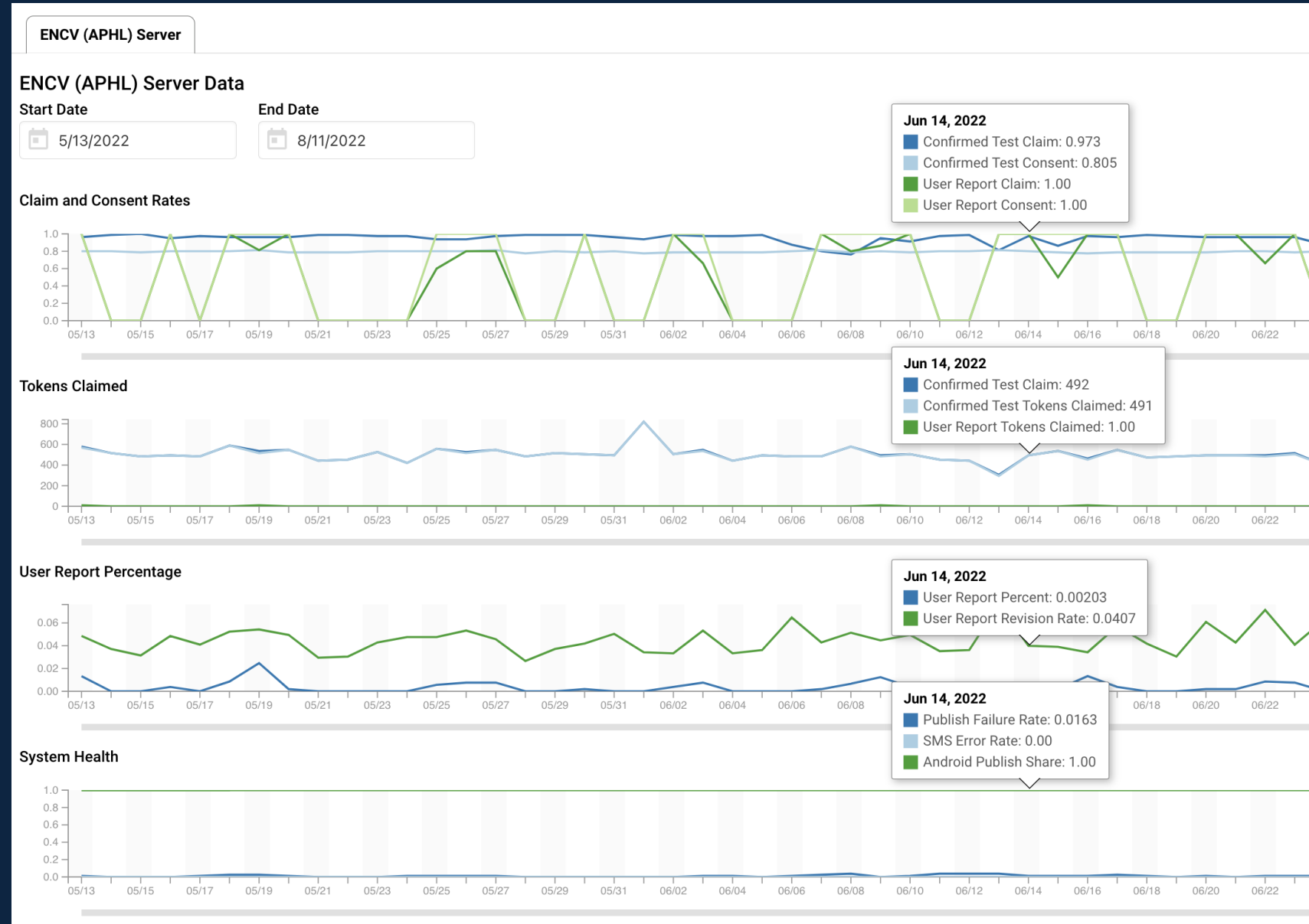
	Name
<input checked="" type="checkbox"/>	Alabama PHA
<input checked="" type="checkbox"/>	Alaska PHA
<input type="checkbox"/>	Georgia
<input type="checkbox"/>	Connecticut
<input type="checkbox"/>	Evil MITRE InfoSec
<input checked="" type="checkbox"/>	MITRE
<input checked="" type="checkbox"/>	Ernieville University
<input checked="" type="checkbox"/>	University of Shawn

After receiving consent from The MITRE Corporation ("MITRE") due to share their data with a third party entity ("Third Party") upon their understanding and agree that all members of that Third Party will be responsible for the creation or enforcement of any Data Usage Agreement (2) is providing this discretionary option "AS IS" and without any warranty, loss, liability, and/or damages of any kind resulting from your decision.

Agree & Update **Cancel**

Integrations

- Claim and Consent Rates
- Tokens Claimed
- User Report Percentage
- System Health
- ENPA Opt-In
- Estimated Users



ENCV Data Integration

Once you have the ENCV/APHL API key ready, the basic flow is this:

- PHA Admin navigates to “Integrations” tab
- PHA enters the ENCV/APHL API key into the field and clicks “Add Integration”
- Upon successful integration, you will be presented with a page showing the details of the API key
- Page includes options to update the API key or delete the integration

The ENCV/APHL API key available from ENCV website

1

COVID-19 ENPA Home { Organizations } About API Docs

Pennsylvania

- Home
- Analysis
- Access Management
- Efficacy
- Integrations**

Name	Pennsylvania
Description	Pennsylvania
Organization Type	Subdivision PHA
Country	United States of America (US)
Subdivision	Pennsylvania (US-PA)
Onboard Status	COMPLETE

This PHA has been validated and is ready to start receiving contact-tracing data from the Exposure Notification System (ENS). Click or tap the **Manage Access** below button to add users and manage access to the PHA's data or **View Analysis** view analysis for this PHA when data becomes available.

[Manage Access](#) [View Analysis](#)

2

COVID-19 ENPA Home { Organizations } About API Docs

Pennsylvania

- Home
- Analysis
- Access Management
- Efficacy
- Integrations**

ENCV (APHL) Server

Exposure Notifications Verification data

API Key*
The API Key used to connect to ENCV (APHL) Server

abcdefg-12345-hijklmnop-67890

Add Integration

ENCV Data Integration

Once the integration is complete, ENCV data will begin flowing into the ENPA system

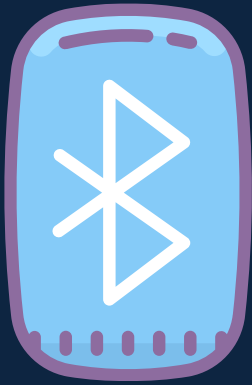
3

The screenshot displays the 'COVID-19 ENPA' web application interface. The top navigation bar includes 'Home', 'Organizations', 'About', and 'API Docs'. The main content area is titled 'Pennsylvania' and features a sidebar with navigation options: Home, Analysis, Access Management, Efficacy, and Integrations (highlighted). The 'Integrations' section shows a tab for 'ENC (APHL) Server'. Below this tab, the 'Exposure Notifications Verification data' is displayed with the following details:

- Name:** ENC (APHL) Server
- API Key:** *****cmqw
- Created by:** Chris Berger
- Created:** 2022-04-01T15:20:33.000Z
- Last Updated:** 2022-04-01T15:20:33.000Z
- Latest Status:** unused

Buttons for 'Update API Key' and 'Delete Integration' are visible at the bottom of the integration details.

Exposure Notification Service



EN Token: pjwc93gfmm



Rotating Token (random, 10-20 min)

EN Token History:

Tokens that the device has generated

pjwc93gfmm	14u06pbx1o
zaz2xuouw8	qm6w6kjwy7
5vc48m0mhz	us02sy5iu

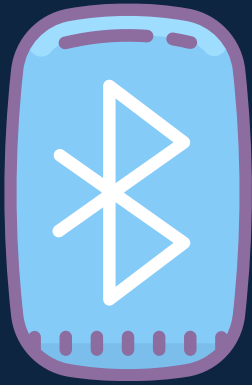
Contact Token History:

Tokens of devices that have made “contact”

ngi8lrhdiy	ridwhki1yt
qsjen0vhf4	



Bluetooth LE for measuring contact



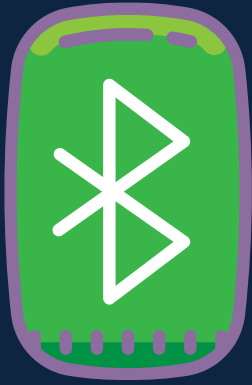
EN Token: pjwc93gfmm

EN Token History:

pjwc93gfmm	14u06pbx1o
zaz2xuouw8	qm6w6kjwy7
5vc48m0mhz	us02syt5iu

Contact Token History:

ngi8lrhdiy	ridwbki1yt
qsjen0vhf4	jwsb1n5xy2



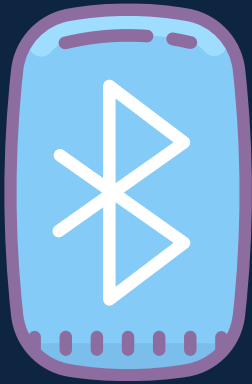
EN Token: jwsb1n5xy2

EN Token History:

jwsb1n5xy2	geu2rbye60
93nwfs3iek	lwkf63o460
agu3tnrgoh	zbvdx9u9m5

Contact Token History:

ngi8lrhdiy	ridwbki1yt
qsjen0vhf4	pjwc93gfmm



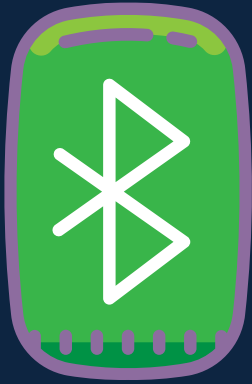
EN Token: pjwc93gfmm

EN Token History:

pjwc93gfmm	14u06pbx1o
zaz2xuouw8	qm6w6kjwy7
5vc48m0mhz	us02syt5iu

Contact Token History:

ngi8lrhdiy	ridwhki1yt
qsjen0vhf4	jwsb1n5xy2



EN Token: jwsb1n5xy2

EN Token History:

jwsb1n5xy2	geu2rbye60
93nwfs3iek	lwkf63o460
agu3tnrgoh	zbvdx9u9m5

Contact Token History:

ngi8lrhdiy	ridwhki1yt
qsjen0vhf4	pjwc93gfmm



Exposure Notification Service

Tested Positive Tokens

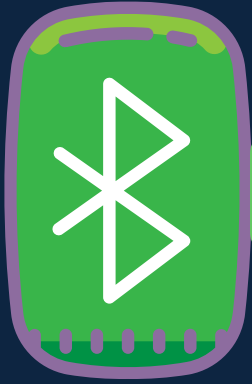
r1qqqq2ops	59t8eq11z6	uplk9ng4cj
3e0t33cj2p	24zokkfaw0	laqu0i7q9c
0x3ykqvs1b	pqnqeslkz6	vmdepfrhn7
p9ghagfq0g	rmd8m0ovh8	75pt2dqofi
iof18jqwu5	lwbqb2044z	rlx9idgtuz
i9fg4wceer	g2jm7hp9wv	c8pplhf19l



<https://github.com/google/exposure-notifications-server>



Sorry, you've tested positive for COVID
PHA Test Result ID: jqfc-0z1n-yjnz-th4b



EN Token: jwsbln5xy2

EN Token History:

jwsbln5xy2	geu2rbye60
93nwfs3iek	lwkf63o460
agu3tnrgoh	zbvdx9u9m5

Contact Token History:

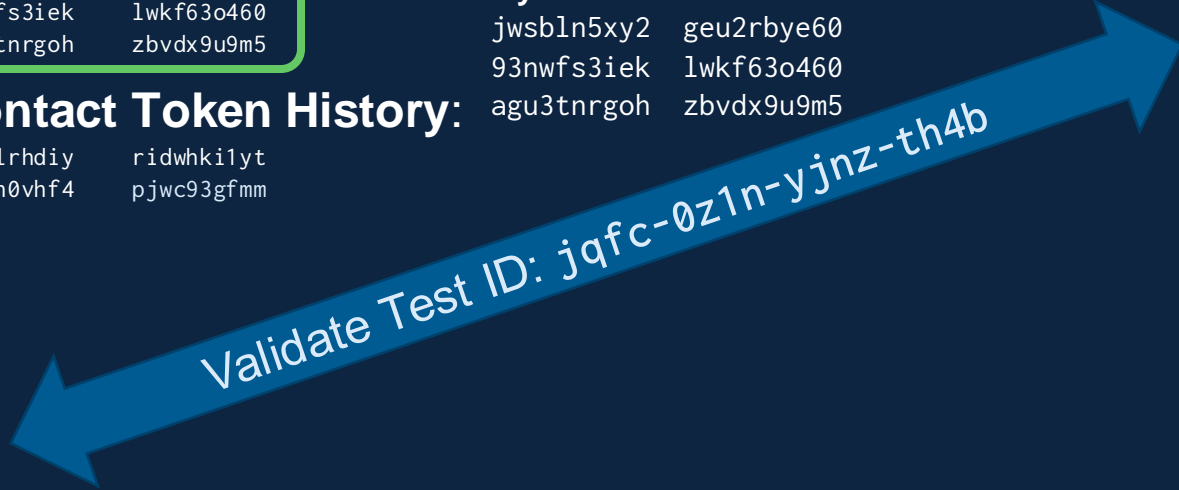
ngi8lrhdiy	ridwhki1yt
qsjen0vhf4	pjwc93gfmm

Tested positive

Test ID: jqfc-0z1n-yjnz-th4b

My Tokens:

jwsbln5xy2	geu2rbye60
93nwfs3iek	lwkf63o460
agu3tnrgoh	zbvdx9u9m5



Exposure Notification Service

Tested Positive Tokens

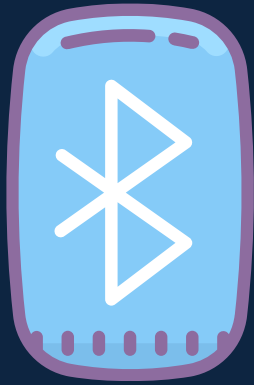
r1qqqq2ops	59t8eq1z6	uplk9ng4cj	jwsbln5xy2
3e0t33cj2p	24zokkfaw0	laqu0i7q9c	93nwfs3iek
0x3ykqvs1b	pqnqeslkz6	vmdepfrhn7	agu3tnrgoh
p9ghagfq0g	rmd8m0ovh8	75pt2dqofi	geu2rbye60
iof18jqwu5	lwbqb2044z	rlx9idgtuz	lwkf63o460
i9fg4wceer	g2jm7hp9ww	c8pplhf19l	zbvdx9u9m5



<https://github.com/google/exposure-notifications-server>



Public Health Authority
MITRE



EN Token: pjwc93gfmm

EN Token History:

pjwc93gfmm	14u06pbxlo
zaz2xuouw8	qm6w6kjwy7
5vc48m0mhz	us02syt5iu

Contact Token History:

ngi8lrhdiy	ridwhki1yt
qsjen0vhf4	<u>jwsb1n5xy2</u>

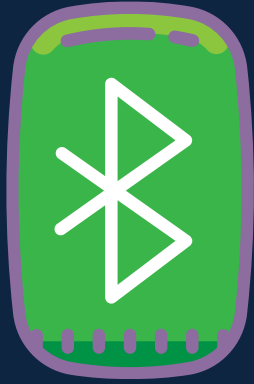
Alert!

You have been in contact with someone who
has tested positive for COVID

[Click here for what to do next](#)

T
r1
3e
0x
ps
ic
is

y2
ek
oh
60
60
m5



EN Token: jwsb1n5xy2

EN Token History:

jwsb1n5xy2	geu2rbye60
93nwfs3iek	lwkf63o460
agu3tnrgoh	zbvdx9u9m5

Contact Token History:

ngi8lrhdiy	ridwhki1yt
qsjen0vhf4	pjwc93gfmm

Tested positive tokens

Exposure Notification Service

Tested Positive Tokens

r1qqqq2ops	59t8eq11z6	uplk9ng4cj	jwsb1n5xy2
3e0t33cj2p	24zokkfaw0	laqu0i7q9c	93nwfs3iek
0x3ykqvs1b	pqnqeslkz6	vmdepfrhn7	agu3tnrgoh
p9ghagfq0g	rmd8m0ovh8	75pt2dqofi	geu2rbye60
iof18jqwu5	lwbqb2044z	rlx9idgtuz	lwkf63o460
i9fg4wceer	g2jm7hp9wv	c8pp1hf191	zbvdx9u9m5



<https://github.com/google/exposure-notifications-server>





ENS Pros and Cons

Pros

- User privacy
- No location tracking
- OS level support
- API access for app development

Cons

- Too much privacy (PHA)
- No data collection
- No analytics
- Cannot support decision making
- Writing apps can be hard

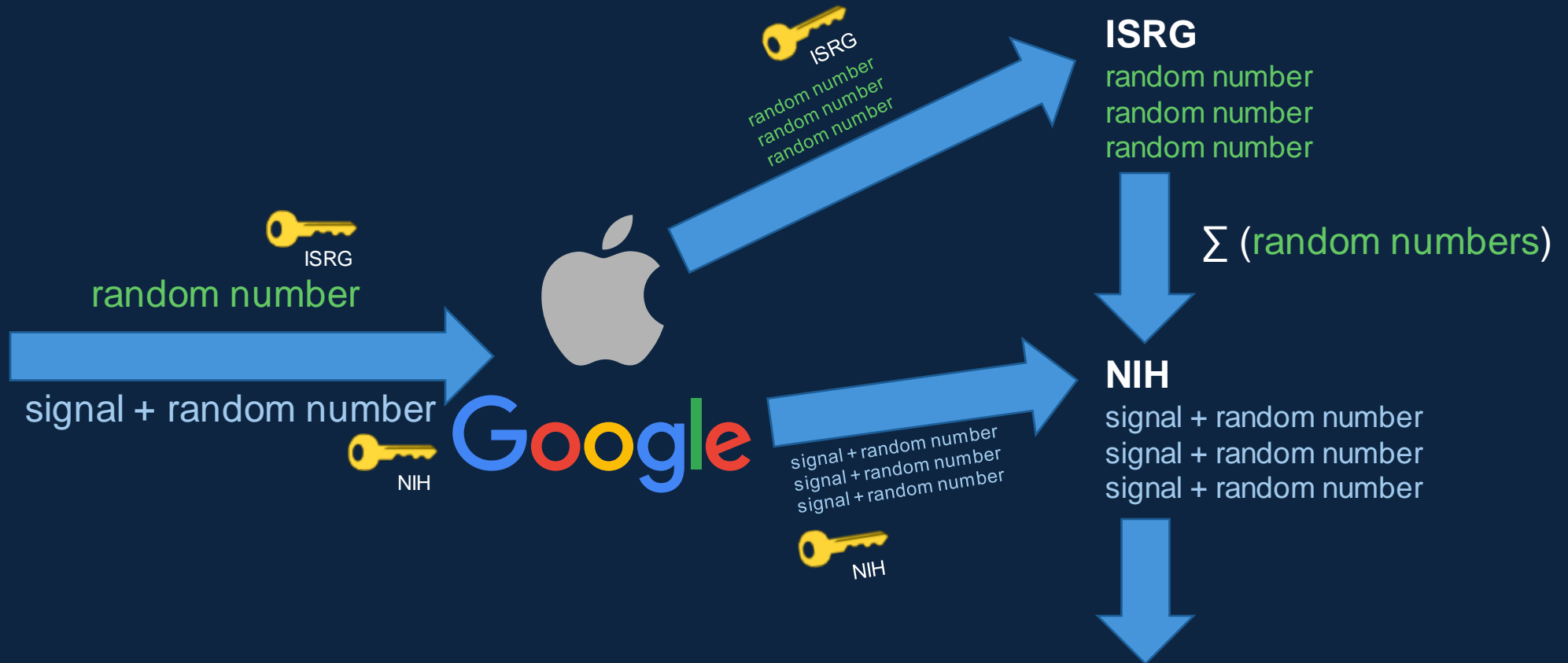
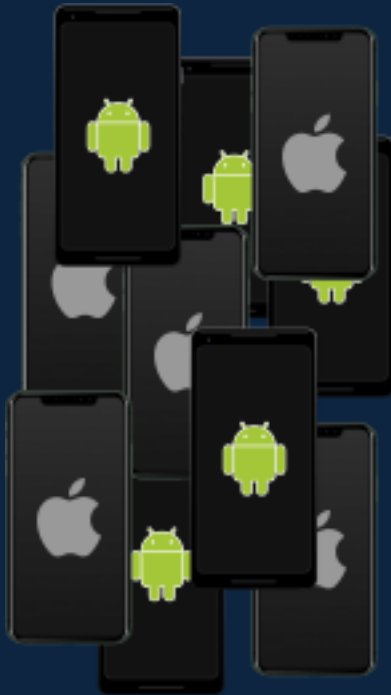
Exposure Notification Private Analytics

Exposure Notification Private Analytics (ENPA) Overview

- Mobile devices send analytic information using secure multi-party compute (SMPC) algorithm Prio ([Stanford U., paper](#))
- Roles
 - **Mobile device:** (End user) sends signals
 - **Ingestion Server:** (Apple / Google) forward data from mobile devices to facilitators and PHA server
 - **Facilitator:** (ISRG) receives and processes Prio shares. Never sees clear-text data
 - **PHA Server:** (NIH) receives and processes Prio shares. Aggregates data
 - **PHA Portal:** web site that PHAs will use to access analytics based on ES data

Prio In a Nutshell

$$\text{signal} + \text{random number} - \text{random number} = \text{signal}$$



$$\Sigma(\text{signal} + \text{random numbers}) - \Sigma(\text{random numbers}) = \Sigma(\text{signals})$$

NIH

ISRG

MITRE

Exposure Notification Private Analytics Architecture

