Mobile Phone Apps Become Medical Devices – The Tale of the NHS Covid-19 App

NHS COVID-19 App

Trace

Get alerted if you've been near other app users who have tested positive for coronavirus.

Alert

View area risk level

Lets you know the level of coronavirus risk in your postcode district.

Check-in

Get alerted if you have visited a venue where you may have come into contact with coronavirus.

Symptoms

Check if you have coronavirus symptoms and see if you need to order a free test.

Test

Helps you book a test and get your result quickly.

Isolate

Keep track of your self-isolation countdown and access relevant advice.

Key non-functional needs:

- Speed, Reach & Precision

- Anonymous & Private

- CE Mark from MHRC

- WCAG AA Compliant

- Support 12 Languages

- Continuous Evolution

- Google/Apple ENAPI

- Open-source:
  https://faq.covid19.nhs.uk/article/KA-01157/

Reflection for context-awareness

zühlke
empowering ideas

Traditional distributed systems were based on the premise of *transparency*: distributed components should be unaware of network connectivity, location, operating system etc

This was widely implemented in distributed computing middleware.

In her PhD thesis, Lica Capra was first to argue that context-awareness is important in mobile computing and that these transparencies need to be given up from time to time

She built a first reflective middleware that would enable applications to adapt to context (which could be defined in terms of signal strength, location, reachability of other services etc).

The Apple/Google Exposure Notification API is an example of such reflective middleware

See L. Capra, W. Emmerich and C. Mascolo (2003). *CARISMA: Context-Aware Reflective mIddleware System for Mobile Applications*. IEEE Transactions on Software Engineering, 29(10):929-945
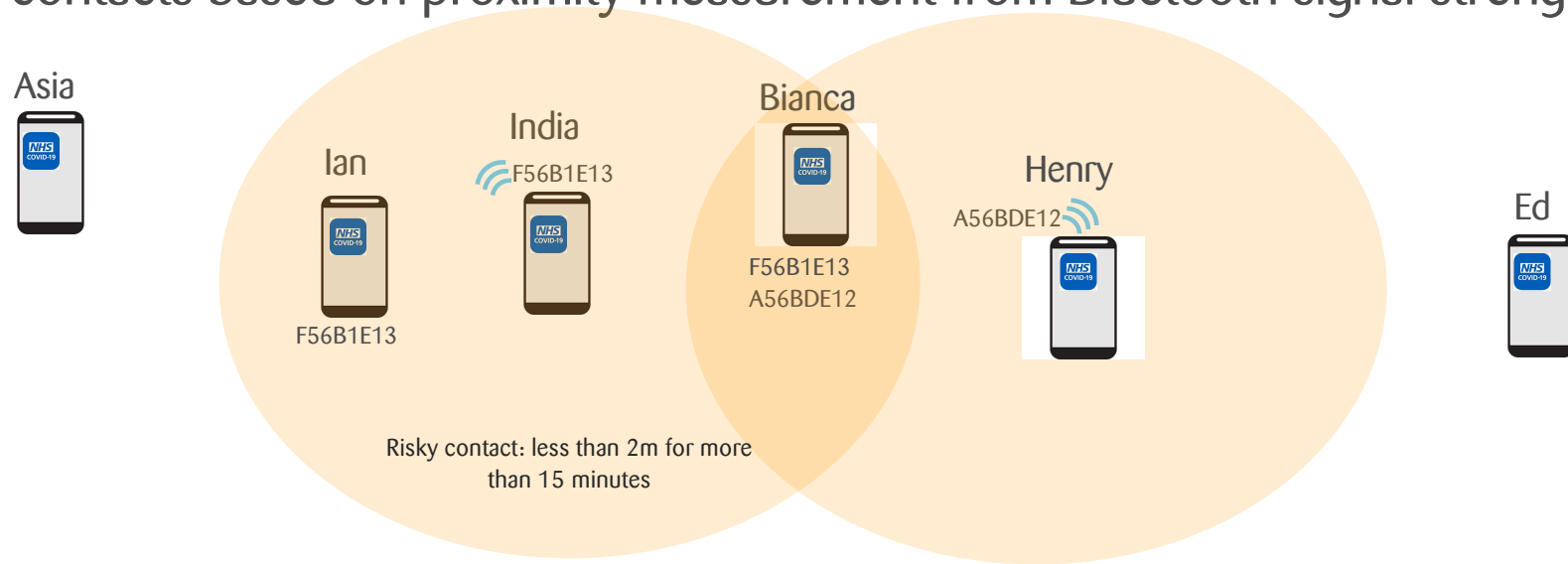
FluPhone

Using Bluetooth signal strength for contact tracing
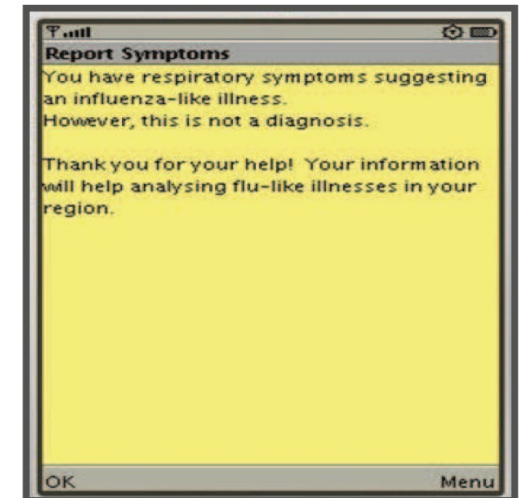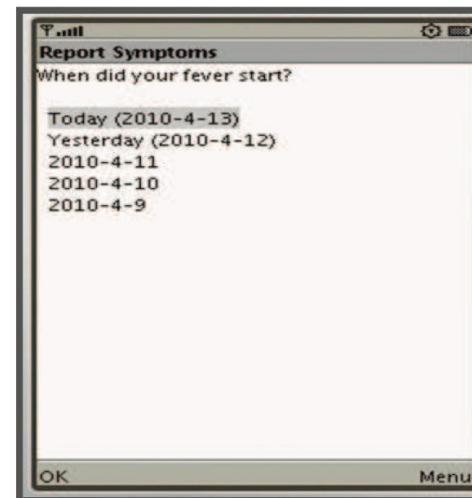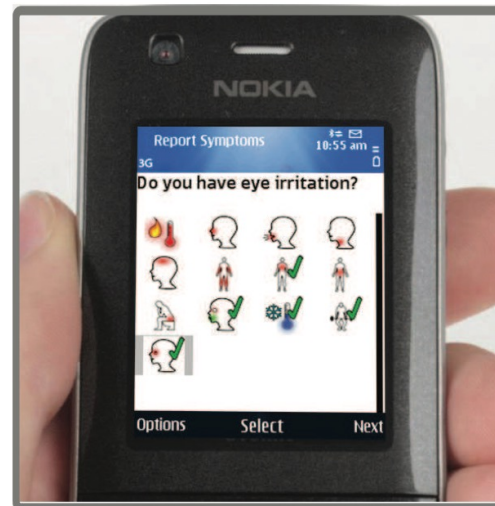
See E. Yoneki, and J. Crowcroft (2011): "EpiMap: Towards Quantifying Contact Networks and Modelling the Spread of Infections Developing Countries ". International Conference on Wireless Technologies for Humanitarian Relief (ACWR), December,
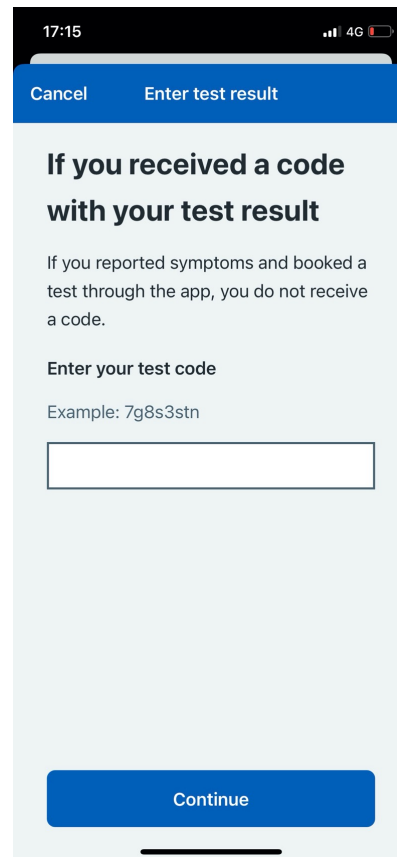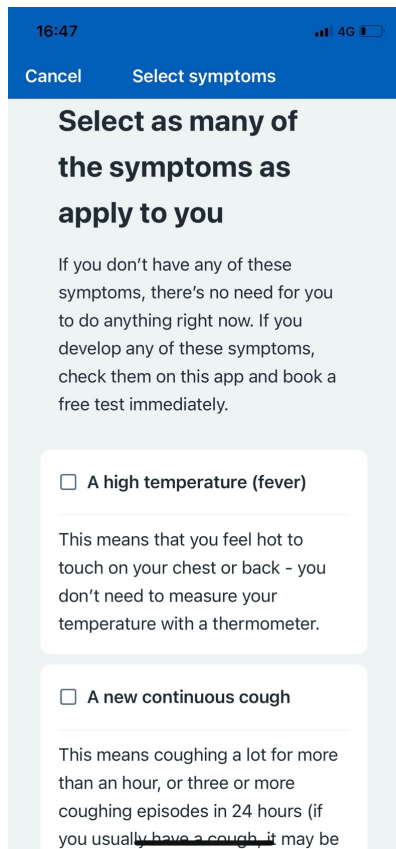
Digital contact tracing

(1) Record contacts based on proximity measurement from Bluetooth signal strength

Asia

Ian

India
F56B1E13

Bianca

Henry
A56BDE12

Ed

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Risky contact: less than 2m for more
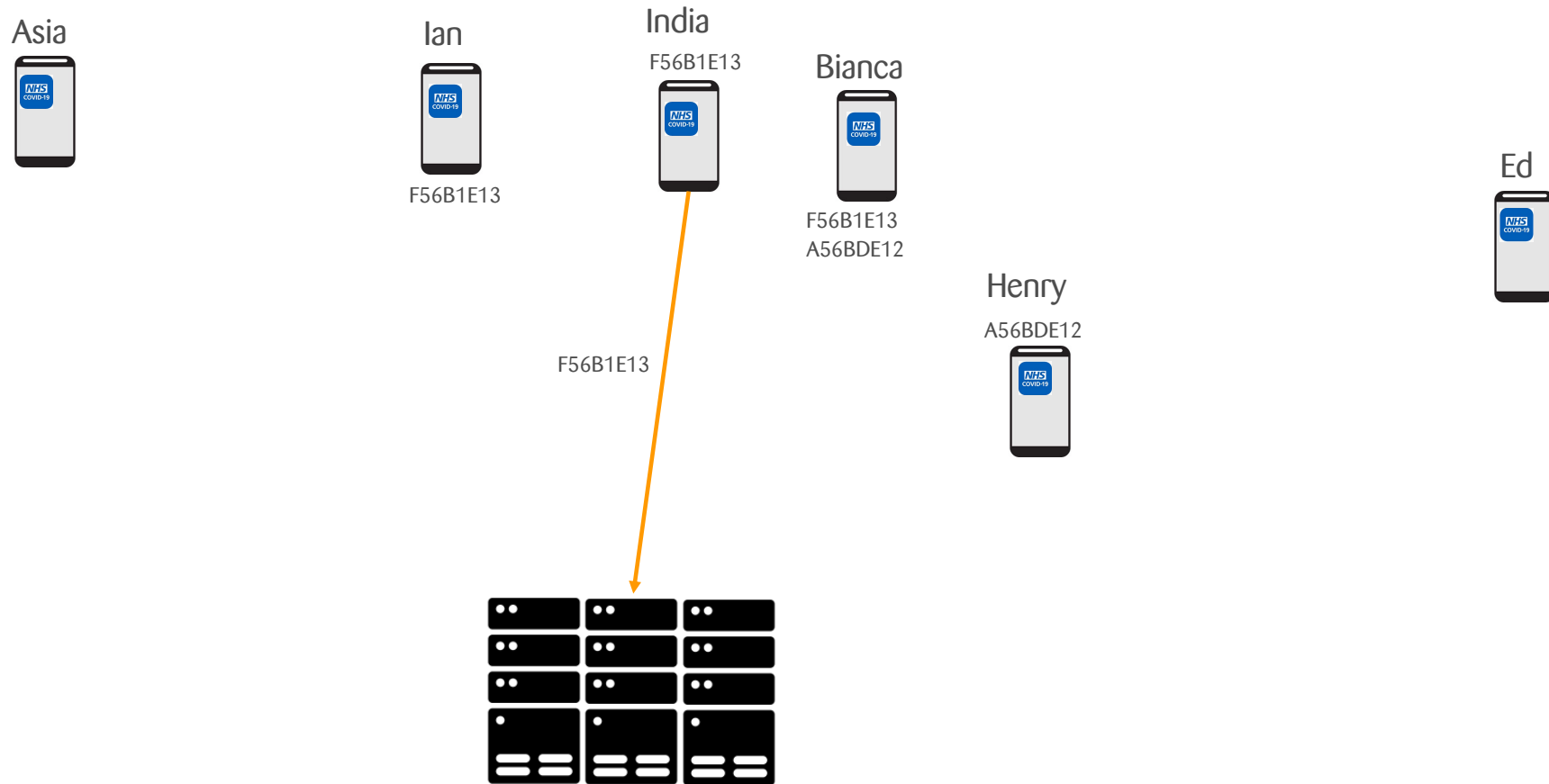than 15 minutes

Symptom Checks and Tests

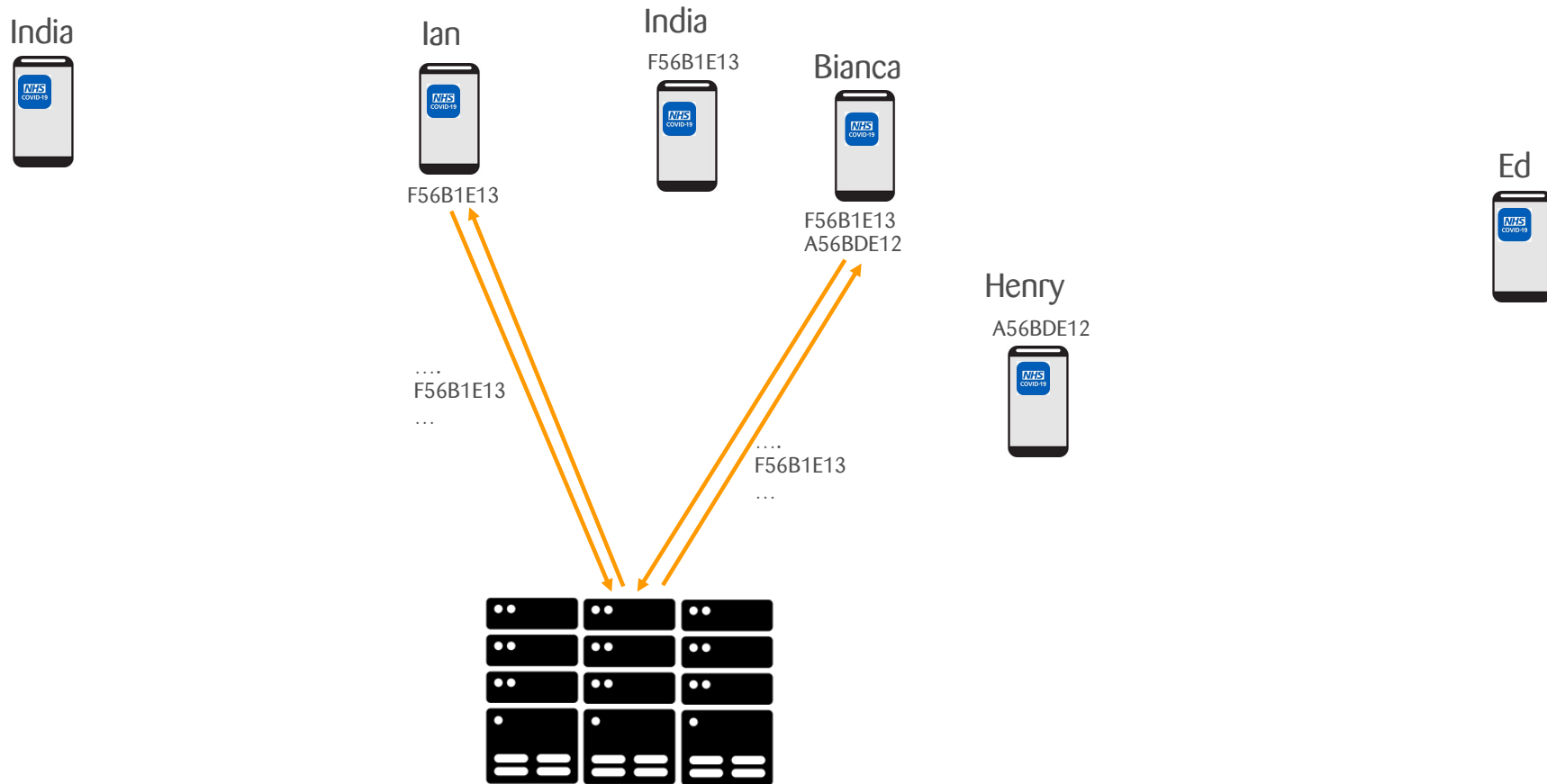## The reason why the app is a Class-1 Medical Device

Digital contact tracing (continued)

(2) Processing a positive test result

Digital contact tracing

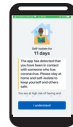## (3) Six daily exposure checks against files with risky contacts

India

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Digital contact tracing

(4) Show exposure notification and switch to self-isolation mode

India

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India
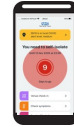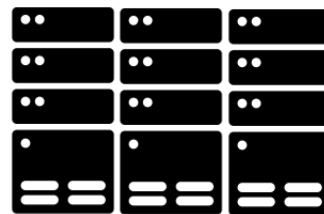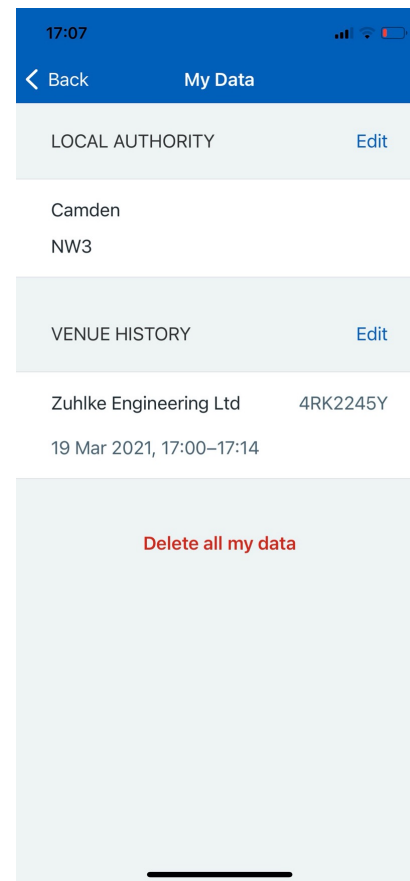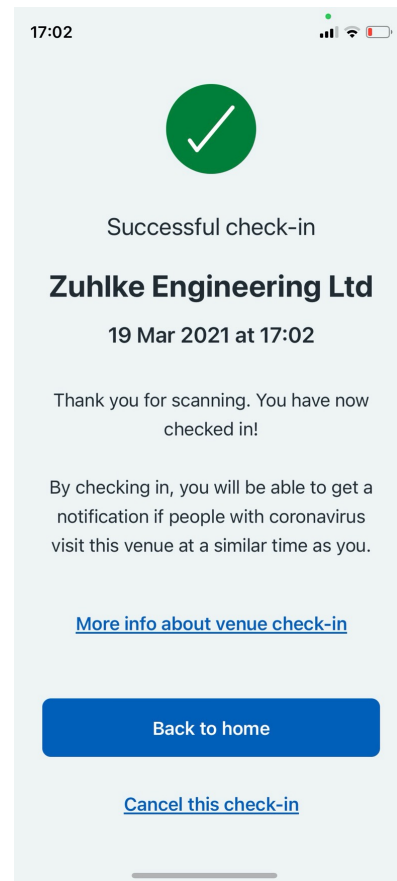F56B1E13

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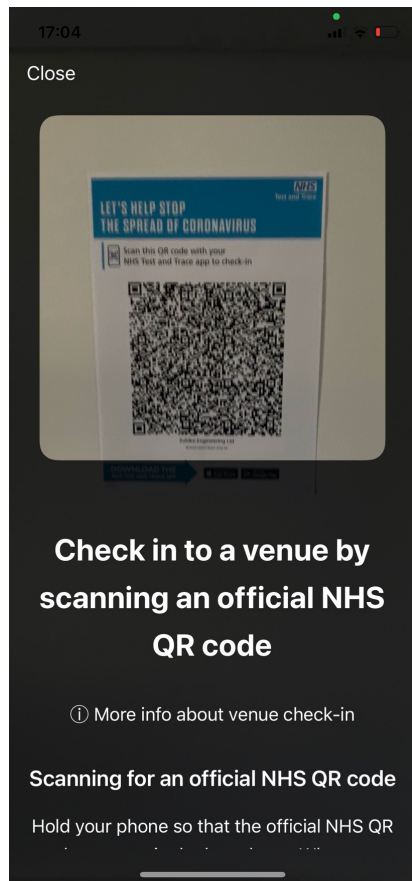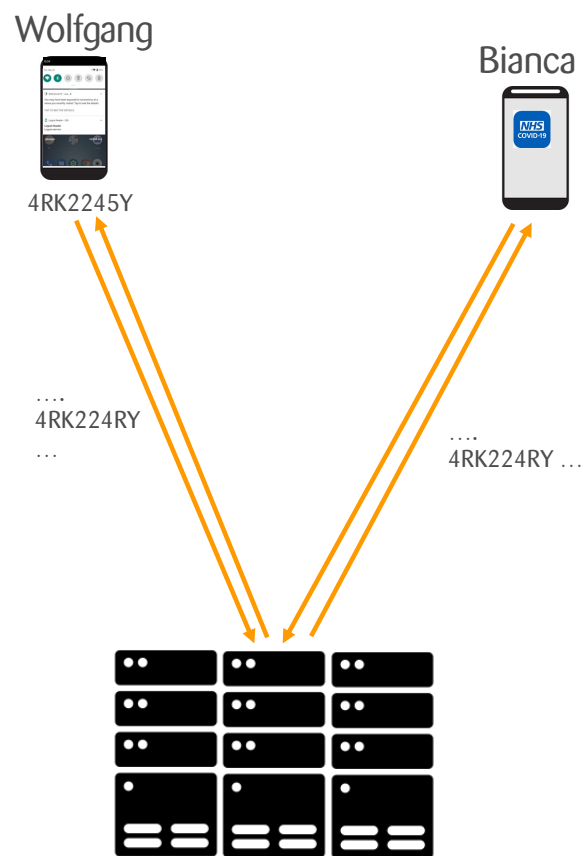A56BDE12

Ed

Venue Check in

Digital contact tracing revisited

(3) Six daily exposure checks against risky venues

Wolfgang

4RK2245Y

Bianca

….
4RK224RY
…

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4RK224RY …

Timeline

Mid-May 2020	Late-June	July	13th August	24th September	Today

Technical Spike	Design	Pilot in Newham & IoW	National Launch	Ongoing Improvements

Technical Spike

Technical ENAPI POC

Field Testing

Design

Decision made to pivot to ENAPI

Rapid UI prototypes

Architecture design

Pilot in Newham & IoW

Rapid incremental delivery of mobile app and APIs

Virology Integration

AWS platform build and security testing

Field Testing

National Launch

Production scale and hardening of AWS

Multi-language support

CE Mark

WCAG AA Compliance

DPIA Published

Ongoing Improvements

ENAPI v2.0

Localised Tier Messaging

UK Interoperability

Responding to Kent variant

Isolation Payments

Data Analytics

Lateral Flow Tests

Check-in improvements

Test to release

Variants of concern

Programme Organisation

Self contained COVID App organisation

Executive Management

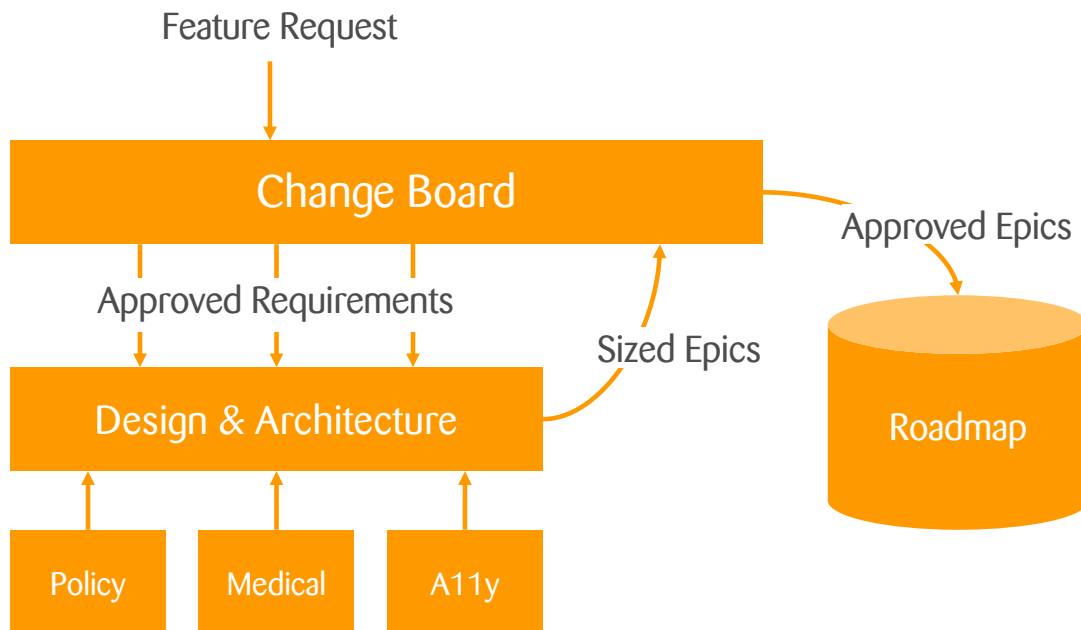| Product Ownership	Design, Delivery & Operation	Assurance	Governance & Compliance	Marketing & Comms	Data Analytics	Research & Science

Policy

Continuous Discovery Process

Feature Request

Change Board

Approved Requirements

Approved Epics

Sized Epics

Design & Architecture

Roadmap

Policy

Medical

A11y

Discovery process
- Service Design
- UI/UX Design & Prototypes
- User Research
- System Architecture
- Policy feedback
- Medical feedback
- Accessibility review

Continuous Delivery Process
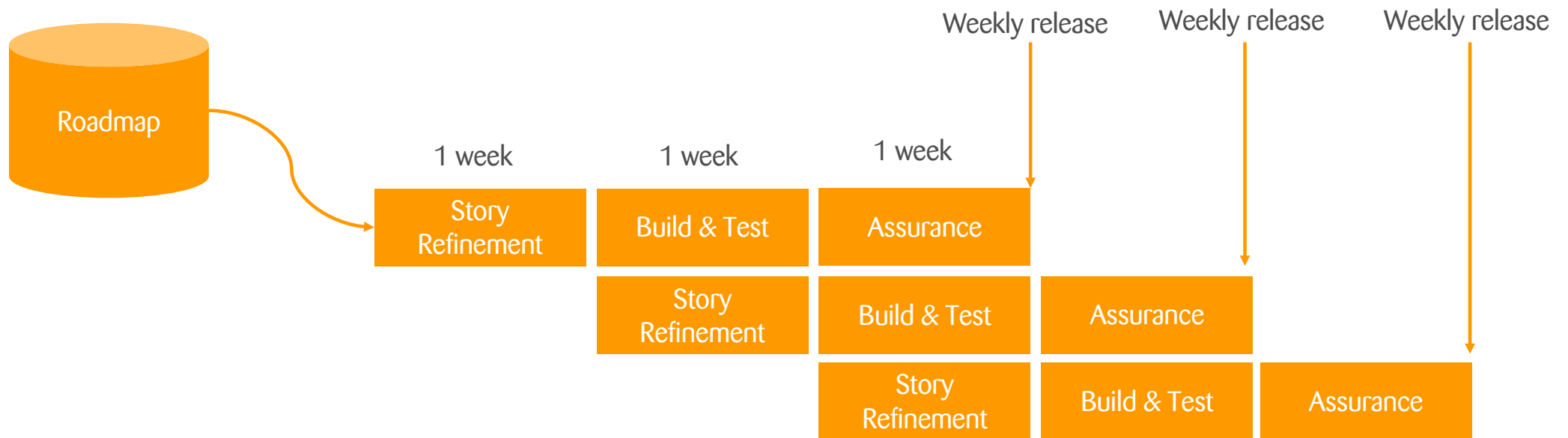
Ongoing Governance & Compliance

Continuous embedded governance

- Government Digital Services

  - Usability testing and user needs research

  - Fully Open Sourced

- ICO approval and ongoing DPIA

- NCSC embedded in team

- WCAG AA Compliance

  - Accessible by design with embedded disability user research

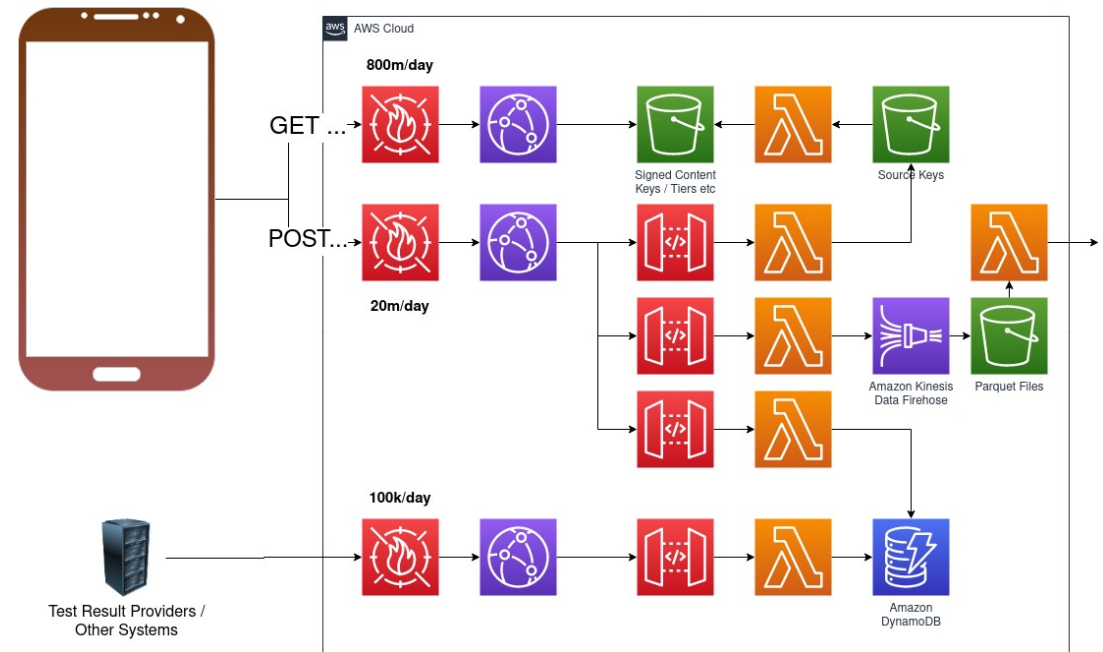 - Published accessibility statement

Architectural Principles

Keep It Simple

Go all in on AWS Cloud-native features

Use limited number of well-understood patterns

- All Inbound is via WAF + CloudFront
- All outbound content is signed
- CDN for high volume
- API Gateway
  -> Lambda for submissions
- S3 or Timer Event
  -> Lambda for processing

AWS serverless architecture enabled us to scale

Ability to scale to millions of users while keeping costs low

- ~28 million installed apps

- 700 million user requests per day and serving up 12TB of data

- Automatic scaling to handle peaks seamlessly

- S3 and CloudFront enable the distribution of exposure keys at scale

- Highest load API is for analytics, steady state of between 20k-40k requests per minute with peaks of 300k requests per minute
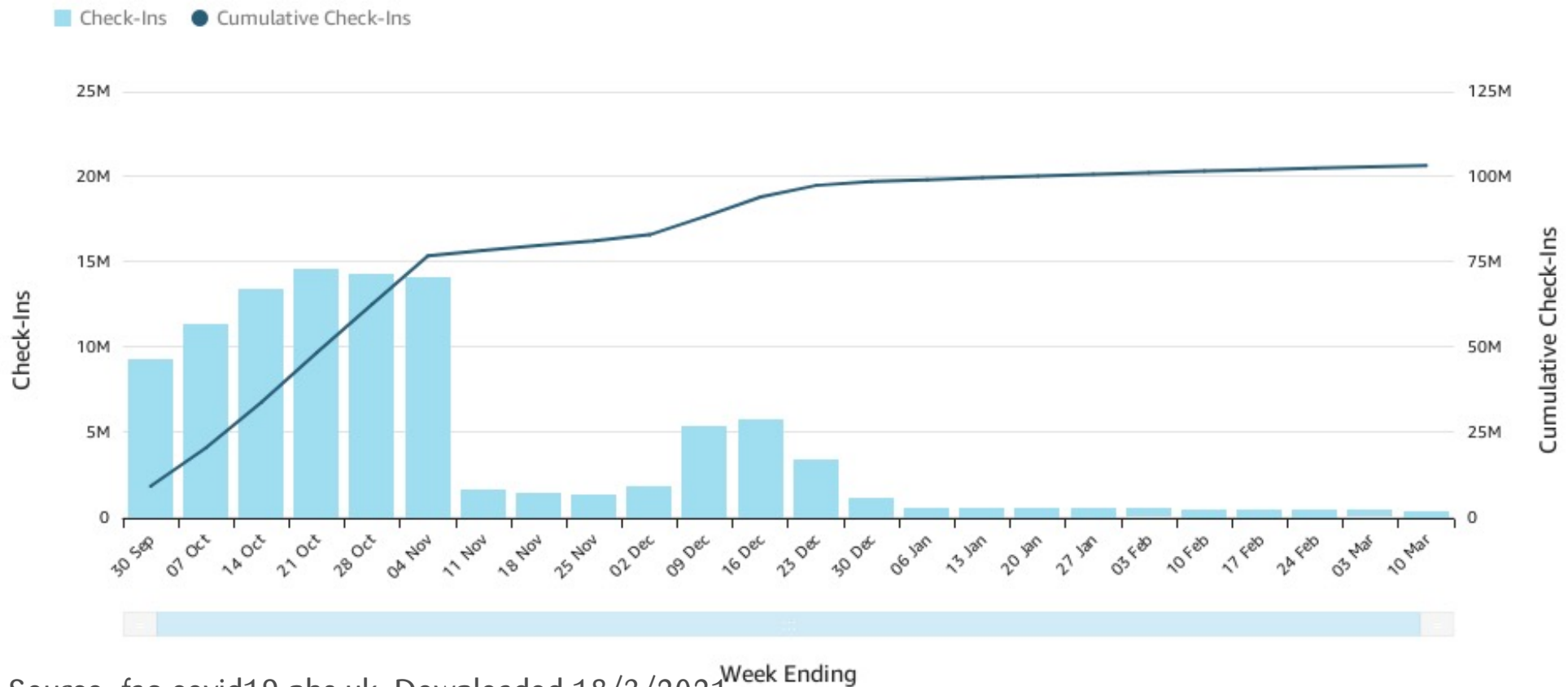
Downloads

Number of app downloads (England and Wales)
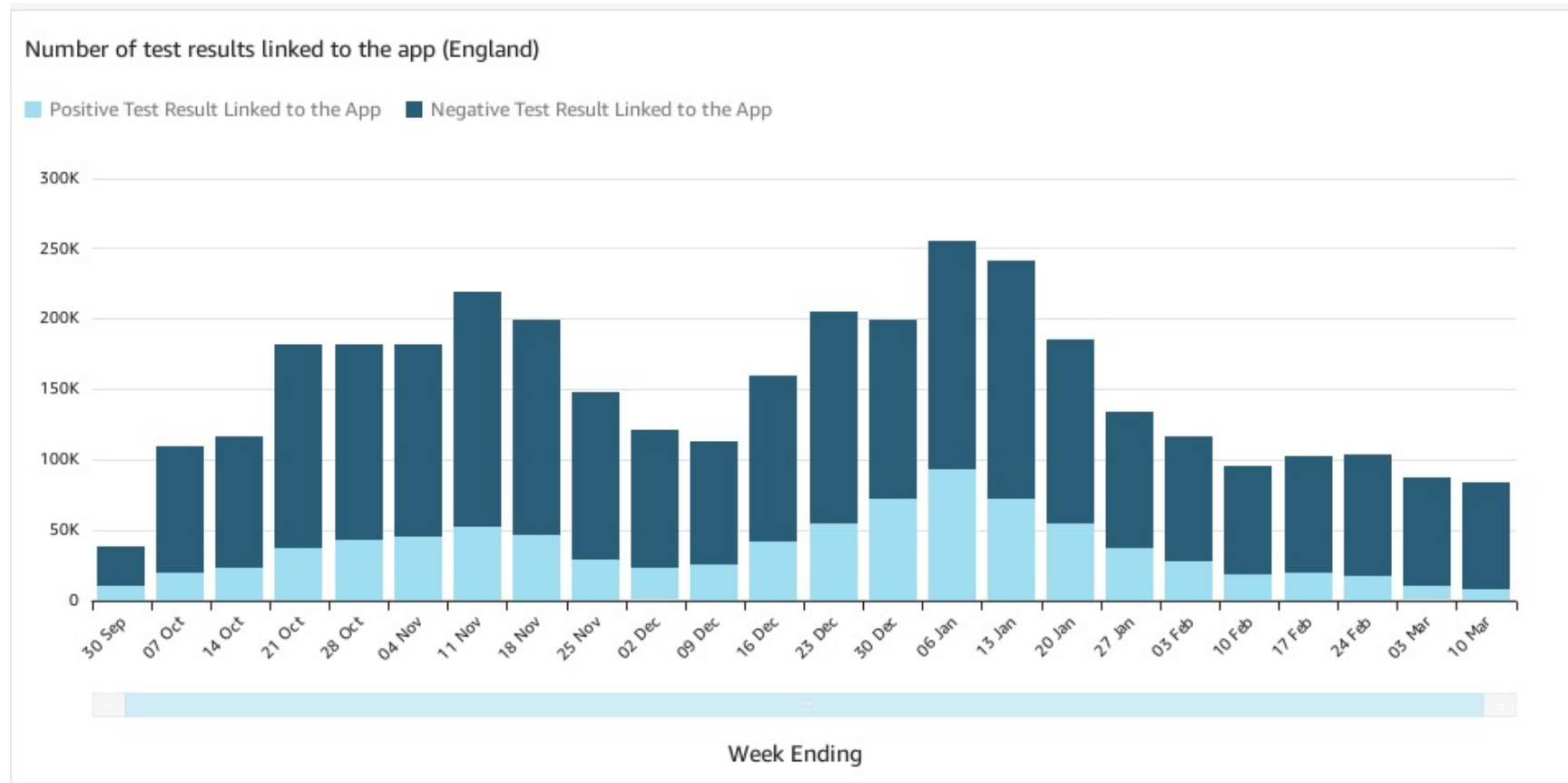

Source: faq.covid19.nhs.uk. Downloaded 18/3/2021

Venue check-ins

Number of check-ins (England)

Source: faq.covid19.nhs.uk. Downloaded 18/3/2021

Test results entered

Number of test results linked to the app (England)

▪ Positive Test Result Linked to the App ▪ Negative Test Result Linked to the App

Week Ending

Source: faq.covid19.nhs.uk. Downloaded 18/3/2021

Contact tracing alerts delivered

Number of contact tracing alerts sent (England)

■ Contact Tracing Alerts ● Cumulative Contact Tracing Alerts
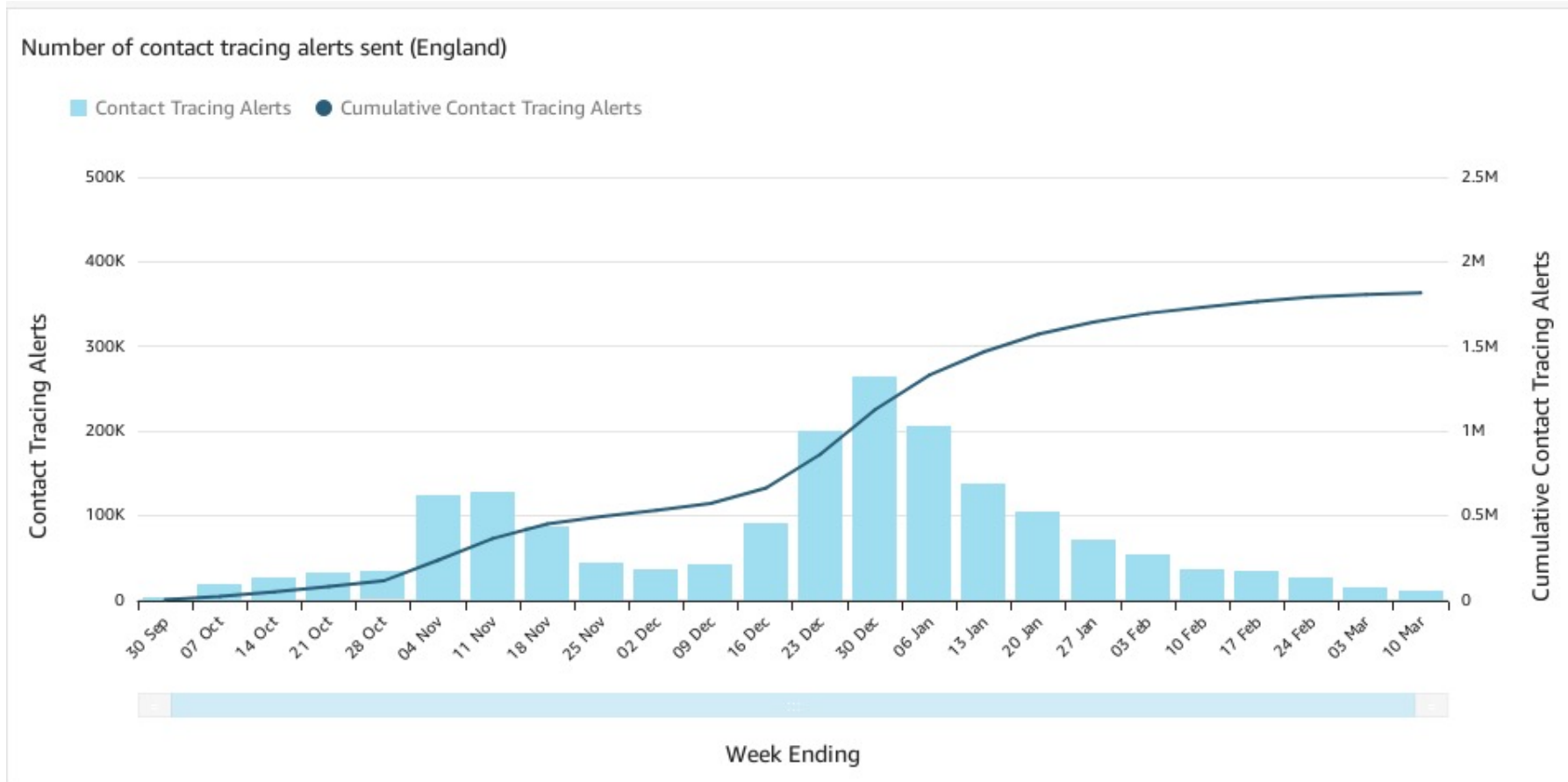
Source: faq.covid19.nhs.uk. Downloaded 18/3/2021

Infections and deaths averted
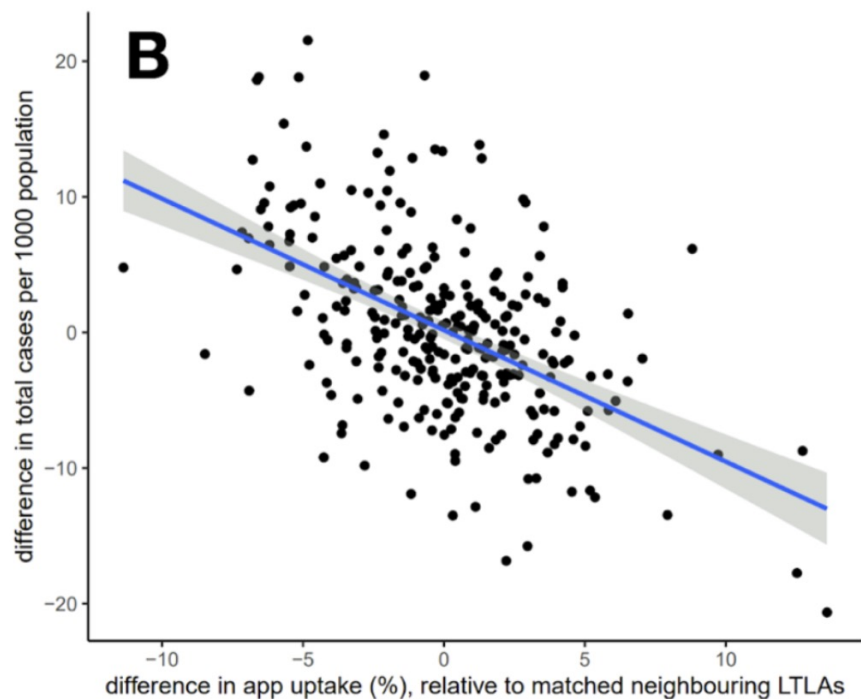
Analysis	Cases averted in phases 1 and 2 combined
Modelling	279,000 (210,000 - 347,000)
Matched neighbours	594,000 (317,000 - 914,000)

Analysis	Deaths averted in phases 1 and 2 combined
Modelling	4,100 (3,100 - 5,100)
Matched neighbours	8,700 (4,700 - 13,500)

Source:
- Wymant, C., Ferretti, L., Tsallis, D. *et al* .The epidemiological impact of the NHS Covid-19 App. *Nature* (2021) DOI: 10.1038/s41586-021-03606-z

Conclusions

- Digital contact tracing through a mobile phone app works and is saving lives

- It provided an effective instrument to respond to challenges of the pandemic

- It cannot replace manual contact tracing and is synergistic with it as it reaches exposures that manual contact tracers cannot reach

- Digital contact tracing will become more important again as the government releases lockdown restrictions

Thank you
Questions?