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TraceTogether: reflections on the future of digital contact tracing apps

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The views and recollections here are the speaker's own; any errors or omissions are mine alone. Nothing in this talk should be read as an endorsement by NUS, GovTech, or the Government of Singapore.





retrospective



The TraceTogether journey, 2015-2023

JUN 2015

South Korea fights to contain MERS outbreak, considers tough measures

MERS prompts the idea of Bluetooth contact tracing

JAN 2020

WhatsApp · 24 Jan

“Any contact tracing app solution?”

The idea resurfaces. Volunteers begin development

20 MAR 2020



TraceTogether launches. 500,000 registrations in 24 hours

9 APR 2020



BlueTrace whitepaper and OpenTrace code published

10 APR 2020



Apple and Google announce their partnership

JUN 2020



Hardware tokens support inclusion for seniors and residents without smartphones

20 OCT 2020

70% adoption target

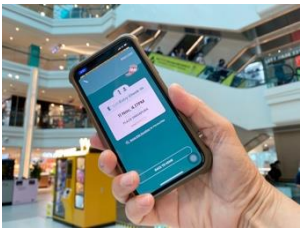
70% adoption condition announced for Phase 3 reopening

17 MAY 2021



TraceTogether becomes de facto means of SafeEntry check-ins

10 AUG 2021



Vaccination or recovery status tied to public venue access

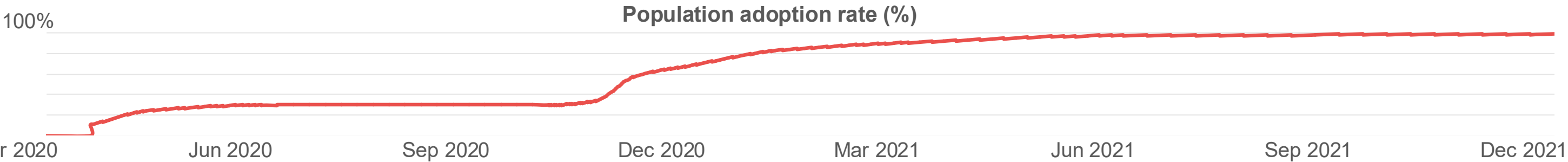
13 FEB 2023

Discontinuation of TraceTogether and SafeEntry

TraceTogether and SafeEntry stand down. Identifiable data deleted

Approximate adoption

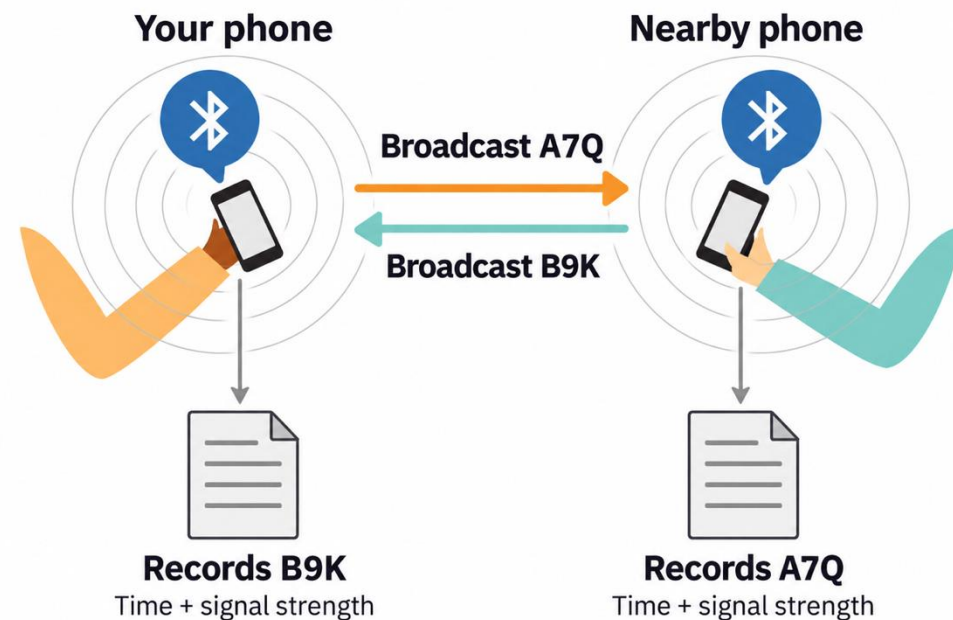
Mar 2020–Dec 2021



Source: GovTech, MOH, MDDI, Reuters, Straits Times. Timeline scale approximate.

How TraceTogether (and many other DCT apps) worked

1 Phones exchange and record tempIDs*



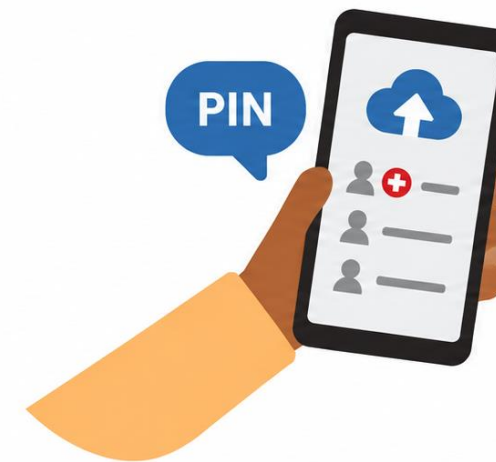
Each device keeps its own encounter and proximity log

2 A diagnosis reaches MOH



PCR results and diagnoses in healthcare settings are reported centrally

3 Patient chooses whether to upload



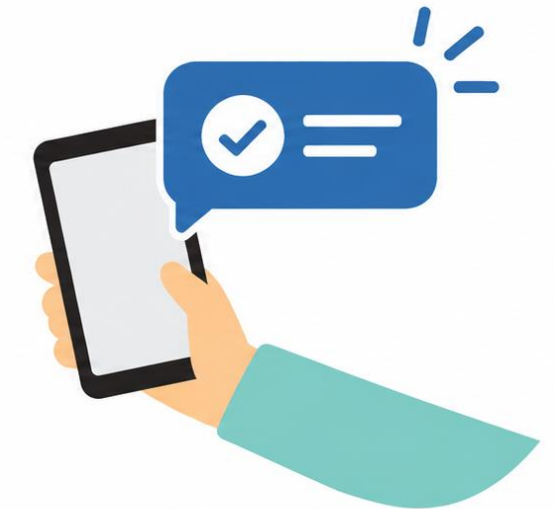
MOH requests the log with an authorisation PIN. The patient decides whether to upload.

4 MOH evaluates exposure risk



TraceTogether server decrypts tempIDs and identifies risky encounters

5 MOH notifies contacts



MOH COVID operations system notifies at-risk users to test/isolate

* tempIDs decrypt to a TT-ID, alongside nonce and validity-period information. The TT-ID maps to an actual user registration.



Explicit consent gates

1 Registration



Users give consent when they register to participate in TraceTogether and receive contact notifications.

2 Upload after diagnosis



After a diagnosis, the patient chooses whether to upload the local encounter log requested by MOH.

3 Stay reachable for notifications



On withdrawal*, MOH deletes the TT-ID/user mapping. tempIDs can no longer resolve to an individual user.

* Withdrawing from system notifications did not block SafeEntry access. The app or token continued to check in and exchange Bluetooth signals normally.





reflections



Six gates between digital tracing and a flatter curve

Gating bottlenecks	TraceTogether's implementation	Estimated fidelity
 Coverage...: did the infected person participate?	Apps and tokens for inclusivity; SafeEntry integration in public spaces; strong political backing	>95% participation <5% attrition
 ...squared: did their at-risk contact participate too?	Coverage had to include both ends of an encounter	>95% participation <5% attrition
 Accuracy: did we capture and flag the risky exposure?	Bluetooth workarounds and calibration alongside manual tracing	>80% concurrence/specificity wrt manual CT
 Testing: was the infection diagnosed in time?	All PCR/health setting diagnoses reported to central COVID test registry, triggering TraceTogether upload prompt	Comprehensive coverage within healthcare system
 Timeliness: did the diagnosis quickly trigger notification?	Testing, upload consent and tracing integrated in one operational flow	70–80% upload consent; median <30 min to consent; mean contact tracing cycle halved to <2 days
 Isolation: did the notified contact change their behaviour?	PHA-administered test/isolation regime	Low attrition assumed due to robust PHA enforcement powers and high compliance culture

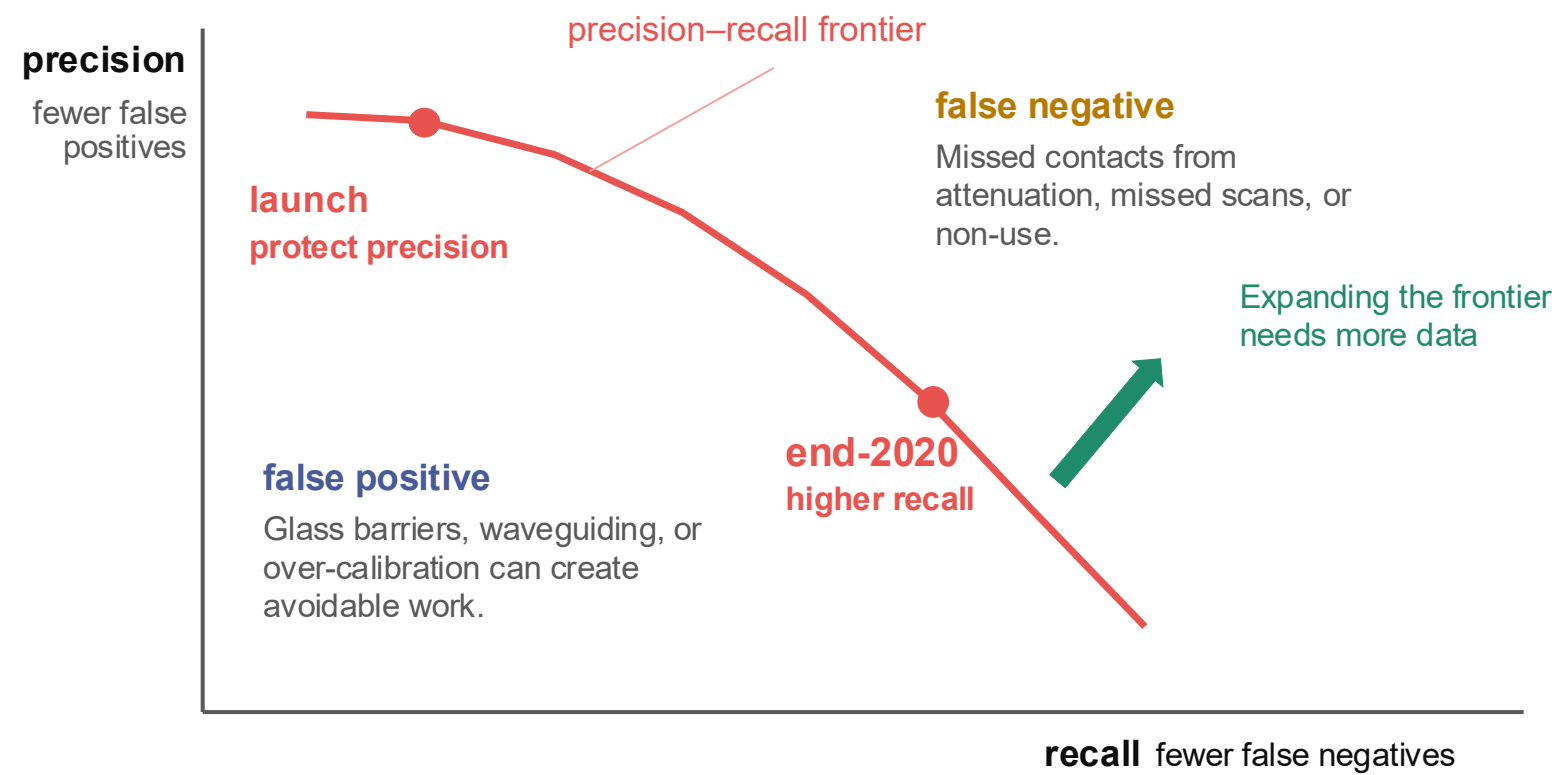
Success requires end-to-end solutioning and systemic involvement; even 80% fidelity through each gate results in only 26% overall effectiveness

Masel J, Petrie J, Bay J, et al. JMIR Public Health Surveill. 2023;9:e49560. doi:10.2196/49560. 80%⁶ is illustrative; estimates are not one measured funnel.

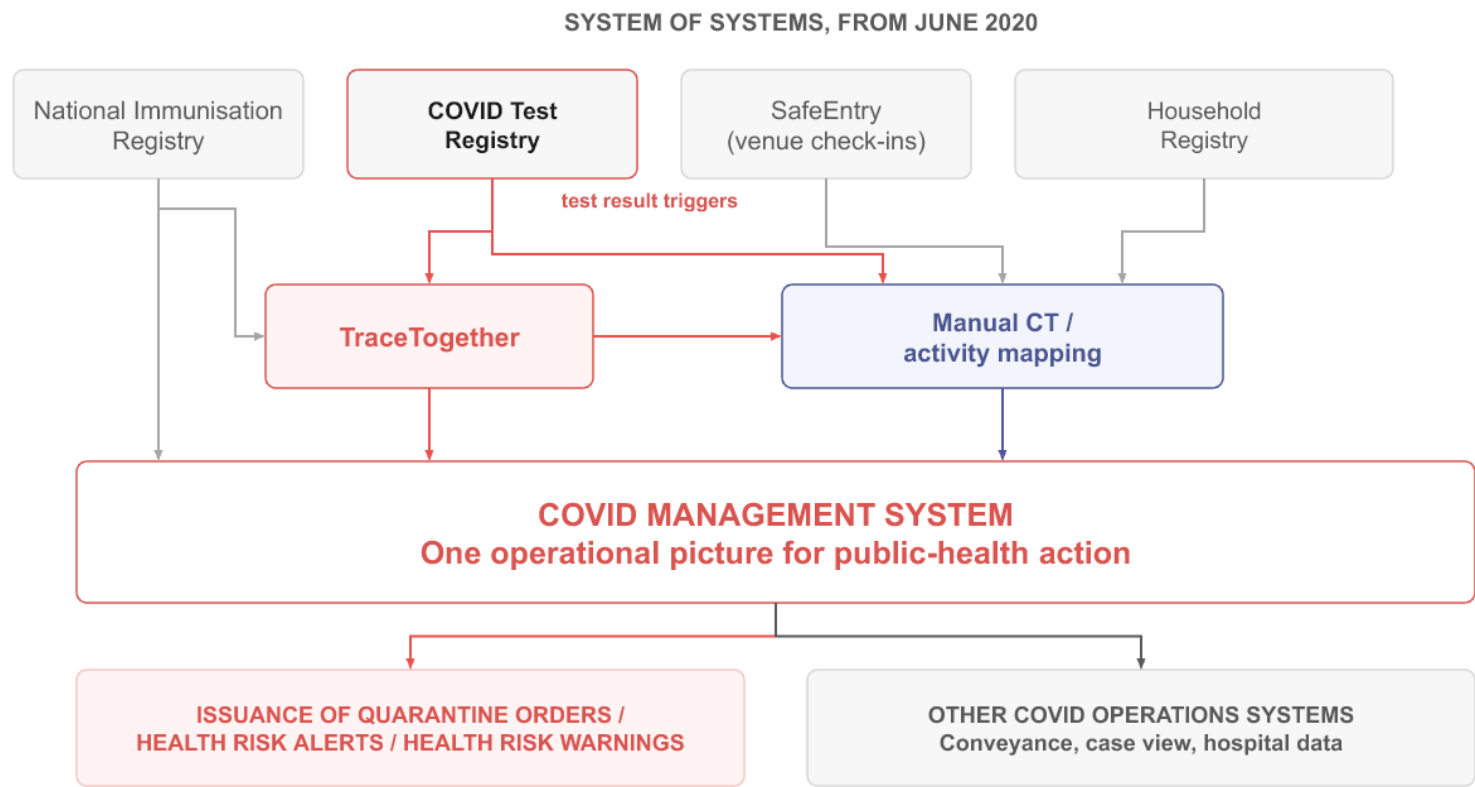
Calibrating for trust; integrating for relevance



CALIBRATION



SYSTEM OF SYSTEMS



We were introducing an algorithm into a human institution. Professional trust mattered as much as technical performance.

Sources: Bay, J, “SaferTogether”, XRDS (2022), pp. 52–53.

Centralisation vs decentralisation: a distracting dichotomy?

Dimension	Centralised approach	Decentralised approach		
 Encoding/decoding of ID/keys	Server issues IDs and resolves identity   	Device derives keys and recognises IDs  Google		
 Storage of encounter logs	Server holds population encounter logs 	Device stores its own encounter history    Google		
 Exposure risk computation	PHA server evaluates uploaded encounters   	Device evaluates downloaded case keys  Google		
 Case report/upload authorisation	Lab / PHA confirms case or authorises upload   †   Verified lab/PHA route	Users self-attest symptoms or a positive self-test  ‡ MassNotify bridged both routes‡		
 Exposure notification	Server triggers the exposure alert   	App generates the exposure alert locally  Google		
 PHA graph visibility	Uploaded logs reveal observed contact links  	PHA receives no contact graph  *  §  Google		
 Follow-up and compliance	PHA directs/enforces follow-up   	Individuals act on advice without PHA compulsion  		
 Google GAEN framework and selected policy overlays	Other architectures			
 Apturi Covid (Latvia)	 MassNotify (Massachusetts)	 TraceTogether	 Aarogya Setu	  StopCovid / ROBERT
		 Smittestopp v1 (2020)	 Bluezone	

* Bluezone: PHA can remotely retrieve keys and exposure matches. † Aarogya Setu: local storage with remotely triggered uploads.
‡ MassNotify: lab-linked or self-requested verification. § Latvia: optional exposed-user reporting, not contact-graph edges. PHA = public-health authority.
Classifications are prone to error/interpretation, and are intended only to illustrate diversity and nuances within approaches.

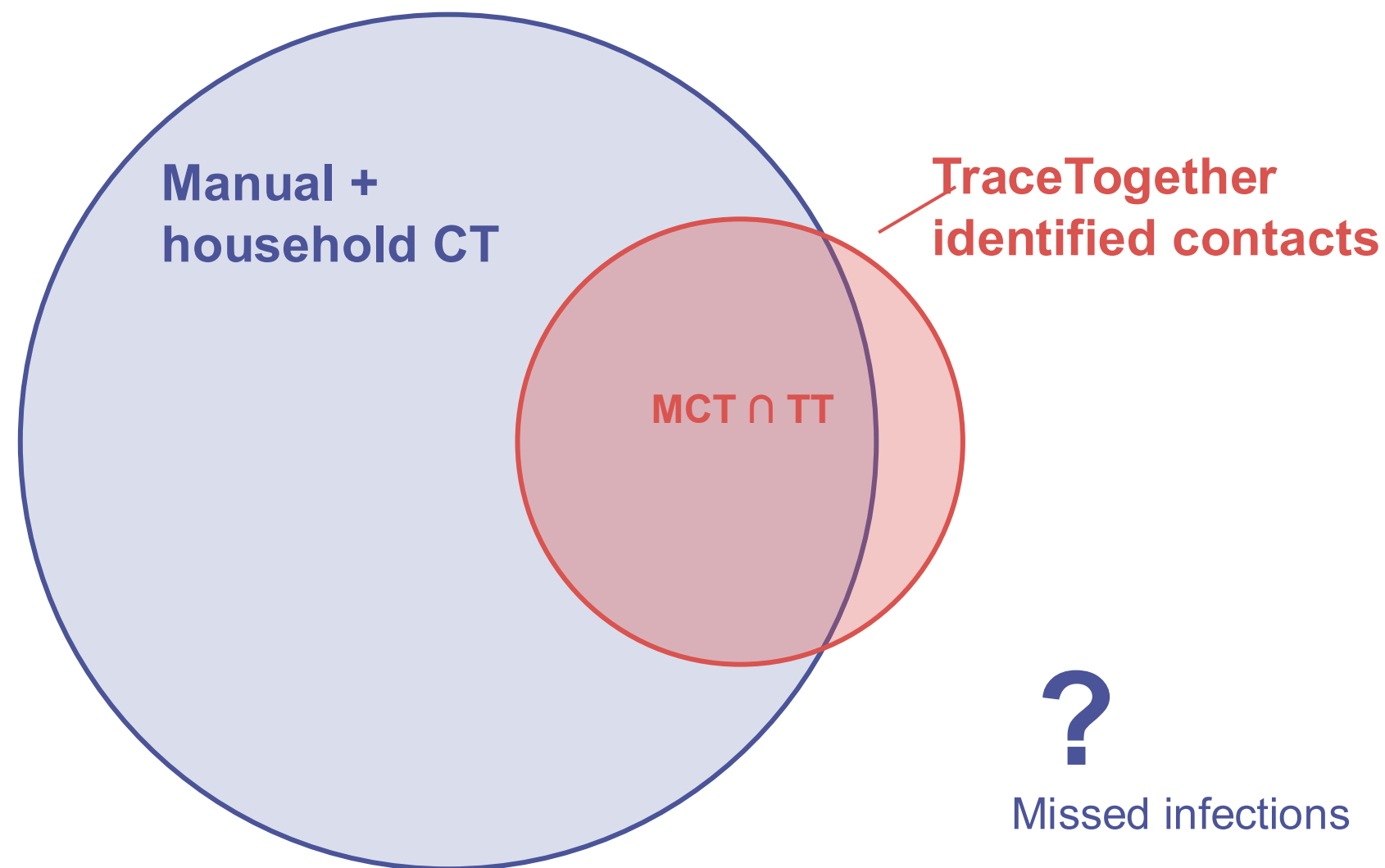


an appraisal



Against the gold standard of manual contact tracing...

Whole CT: the combined quarantine list



Drawn to approximate scale

Source: Author's recollection, March 2021. Relative precision range: author's synthesis of several exploratory dipsticks.



PRECISION

Among at-risk contacts flagged – who later tested positive?

4–6×

TT precision was 4–6× all-source CT precision in exploratory dipsticks

>80% concurrence

More than 80% of TT contacts also appeared in manual CT / household data, but TT found them faster

Results suggest headroom to reduce excessive isolations/quarantines and social/economic disruption

Not coverage, but speed



TraceTogether launch briefing, March 2020

INITIAL PROMISE

TraceTogether would identify more contacts, including strangers manual tracing might miss

Empirically, the main gain was speed not coverage

BEFORE

≈4 days



WITH TRACETOGETHER + SAFEENTRY

<2 days

Coverage was not TraceTogether's comparative advantage.
Singapore's PHA already pursued very aggressive contact tracing coverage.

YMMV – coverage may be the key contribution in the absence of an established contact tracing capability with sufficient capacity



TraceTogether

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Coronavirus Contact tracing

Time taken to trace contacts of Covid-19 patients halved

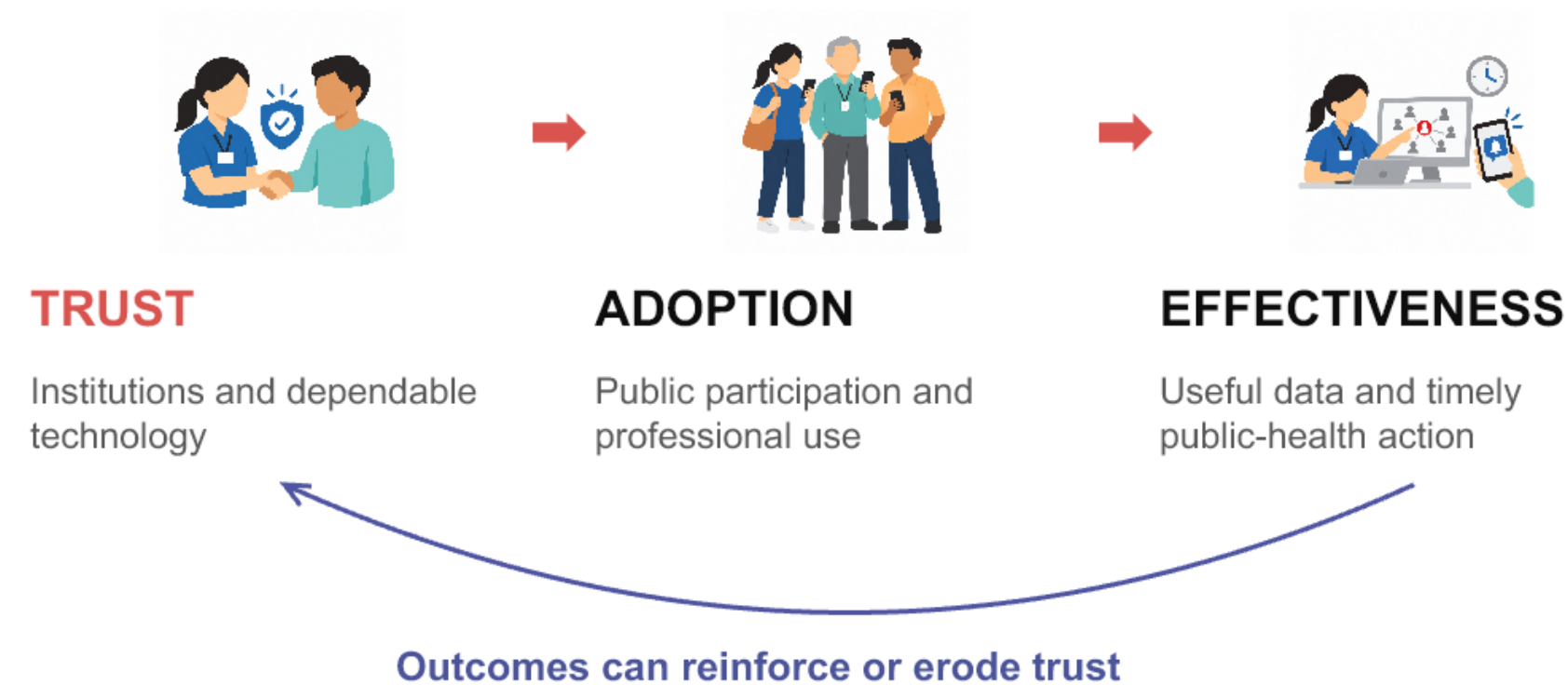
Contact tracers say technological tools have made the process easier and faster



Associate Professor Vernon Lee, head of the Ministry of Health's contact tracing centre, said the time span from the moment a patient is identified, to when he and his close contacts are quarantined, could now take less than two days with the use of TraceTogether and SafeEntry data, compared with four days before. ST PHOTO: GUYAN FOO

Images: Launch briefing and The Straits Times.

Trust in public health and digital tools



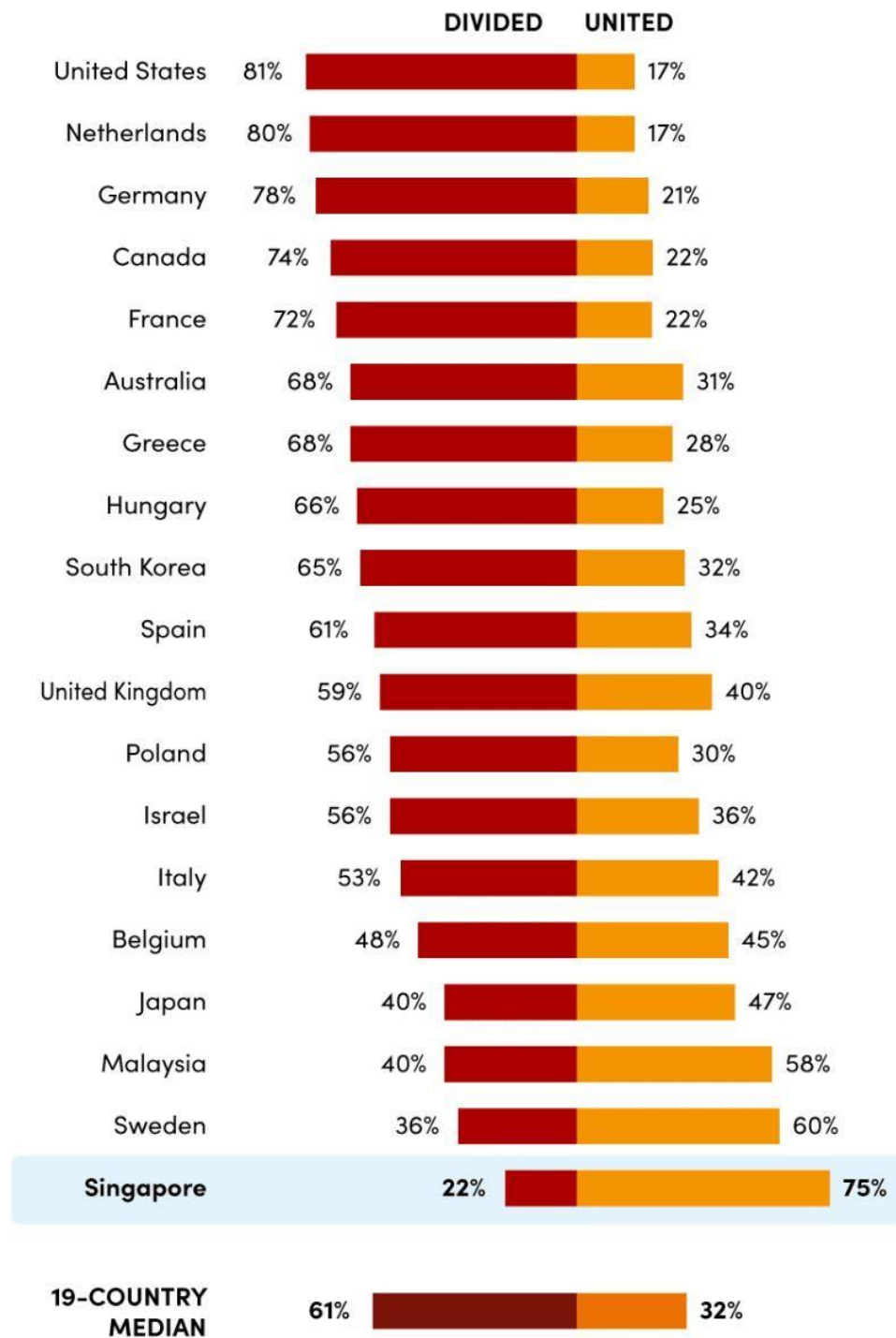
TRUST HAS TWO AUDIENCES

THE PUBLIC Participate, consent to upload data when requested

PUBLIC HEALTH PROFESSIONALS Integrate the system within pandemic response toolkit

MAJORITIES IN MOST PLACES SAY CORONAVIRUS HAS BEEN DIVISIVE

% who say their country is now more _____ than before the coronavirus outbreak



Note: Those who did not answer are not shown

Infographic: Rafa Estrada

Source: Pew Research Center, Spring 2022 Global Attitudes Survey



Physical devices: to do or not to do?



JAN 2020	≈20%	MAR 2020	28 JUN 2020
Wearables were paused while resources went into infrared fever scanners	Assumed to lack a suitable smartphone; inclusion/equity needed another option	Rapid app adoption sparked interest in adding wearable “tokens”	Token launch; offline upload lowered component cost and addressed privacy concerns; anyone could get a token, so ~60% do

Active carriage rates were similar... But upload rates diverged significantly

PHONES + BACKEND	TOKENS	The upload gap came later	
200,000 uploads @ ~US\$15 million	20,000 uploads @ ~US\$120 million	10×	Observed upload ratio
≈ US\$75 / case upload	≈ US\$6,000 / case upload	1/8×	Enrolment cost ratio
		80×	Unit costs ratio

Compare with the imputed labour cost of 2–3 man-days to contact trace one case

What is the right price for equity/inclusivity?

Is an offline-only token and its associated logistical difficulties the right design trade-off?

MY HOT TAKE: Equitable access vs equitable efficacy;
limit wearable distribution by need and/or build in connectivity

OCT 2021: LOGISTICAL CHALLENGES



Collection required PPE-clad house visits, sometimes up to a week after case report. Users may also have entered quarantine without their tokens. Further delays followed before upload.

Active carriage: internal analysis, March 2021. Costs, upload counts and backlog: author estimates / recollection.

Source: Author’s recollection/estimates. Parliamentary Written Answer, 7 May 2026. Views are the author’s own.

What should the digital contact tracing system for the next pandemic look like?

A letter to the future



Three principles for the next DCT system



EVOLVE BETWEEN OUTBREAKS

- Keep capability warm and ready for day 1, when epidemiological data is most needed
- Update with evolving tech – don't build febrile scanners for COVID
- Establish governance principles, activation protocols/agreements – who decides and when?

EVOLVE DURING OUTBREAKS

- Match phases with outbreak stages – more granular data initially?
- Subsequent linkage to vaccination and other public health status for analytical value

TECHNICALLY PRIVATE; SOVEREIGN CHOICE

- Keep systems private by technical design
- Place onus on individuals to consent and governments to justify tradeoffs for public benefit

Build the technical and governance capability in advance

Respect the prerogative of individual societies and their constituents to choose, and to own their choices



Building consensus before the next crisis

Multistakeholder dialogue needed: PHAs, health professionals, privacy experts, technology providers, researchers...

Scope	Who decides	Who explains and answers for it
Shared principles	The forum agrees safeguards, evaluation standards and interoperability	The forum publishes evidence, rationale and points of disagreement
Technical design	Providers implement agreed safeguards and interfaces; identify technical limits	Providers explain available technical protections; governments / PHAs defend choices
Local implementation	Governments / PHAs, with citizens, choose activation, data access and follow-up procedures	Governments / PHAs own and make the case to their citizens as part of public health response

Whoever has the best information, whoever bears the consequences, and whoever decides – dysfunction follows dispersal of/misalignment across these roles; public health should be at the table



Thank you

Ops-tech integration requires an “ops pull” from public health, as much as a “tech push”.

Public health practitioners need to first be familiar with the technology to understand how to use it, and guide its development.

If you’re not at the table, you’re on the menu.

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