

Advancing the Sensitivity Frontier in digital contact tracing: Comparative analysis of proposed methods toward maximized utility

Junko Ami, Yanbo Pang, Hiroshi Masui*, Takashi Okumura*, Yoshihide Sekimoto

* Kitami Institute of Technology

Background

With the widespread use of mobile phones, public health has explored their potential for infection control, particularly through Digital Contact Tracing (DCT). In Japan, the COCOA app, introduced during the COVID-19 pandemic in 2019, used short-range Bluetooth to log close contacts between smartphones. While intended to identify potential exposures and limit transmission, its effectiveness was limited by a low adoption rate of around 33%. To overcome this limitation, we proposed CIRCLE (*), a location-based alternative to COCOA (Figure 1). Unlike Bluetooth-based methods, CIRCLE assesses exposure risk using mobile phone location data without requiring individuals to share personal movement history or location with the government. This approach balances privacy protection with effective risk communication.

(*): CIRCLE: Computation of Infection Risk via Confidential Locational Entries

Method and results

From a public health standpoint, DCT systems should prioritize high sensitivity, accurately identifying contacts of infected individuals, during the early stages of an outbreak. As the infection spreads, the focus should shift toward specificity, correctly excluding those not at risk. We compared the sensitivity and specificity of COCOA, Japan's Bluetooth-based DCT app, with CIRCLE, a location-based alternative. Sensitivity is constrained by smartphone penetration and app usage; CIRCLE was estimated to have over seven times the sensitivity of COCOA (Figure 2). In contrast, specificity, estimated using pseudo-PFlow data from the Sekimoto Laboratory and public datasets, was found to be less than half that of COCOA*.

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figure 1: Overview of the CIRCLE Method.

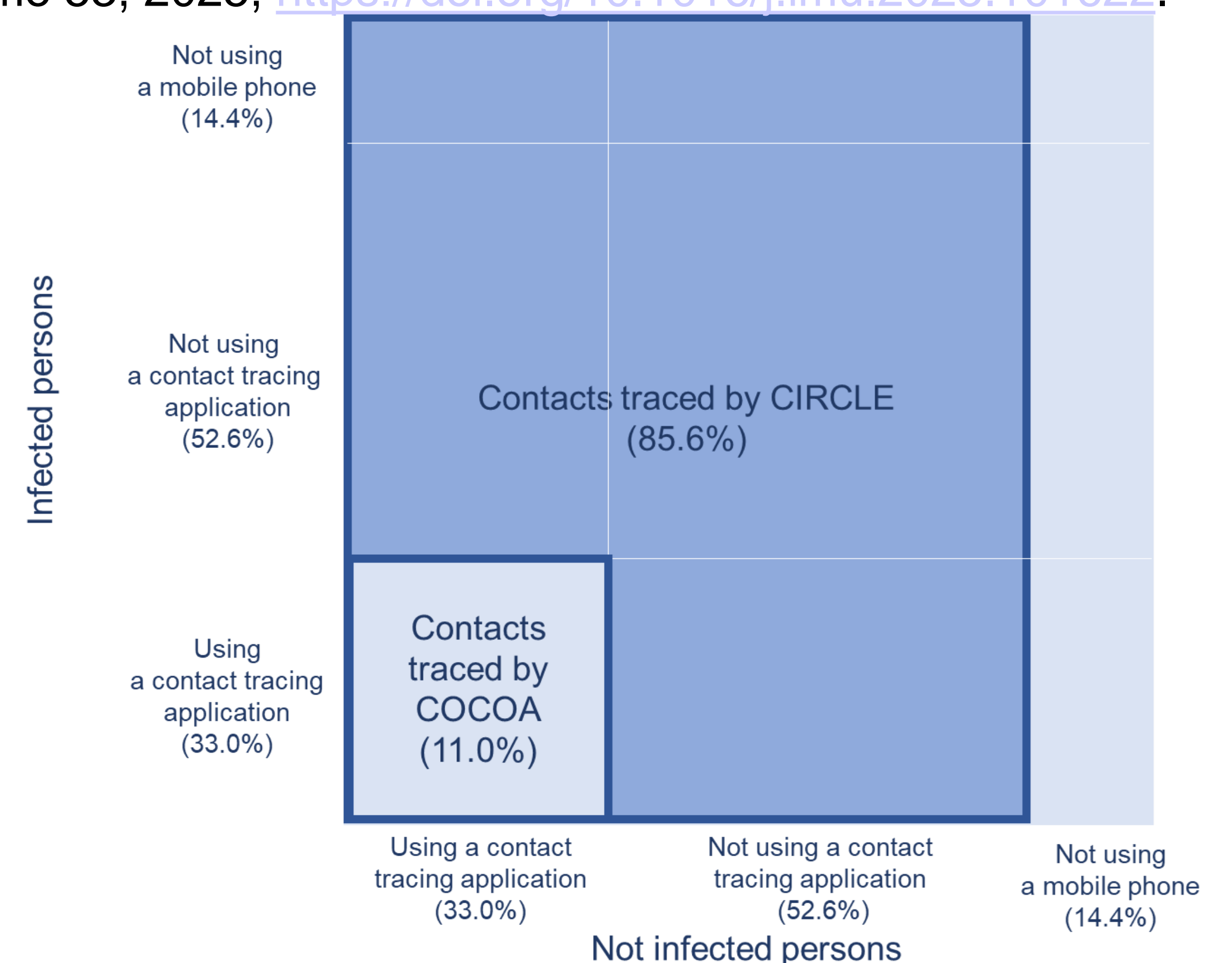


figure 2: Sensitivity of BLE-based DCT and CIRCLE.

Future challenges

CIRCLE, a DCT method utilizing mobile terminal connection data to cellular base stations, has demonstrated the potential for substantially higher sensitivity compared to Bluetooth-based approaches such as COCOA. However, its specificity is expected to decline as the number of infected individuals increases. To prepare for future pandemics, it is essential to develop and maintain multiple DCT systems with complementary characteristics, enabling a flexible transition from sensitivity-focused approaches in the early stages of an outbreak to specificity-focused strategies as transmission progresses. Our ongoing research aims to advance this concept by integrating diverse methods, thereby redefining DCT and contributing to more practical and adaptive infection control solutions.