Digital contact tracing for COVID-19: Overview of existing systems and framework for future innovation

ISPOR Poster Code: EPH219

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Background & Objective

- The COVID-19 pandemic catalyzed innovation in infection control measures, including the widespread use of digital contact tracing.
- However, these technologies were not well understood by the general public and were complex for the public health community to implement, hampering adoption.

Objective

To provide an overview of existing digital contact tracing systems, creating a framework for understanding design elements that impact their effectiveness and offering a rubric for decision-makers to evaluate different systems for selection and implementation.

Methods

- Scientific literature and publicly available information from relevant health authorities and other stakeholders was reviewed.
- Information was synthesized to develop a conceptual framework explaining how key design elements impact effectiveness of digital contact tracing systems and highlighting opportunities for future improvement.

Results

- A range of digital contact tracing interventions were deployed by governments and professional sports leagues worldwide.
- Key design elements of the systems include:
  1) **Data architecture:** centralized versus decentralized systems (Figure 1), affecting data privacy guarantees and availability
  2) **Proximity detection technology:** type of device signaling (Figure 2)
  3) **Alert logic and timing** (Figure 3A-3C)
     - Risk score components & alert thresholding, impacting alert sensitivity/specificity
     - Real-time proximity alerts, impacting scope of infection prevention
     - Recursive alerting, impacting alert sensitivity/specificity and prevention scope
  4) **Population:** participation had implicit *(e.g., apps did not function on older phones)* and explicit restrictions *(e.g., employee-only in occupational settings)*
  5) **Integration with public health system & resource availability:** test availability & timeliness, integration with traditional contact tracing, etc.
- Several examples demonstrated value in response to COVID-19
  - › In the first year of use, the UK's system prevented approximately 1 million cases, 44,000 hospitalizations, and 9,600 deaths. [1]
    - For every 1% increase in app adoption, there was a 0.8-2.3% reduction in COVID-19 transmission. [2]
  - › Data from a centralized, wearable-based system allowed refinement of definitions of high-risk contact for COVID-19 transmission. [3]

Figure 1. Schematic of risk notification processes for centralized and decentralized digital contact tracing systems

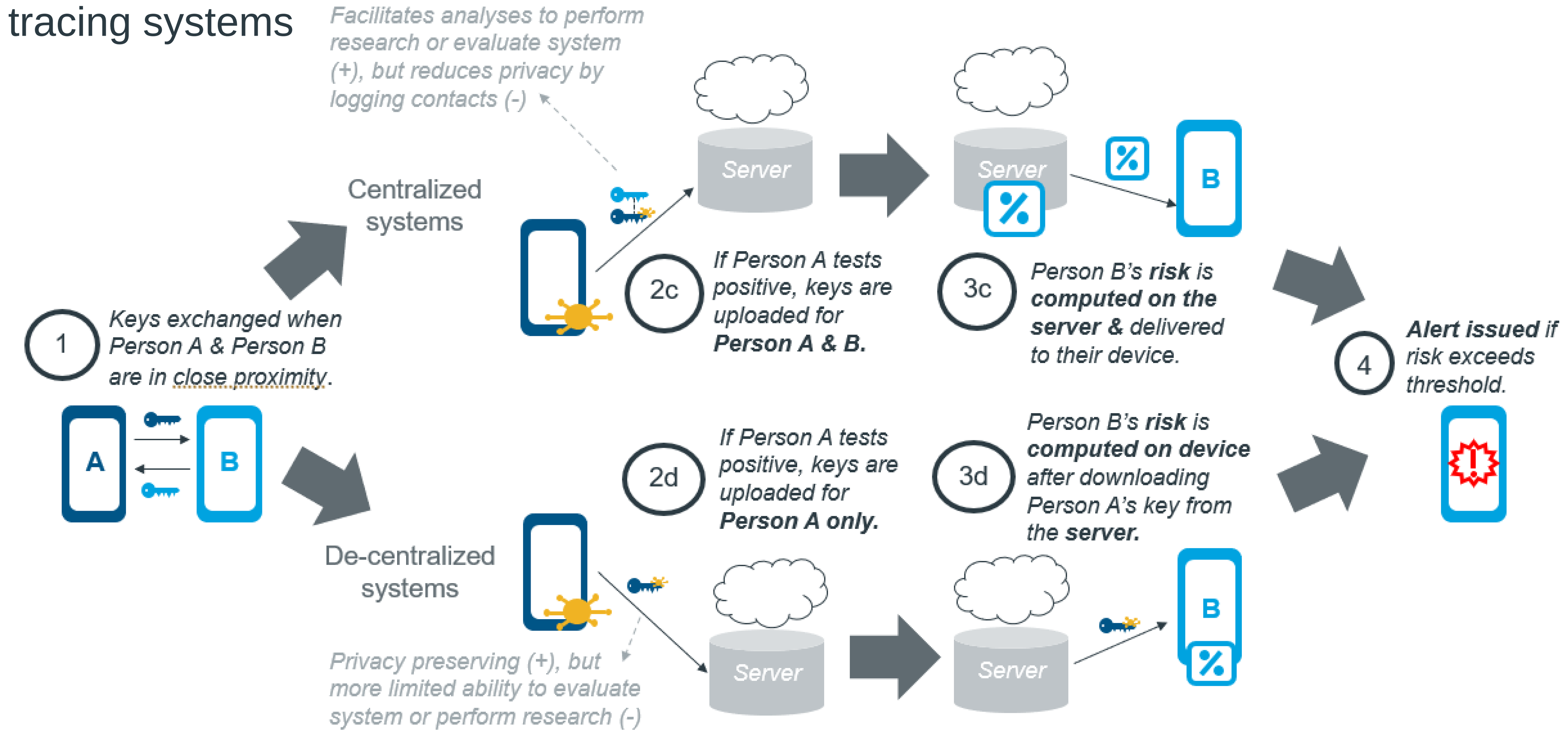


Figure 2. Types of proximity detection technology used in digital contact tracing system for COVID-19

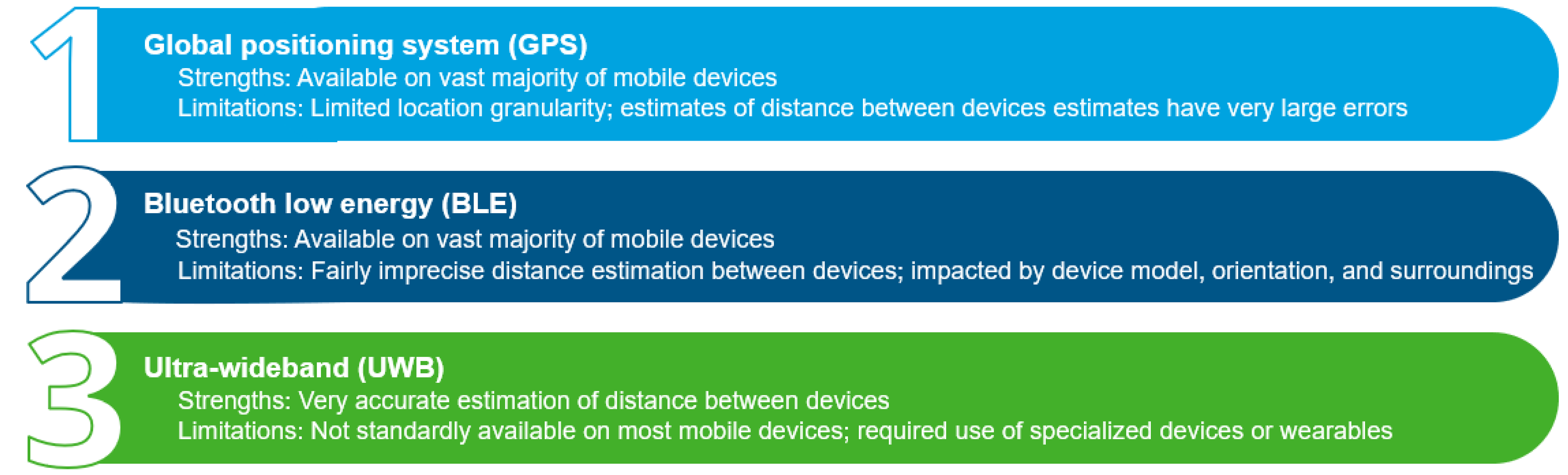


Figure 3A. Risk scoring components and alert threshold impact system sensitivity and specificity

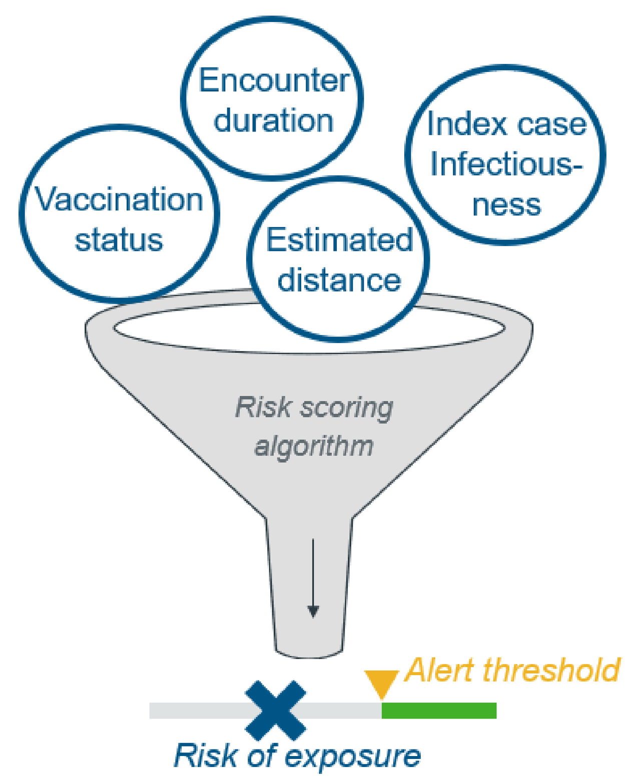


Figure 3B. Recursion enables alerts to be sent to the contacts of contacts of an index case

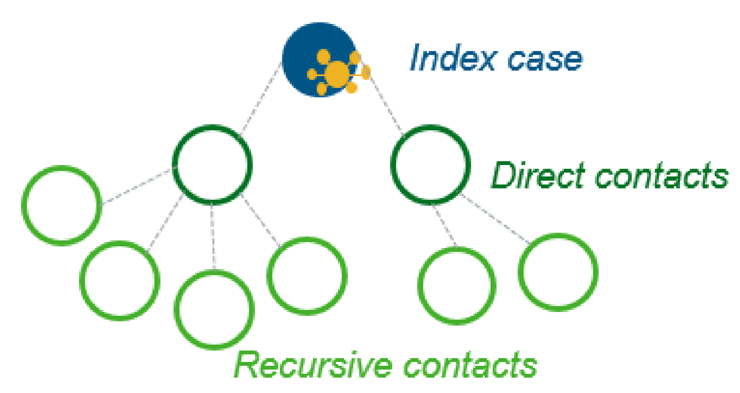
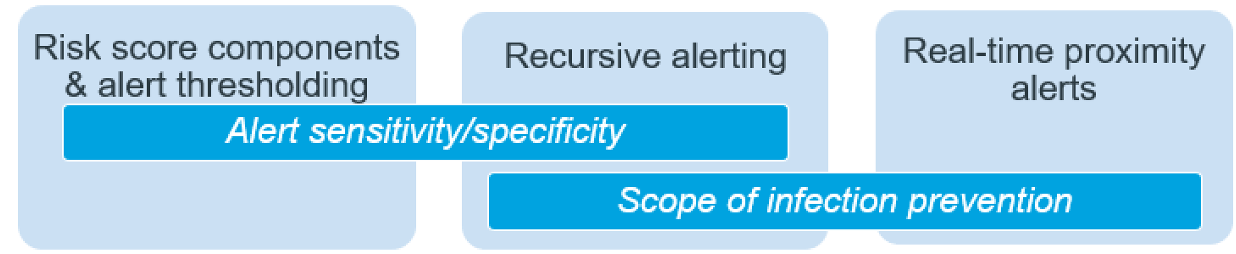


Figure 3C. Summary of impact of alert logic and timing decisions



Conclusions

- Opportunities for improving digital contract tracing systems for future outbreaks include better public communication to build trust and increase adoption, improved public health system integration to increase synergies with manual contact tracing, and wider adoption of accurate proximity detection technology to reduce rates of both false positive and false negative alerts.
- Digital contact tracing systems have the potential to mitigate the economic and public health impact of future infectious disease outbreaks, reducing community transmission and detecting potential cases earlier in the disease course.
- Lessons learned from solutions deployed during the COVID-19 pandemic provide an opportunity to improve multiple aspects of these systems, enhancing preparedness for future outbreaks.

References

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