A Rapid Prediction and Response System (RPARS) to Facilitate Guided Self-Regulation During Pandemics

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ented technologies such as digital contact-tracing and vaccine passport apps have been tried, advanced privacy-preserving approaches are needed to ingest user information in real-time, and better adapt to changing epidemiological circumstances. In response, this paper: 1) briefly discusses guided self-regulation as a possible means of disrupting viral transmission via the use of digital technology, 2) outlines a prototype Rapid Prediction and Response System designed to facilitate guided self-regulation in an advanced privacy-preserving approach, 3) describes the significance of the prototype system to research and practice, and 4) presents a high-level evaluation plan.

Keywords: Guided Self-Regulation, Privacy Preservation, Agent-based Simulation, Viral Transmission, Digital Technology, Public Health, Pandemics.

1 Facilitating Guided Self-Regulation During Pandemics

Deadly viruses spread quickly in communities, even when pharmaceutical [1] and population-level [2] interventions are in place. It is therefore necessary to develop targeted methods to disrupt viral transmission by guiding individual behavior. In doing so, we must develop forward-looking methods to continually process personal risk information in secure and privacy-preserving approaches. The notion of guided self-regulation extends the theoretical foundation of behavioral self-regulation [3–5], and consists of three technology-enabled behavioral sub-processes intended to disrupt viral transmission events: *self-detection*, *self-prevention*, and *self-tracing* [6]. *Self-detection* consists of routines to continuously monitor personal symptoms and health changes towards predicting whether a viral load is present. *Self-prevention* consists of routines to improve individual behavioral adherence performance towards reducing primary transmission events. *Self-tracing* consists of routines to track shared viral exposures towards reducing secondary transmission events [6]. Digital technologies may be leveraged to facilitate guided self-regulation by providing individuals with personalized epidemiological information, predicting individual transmission risk, and delivering targeted guidance, while still preserving individual privacy [7–9]. For example, in the context

2 Rapid Prediction and Response System Architecture

The Rapid Prediction and Response System (RPARS), a prototype under development at Rotterdam School of Management - Erasmus University, is designed to facilitate guided self-regulation during pandemics. The broad purpose of the system is to first predict risk of viral transmission in communities, and then proactively guide individual behavior to disrupt transmission events. To do so, it dynamically integrates personal information derived from *real-world behavioral contexts* with information derived from *simulated-world epidemiological networks* within a privacy-preserving framework. The RPARS architecture consists of three interacting mechanisms: 1) A *Dynamic Messaging Mechanism*, which facilitates individual guided self-regulation sub-processes: *self-detection*, *self-prevention*, and *self-tracing*. 2) A *Dynamic Risk Assessment Mechanism*, which generates risk information derived from simulated epidemiological networks approximating *social patterns*, *infection spread*, and *disease progression* within focal communities. 3) A *Privacy-Preserving Integration Mechanism*, which dynamically integrates information between system components via distributed *contextualization*, *translation*, and *matching* processes. A conceptual representation of the RPARS architecture is shown in Figure 1.

Fig. 1. Conceptual Representation of RPARS Architecture

2.1 Dynamic Messaging Mechanism

The *Dynamic Messaging Mechanism* guides individual self-regulation activities within real-world behavioral contexts through the delivery of personalized risk messages via the user's mobile device. Displayed messages refresh when new epidemiological information emerges. For example, when a user's health changes significantly, when entering crowded locations, or when viral variants emerge. This mechanism facilitates guided self-regulation within the three sub-processes outlined above. For example, for *self-detection*, health change information, combined with contextual information, is used to determine the propensity to contract a virus. For *self-prevention*, personalized risk messages inform users of recommended actions based on predicted transmission role (the likelihood of becoming a transmitter or receiver of viral particles), level of risk (the likelihood of participating in a transmission event), and personal risk tolerance. For *self-tracing*, contextual information is logged, together with user location and duration of exposure, to track exposure moments and identify community transmissions.

2.2 Dynamic Risk Assessment Mechanism

The *Dynamic Risk Assessment Mechanism* produces risk information derived from simulated-world epidemiological networks using an agent-based modeling framework adapted from [10]. The adapted framework simulates *social interactions*, *infection spread*, and *disease progression* information are displayed to the user. Decision rules may be updated by deploying new scripts from a