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Pandemic Informatics: Vaccine Distribution, Logistics, and Prioritization

March 22, 2021 Addendum to Pandemic Informatics: Preparation, Robustness, and Resilience

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When we authored our original quad paper in November 2020, we were writing from a distinct point at a unique moment in human history. Several months later, we find ourselves nearing what is hopefully the end of an exhausting marathon while facing a new and different set of challenges that are both surprising and yet also somehow predictable. There is much hope, but we must also acknowledge two key facts: (1) some parts of our society will be fortunate to make their way across the finish line while others still have many miles to go, and (2) the "once-in-a-lifetime" worldwide disruption caused by COVID-19 is likely to happen again, sooner than we wish to admit. With this in mind, and with the belief that computing research can play an important role now and in the future, we have decided to supplement our quad paper periodically with in-the-moment challenges where concerted effort now could produce solutions that would reduce suffering later. Each phase of the pandemic has had lessons to teach, and it seems prudent to do our best to document them as they arise so that we can learn from them.

In November, multiple companies announced successful trials of COVID vaccines. This was welcome news -- it told us that we finally had a pharmaceutical solution that can be used to manage the pandemic. While vaccine development was extremely successful, the distribution of vaccines has turned out to be tumultuous and chaotic. One major reason for this has been vaccine prioritization.

In an ideal world, one would have a single registry that would be used to track the end-to-end problem of how individuals are selected, how they are contacted, and how the vaccines are administered. This, however, is not how healthcare in the United States is administered, so it has to be done on a state-by-state basis. Each state manages its vaccine distribution through local constraints and objectives, which was led to a multitude of solutions.

The problem remains: how can we get vaccines in the arms of individuals efficiently? Efficiency is measured in multiple ways, (i) including providing clear, simple, and transparent methods for individuals to register, (ii) contacting individuals as vaccines start to arrive, (iii) ensuring that individuals get the vaccines based on the assigned priorities, (iv) ensuring that vaccines are not wasted, (v) ensuring that all eligible citizens are informed and have a chance to receive the vaccines, especially those from underrepresented communities, and (vi) ensuring that misinformation about availability, hoarding, scalping, and side effects is reduced to the smallest extent possible.

The challenges in addressing the problems outlined above stem from several underlying structural issues:

- Lack of transparency in terms of vaccine production schedule and access to vaccination centers.
- Many citizens do not use the Internet or are not versatile in its use.
- Vaccine hesitancy stemming from lack of trust in the government, perception of side-effects, and related misinformation.
- One and two-dose vaccines, require to reserve vaccines in three/four weeks (based on the type) for individuals who got their first shot.
- The stringent cold chain requirement makes it challenging to store the vaccines for a long time and then use them within a specified period.
- Game-theoretic issues:
    - Providers and vaccine seekers try and find ways to get the vaccine.
    - Some people will never get the vaccine but should still benefit if others are vaccinated as herd immunity begins to increase.

These structural issues could be solved or addressed in the future through the following computer science research:

- Access to signups and status should be universally accessible and user-centered design should be employed. UX/UI and AI research could enable voice assistants such as Alexa and Siri to help achieve these goals.
- Vaccine signup websites do not scale to the traffic they are receiving. While this can be done because there are existence proofs (commercial online streaming services), it is hard to develop robust, scalable, universally accessible systems on a very short timescale. Research is needed to learn how to very quickly build, debug, and thoroughly test systems for the mass public.
- The rules for who is eligible vary widely and how they are coded in automated systems is unclear. This is an AI research problem: taking human-language specification of the priorities and the goals from public health experts as input, interpreting those in a way that assures high accuracy and fairness, and then continually monitoring the system to make sure it is achieving its goals and adjusting performance as necessary. Such systems should promote compliance with scientifically-based prioritization, but also enable flexibility, fairness, and speed in varied local contexts. These are FAIR (Findable, Accessible, Interoperable, Reusable) Principles, which put specific emphasis on enhancing the ability of machines to automatically find and use.
- Hundreds of thousands of municipalities are fielding their systems. Instead, it may make more sense to employ a few very high-quality community-developed and vetted open-source reference designs that are made freely available and customizable with minimal extra effort.
- Developing an information integration system that could be used to provide easy access to citizens as regards to availability, closest centers, priorities, etc. Some of this is now coming online by state health departments and CDC.

See the initial November 2020 Paper here (https://cra.org/ccc/wp-content/uploads/sites/2/2020/11/Pandemic-Informatics_-Preparation-Robustness-and-Resilience.pdf).

This addendum is part of a new monthly series of pandemic related addendums spurred by the continuing conversations of the Pandemic Informatics: Preparation, Robustness, and Resilience authors.

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