An international supply chain network to respond to epidemics: Lessons learned from WHO priority diseases

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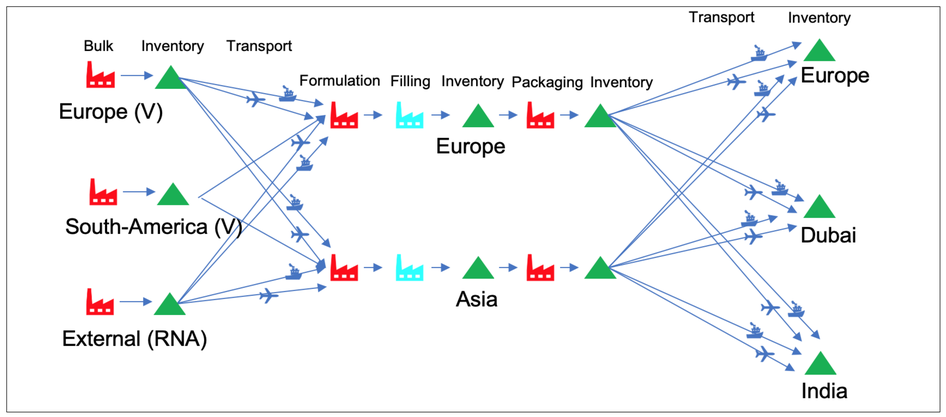
Background

- Vaccines are a strong preventive tool against epidemics. Stockpiling them at strategic locations could mitigate outbreak impact.
- The Coalition for Epidemic Preparedness Innovation (CEPI) defined designing a vaccine manufacturing and distribution network to prepare for disease outbreaks as one of their priorities.
- Designing this network is challenging as it requires a substantial capital investment, while many unknowns and uncertainties reside (e.g., timing and location of disease outbreaks, pathogen type, disease spreading pattern).
- This research looks at 5 of the diseases prioritized by the WHO to focus R&D efforts on: MERS (family of COVID-19), Lassa, Nipah, Rift Valley Fever and Chikungunya. These pathogens are of great importance to countries in sub-Saharan Africa as outbreaks have a considerable impact on the health systems of these countries.

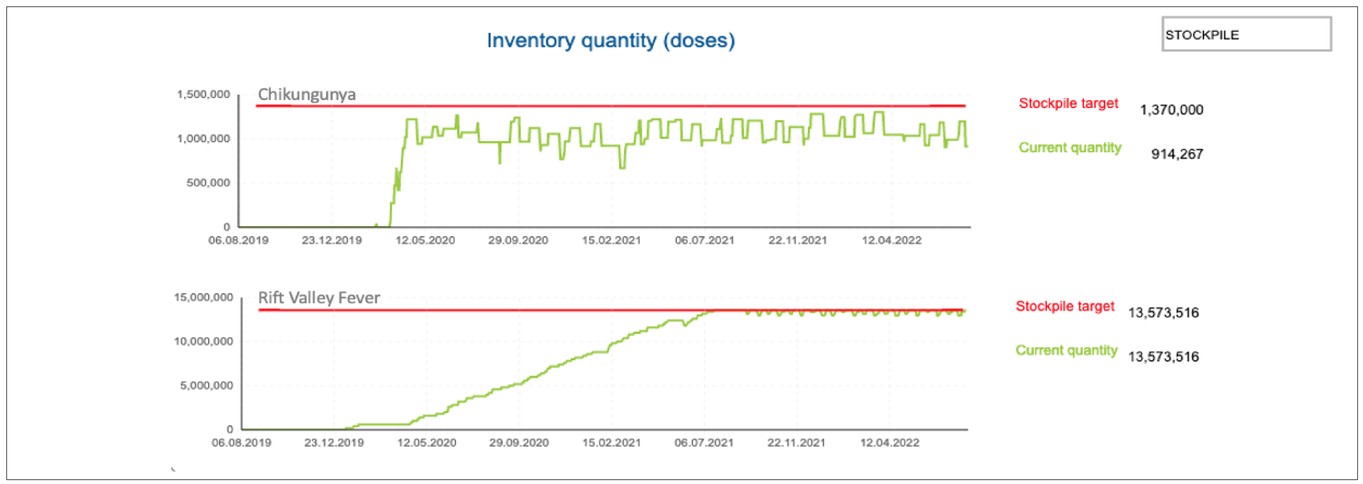
Methods

- Discrete-event simulation model to test performance of supply chain designs in different outbreak and stockpiling scenarios.
- Main model characteristics: global supply chain locations (manufacturing, warehousing and transport), large uncertainty in the volume and timing of the vaccine demand, and multiple vaccines sharing manufacturing capacity.
- Close collaboration with CEPI through regular focused sessions with experts to include the latest knowledge.



Results

- Given a specific capacity investment (i.e., number of bioreactors in each location), we show how long it takes to build up the desired outbreak stockpile levels and how the stockpile is affected by an outbreak and/or routine (smaller and local) demand. Example:



- Insights on supply chain design elements that impact the time to reach the desired stockpile:
  - **As regulatory release time** is part of the critical path, ensuring a fast release process is crucial to lower the time needed to reach the desired stockpile levels.
  - **Inventories** at all factories in the supply chain are especially valuable to hedge against shocks observed by the final inventory caused by vaccines that are expired in the stockpiles.
  - **Sequence of vaccine production** (batches) in shared facilities had a significant impact.
  - **Shared capacity** between vaccines with a similar outbreak/demand pattern should be avoided.

Conclusions

- We develop a generic model that can be easily adapted to include a variety of pathogens and potential vaccine candidates. Currently, we are extending it to the COVID-19 vaccine candidates.
- Our results contribute to discussions by CEPI and policy makers regarding: (i) strategic capacity investments needed in the supply chain network to prepare for outbreaks of any of the investigated pathogens, (ii) the effect of speeding up regulatory release processes, and (iii) managing the expectations with respect to universal coverage and equity.
- In case of large outbreaks, this model serves the humanitarian actions related to the outbreak response.