

---

# Guest editorial: Vaccine supply in perspective: from end-to-end supply chains to full-fledged immunization systems

---

## Background

Infectious diseases pose a serious threat to global health and the economy, as the COVID-19 pandemic has painfully shown. The recent evolutions emphasize again that the pandemic is not yet fully over and it may stay with us for a long time. As such, we trust that this Special Issue contributes directly or indirectly to an improved preparedness and subsequent response.

In terms of prevention, vaccines are widely recognized as a powerful tool to fight epidemics. However, not only is the development of vaccines challenging but also the manufacturing and distribution of vaccines on a potentially global scale is anything but trivial. This requires a substantial investment, both in physical and human capital, in which many unknowns and uncertainties reside. To avoid delays once the vaccine candidates are ready for scale-up, a global and sustainable vaccine manufacturing and distribution network needs to be established, both to support planned immunization as well as to be prepared for outbreak response. It has been observed that the pandemic supply chains in many situations relied heavily on the routine vaccine supply chains. Therefore, in an End-To-End approach (De Boeck *et al.*, 2019; Lemmens *et al.*, 2016), multiple aspects of the supply network need to be considered and coordinated, in a way that many upstream decisions and aspects in R&D have a considerable impact on the downstream supply network up to the very last mile and point of vaccination.

However, modeling the supply chain is only part of the job. In an extended End-To-End view, a system-wide approach is mandatory. At the point of vaccination the vaccine supply system meets two other crucial flows: the capacity to vaccinate and the person to be immunized (Decouttere *et al.*, 2021a, 2021b). The capacity to vaccinate includes the contextual setting of the health service providing vaccination and encompasses both physical and human resources. All equipment, facilities and commodities are equally crucial to skilled vaccination healthcare workers. The presence of the person to be vaccinated is the outcome of the complex demand side part of the immunization system. It entails

various aspects of access to vaccination services, ranging from very practical and material issues (e.g. outreach), over information, communication and support, up to hesitancy, with its constituting factors of convenience, confidence and complacency.

Even more, a successful vaccination is not the end-point. Here the feedback kicks off with the assessment of the health outcomes of the vaccination operations. Based on this, vaccination strategies and (inter)national immunization plans are adapted, modified and refined, and are aligned with funding and procurement engagements. At this point sustainability and a long-term perspective are at stake which connect back to the R&D and manufacturing aspects of the End-To-End supply network.

As a final remark, a well-performing planned immunization system will reduce the frequency of activation of outbreak response mechanisms.

Despite the current focus and intense attention to COVID-19 response on almost every aspect of vaccine supply, integrated systems-based research embedding vaccine supply remains scarce (Decouttere *et al.*, 2021a, 2021b). This Special Issue aimed to address this aspect of vaccine supply chains, in a way to make them more sustainable and resilient to withstand future challenges.

As a response to the call for this Special Issue, the Guest editors received multiple submissions. All submissions were subject to the regular review process of the *Journal of Humanitarian Logistics and Supply Chain Management*. After several rounds of review, the outcome lays down here. We suggested six articles in the Call for Papers, and it turned out that we organically landed at six contributions. It turned out to be the wished mixture of both qualitative and conceptual as well as quantitative and modeling articles that put vaccine supply chains in their broader context. Additionally, the papers make contributions on the aspect of sustainability, practical relevance and/or applicability.

The first paper “A Two-Regime Analysis of the COVID-19 Vaccine Distribution Process”, by Hedge, Mahmassani and Smilowitz, kicks off on the aspect of vaccine distribution by considering demand and supply constraints simultaneously. Both regimes, supply-constrained modeled as limited capacity as well as demand-constrained modeled as hesitancy, are analyzed using queueing, varying across the United States. It showed from an End-To-End supply chain perspective, that supply was basically constrained by last-mile administration issues and not manufacturing and transportation issues.

In the second paper “COVID-19 Vaccine Order Allocation: An Optimization Model with Substitution”, by Sarigol, Ozdemir and Bayraktar, the issue of vaccine allocation is tackled. Based on a weighted-sum minimization approach, a compromise among inefficiently vaccinated people, postponed vaccinations and purchasing costs. By studying various uncertainty levels through scenarios and using vaccine substitution ratios, insights for vaccine allocation are obtained.

The third paper “Vaccine Network Design to Maximize Immunization Coverage”, by Russell, Goentzel, Carretti and Hashimoto, studies vaccine network design with the objective of maximum coverage. Through a collaboration with UNICEF to increase routine immunization coverage in Low and Middle-Income Countries with the primary objective of community outreach, network approaches were applied to design vaccine networks intended for pandemic vaccination response. The

---

The current issue and full text archive of this journal is available on Emerald Insight at: <https://www.emerald.com/insight/2042-6747.htm>



Journal of Humanitarian Logistics and Supply Chain Management  
13/2 (2023) 109–110  
© Emerald Publishing Limited [ISSN 2042-6747]  
[DOI 10.1108/JHLSCM-05-2023-133]

approach focuses on distribution with the primary decisions of facility location and resource deployment, while taking demand considerations into account using a mixed integer programming approach and combining empirical research and spatial analysis.

The next paper “Enhancing the Environmental Sustainability of Emergency Humanitarian Medical Cold Chains with Renewable Energy Sources” by Saari extends toward sustainability by focusing on the cold chain aspects of vaccine supply chains. Using qualitative research methods complemented with literature findings, the opportunities and barriers to applying renewable energy sources in emergencies are studied to reduce the environmental impact.

The fifth paper “A Lean-Agile Green (LAG)based framework to overcome the challenges of the sustainable vaccine supply chain: an Integrated Best Worst Method (BWM)– Measurement of Alternatives and Ranking to Compromise Solution (MARCOS) approach”, by Yadav and Kumar uses qualitative ranking methods to assess challenges and solutions with respect to vaccine distribution in Low and Middle-Income Countries. Wastage, stakeholder coordination and management support turned out to be the hardest issues.

The sixth paper “Investigating sustainable development for the COVID-19 vaccine supply chain: a structural equation modeling approach”, by Mukherjee, Baral, Chittipaka, Pal and Nagariya studies sustainable COVID-19 vaccine supply chains by making use of structural equations. Relationships between internal process, organizational growth, and three pillars of sustainable development (environmental sustainability, economic sustainability, and social sustainability) are modelled after conducting a survey -based data collection phase.

Finally, the seventh and closing paper “Modeling a closed-loop vaccine supply chain with transshipments to minimize wastage and threats to the public: a system dynamics approach”, by Andiç-Mortan and Gonul Kochan, shows by means of a causal loop diagram causal relationships with respect to vaccine waste management and the consequential public health threats. Several implications for improved vaccine wastage management are suggested, where the

concept of Closed-Loop Vaccine Supply Chain turns out to be a key lever for improvement.

We are grateful to both the authors and the reviewers for their endured time and efforts. The COVID-19 period was hard for all, but researchers working on implementable results and often in response to decision-makers’ demands, were extremely time constrained. There was a huge shortage of writing and reviewing time for all who were engaged in COVID-19 research. Special thanks to the Editor-in-chief, Nezh Altay, for his continued support in getting our work done.

**Nico Vandaele**

*KU Leuven, Leuven, Belgium, and*

**Catherine Decouttere**

*Faculty of Economics and Business, KU Leuven, Leuven, Belgium*

## References

- De Boeck, K., Decouttere, C. and Vandaele, N. (2019), “Vaccine distribution chains in low- and middle-income countries: a literature review”, *Omega*, Vol. 97, pp. 1-19, available at: [www.doi-org.kuleuven.e-bronnen.be/10.1016/j.omega.2019.08.004](http://www.doi-org.kuleuven.e-bronnen.be/10.1016/j.omega.2019.08.004)
- Decouttere, C., Vandaele, N., De Boeck, K. and Banzimana, S. (2021a), “A Systems-Based framework for immunization system design: six loops, three flows, two paradigms”, *Health Systems*, Vol. 12 No. 1, doi: [10.1080/20476965.2021.1992300](https://doi.org/10.1080/20476965.2021.1992300).
- Decouttere, C., Banzimana, S., Davidsen, P., Van Riet, C., Vandermeulen, C., Mason, E., Jalali, M.S. and Vandaele, N. (2021b), “Insights into vaccine hesitancy from systems thinking, Rwanda”, *Bulletin of the World Health Organization*, Vol. 99 No. 11, pp. 783-794, doi: [10.2471/BLT.20.285258](https://doi.org/10.2471/BLT.20.285258).
- Lemmens, S., Decouttere, C., Vandaele, N. and Bernuzzi, M. (2016), “Integrated supply chain network design models for vaccines: a literature review”, *Chemical Engineering Research and Design*, Vol. 109, pp. 366-384, doi: [10.1016/j.cherd.2016.02.015](https://doi.org/10.1016/j.cherd.2016.02.015).