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Cluster-based lateral transshipment model for the Zambian health supply chain

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In low- and middle-income countries, including Zambia, resource constraints such as chronic shortages of transportation and health center staff, inventory scarcity or poor road conditions result in unreliable distribution of health commodities leading to high stock-outs and high variation in service levels across health facilities. When facing stock-outs of health commodities, health facilities often reach out to other, nearby facilities. Our work investigates how transshipments improve system-wide service level, equity across facilities and average inventory held of malaria medicines in Zambia's public pharmaceutical supply chain. The distribution problem of malaria medicines is challenging as it is heavily impacted by the rainy season leading to seasonality and uncertainty in both demand and lead times, lost sales and heterogeneous delivery locations.

We propose a scalable cluster-based transshipment model that is able to include a high number of facilities in a cluster and explicitly considers the key features related to the resource-constraint setting of our problem. Deep reinforcement learning (DRL) has been coined as a promising research avenue for policy-making as it requires little domain knowledge and does not rely on restrictive assumptions. Current applications of DRL in inventory control, however, mostly assume stationary environments and little work has applied DRL to problems that are grounded in practice (characterized by realistic and challenging features). We therefore analyze the (added) value and usefulness of DRL for policy-making in humanitarian settings by comparing its performance to currently available, easy-to-use heuristics (that can be more easily implemented). We validate our approach on a case study of 212 Zambian health facilities. Numerical experiments indicate that when system-wide inventory is scarce, advanced solution methods such as DRL may be worthwhile as they can find policies with improved service level equity compared to transshipment heuristics. Clustering has, however, a big impact on final transshipment performance and is recommended to take service levels into account when assigning facilities to clusters.