<NET-HACK> 2022 Integrated Network Infrastructure for PPE Redistribution during Pandemics

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Abstract

Rising demand, panic, and misuse of PPE during the onset of the COVID-19 pandemic led to a gross imbalance of PPE distribution, which exacerbated the lethality of the pandemic and applied additional mental and physical pressure on healthcare workers and their patients [2]. To combat this problem, Team 4 proposes the Integrated Network Infrastructure for PPE Redistribution (INI-PR), a more efficient, UAV-based, regional redistribution chain to enable effective utilization of PPE among collaborating Healthcare Facilities during Pandemics.

Problem Background

- A main perpetrator of the PPE imbalance during past pandemics was inefficient supply chain protocols, which restricted hospitals from freely redistributing excess equipment due to contracts with third-party suppliers.
- During the COVID-19 pandemic, the WHO announced severe and mounting disruption to the global supply of PPE, reporting that demand was 100 times higher than baseline, and that costs were 20 times higher [2].
- The WHO also reported that 11% of Healthcare workers reported that they had no PPE or other medical equipment available to last for even 1 day [2].
- Additionally, these supply chain issues disproportionately affect smaller, rural communities
- INI-PR will be independent of distribution centers and allow Healthcare facilities, with higher cases, infection rates, and other relevant metrics, receive PPE much faster.

Objective

Dynamically redistribute personal protective equipment from healthcare facilities with excess equipment to facilities that would greatly benefit from the equipment given current transmission rates, patient capacity, and total cases.

Solution and Impact

Components:

1. Spatiotemporal analysis of regional hospitalization and equipment-utilization trends to predict future demand and equipment imbalances.
2. Drones for rapid redistribution of medical surplus and quick response to unforeseen circumstances.
3. Standardized database infrastructure for retrospective inventory and billing of redistributed supplies.

Result: More equitable use and distribution of medical equipment in times of crisis, which would reduce stress and save lives.

Feasibility and Previous Research

- During the COVID-19 Pandemic, China introduced a UAV based approach to transport medical equipment to harder to reach regions. This effort highlights the feasibility and growing impact of UAVs on mitigating the affects of pandemics [1].
- Leveraging Machine learning alongside current Supply Chain systems and previous work in Drone Delivery Models supports the production of such infrastructure [4].
- Estimated total cost for the system is $24,000 - $54,000 depending on the scale of system. Major expenses include UAVs and the Database infrastructure.

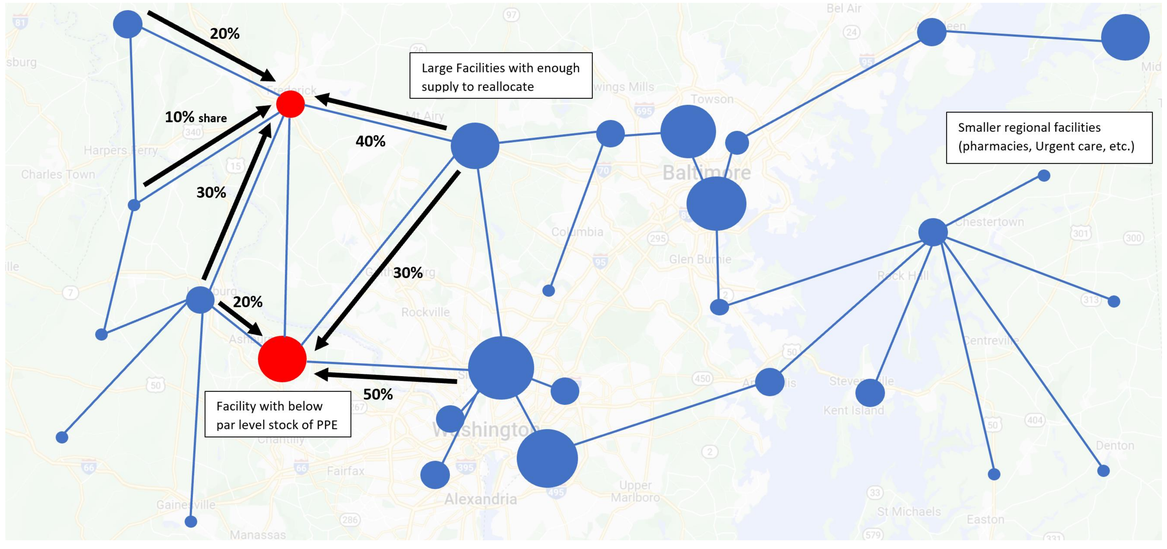
Opportunity and Challenge

- INI-PR will allow Healthcare facilities to receive adequate supplies within a day during emergency situations without the reliance on third party distribution centers. INI-PR will also be cost effective as it does not require overproduction and misallocation of PPE. The implementation of UAVs will allow for time sensitive redistribution.
- Use of UAVs may require additional Federal approval and governance through the FDA and FAA. Recent advances have allowed for special permission UAV fly zones, particularly in the case of medical emergencies [3].
- Possible UAV challenges include technically difficulties and inclement weather during deliveries [3].

Solution Explanation and Model

Initialize network of healthcare facilities based on region, system, etc. → Create Database to track current par level stock of PPE in each facility; Track patient and case trends → Deploy ML Model (regression & classification) to predict adequate PPE levels needed → Apply classification model to locate facilities with emergency shortage of PPE at any given time → Deploy BFS to locate nearby facilities that can feasibly reallocate supply via UAVs

Integrated Network Infrastructure for PPE Redistribution for Baltimore-Washington Metropolitan Area



This illustration gives a graphical representation of INI-PR for the Baltimore-Washington Metro Area. The model highlights two facilities requiring immediate restock of PPE given rise in new emergency cases. INI-PR locates the nearest neighbors that are equipped with enough PPE and deploys UAVs to transport the PPE in a time-effective manner.

References and Acknowledgments

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