Emergency Medical Response Optimization in Developing Urban Centers

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The lack of emergency medical transportation is viewed as the main barrier to the access and availability of emergency medical care in low and middle-income countries (LMICs). In this talk, we present a robust optimization approach to optimize both the location and routing of emergency response vehicles, accounting for uncertainty in travel times and spatial demand characteristics of LMICs. We traveled to Dhaka, Bangladesh, the sixth largest and third most densely populated city in the world, to conduct field research resulting in the collection of two unique datasets that inform our approach. This data is leveraged to develop machine learning methodologies to estimate demand for emergency medical services in a LMIC setting and to predict the travel time between any two locations in the road network for different times of day and days of the week. We combine our robust optimization and machine learning frameworks with real data to provide in-depth investigation into three policy-related questions. First, contrary to standard practice in high-income countries, we demonstrate that outpost locations optimized for weekday rush hour lead to good performance for all times of day and days of the week. Second, we find that significant improvements in emergency response times can be achieved by re-locating a small number of outposts and that the performance of the current system could be replicated using only 30% of the resources. Lastly, we show that a fleet of small motorcycle-based ambulances has the potential to significantly outperform traditional ambulance vans. In particular, they are able to capture three times more demand while reducing the median response time by 42% due to increased routing flexibility offered by more nimble vehicles on a larger road network. Our results provide practical insights for emergency response optimization that can be leveraged by hospital-based and private ambulance providers in Dhaka and other developing urban centers.