**Research Statement**

As a PhD student specializing in operations research, my research interests mainly lie in combinatorial optimization problems that arise in supply chain management. The main focus of my research has been developing efficient heuristic algorithms for NP-Hard problems that are typically modeled as mixed integer nonlinear programs with stochastic elements. With specific applications in scheduling and strengthening, the problems that were addressed in the context of healthcare, distribution, and infrastructure networks.

**Graduate Research Experience**

During my graduate studies I had the chance to explore and gain experience in a variety of areas. My early work completed during my master’s studies, *Learning Price Promotion Effects on Recurring Sell-In Purchases from Simulated Store Level Sales Data*, employs Bayesian hierarchical models for order quantities in a wholesaler’s revenue maximization problem and uses a hybrid of different Markov Chain Monte Carlo methods to update model parameter posterior distributions. My doctoral research experience spans a variety of research streams from healthcare scheduling to network resilience.

1. **Network Resilience**

The first work, *Fortifying Distribution Network Nodes Subject to Network-Based Disruptions*, submitted to IISE Transactions, considers a distribution network that delivers a good or service to a set of nodes, each of which serves a set of customers. All network nodes are vulnerable to a future disturbance due to a potential natural or man-made disaster, the severity of which follows some measurable probability distribution. For each node in the network, the aim is to determine a fortification level that enables the node to withstand a disturbance up to a given severity level, while minimizing the expected number of customers who experience a service interruption under a limited fortification budget. This optimization problem is formulated as a continuous, nonlinear knapsack problem with precedence constraints and demonstrated as NP-Hard for general tree networks and general disturbance severity distributions. The study provides a polynomial-time solution algorithm for serial systems, which forms the basis for an effective heuristic approach to problems on tree networks. Computational test results demonstrate the ability of the proposed heuristic methods to quickly find near-optimal solutions.

The second work, *Fortifying Distribution Networks Against Node-Based Disruptions*, considers a similar problem setting as the previous work, which consists of a distribution network in which each node receives flow via a path from one or more source nodes, implying that a node's service level depends on flow from upstream nodes. Building on the previous work, this study expands the setting by assuming different disruption levels affecting each node. The problem is shown to be NP-Hard for general tree networks and general disturbance severity distributions. The study develops a heuristic algorithm for serial systems by forming ‘supernodes’ that are based on iteratively reducing the problem into two-node subsystems and finding the exact solution using the KKT conditions for each, while providing the exact solution for two-level network systems. Computational test results establish the effectiveness of the proposed heuristic approaches in terms of generating fast and near-optimal solutions. Currently, this work is being extended to include convex cost functions for fortifying the nodes and multiple sources that could provide service through different paths in the network. Addressing these challenges could better reflect the characteristics the real-life distribution networks that are vulnerable to natural hazards and manmade disruptions.

1. **Healthcare Applications**

The first work, *Block Scheduling in Two-stage Outpatient Clinics: Appointment Template Design*, submitted to IISE Transactions, develops an outpatient appointment scheduling system for two-stage outpatient clinics under patient heterogeneity and service time uncertainty. The problem setting consists of a two-stage outpatient clinic with one physician’s assistant in the first stage and one physician in the second, in which all patients receive treatment first at stage 1, and may continue to stage 2 if they need further treatment. The objective of the study is to find daily appointment templates, based on block scheduling, that minimize a weighted sum of performance metrics, including the healthcare providers’ idle time and overtime and patient waiting time. A block schedule divides the overall schedule into several time blocks and assigns patients of different types into each block in proportion to their daily demand. In this way, the workload is balanced throughout the day and for multiple blocks. Since the problem is shown to be strongly NP-Hard, a heuristic algorithm was developed. The study was expanded to include stochastic service times and a stochastic programming model. The heuristic algorithm provides a no-idle time appointment template that is easily implementable under deterministic service times and yields an efficient block schedule under practically relevant conditions with service time uncertainty. Comparing the heuristic to a First Come, First Appointment scheduling rule, it was demonstrated that the heuristic is able to better minimize provider idle time, which mimics many real-life settings where clinics prioritize the efficiency of the healthcare providers.

The next work, which was completed as a part of a research group with multiple collaborators, *Hospital Diversity Management Programs: Community Diversity Factors and Hospital Outcomes*, submitted to International Journal of Operations & Production Management, examines the association between hospital diversity management programs (DMP) and hospital performance outcomes using empirical analysis on panel data merged from the American Hospital Association, the United States Census Bureau, the Centers for Medicare and Medicaid Services, and the Hospital Consumer Assessment of Healthcare Providers and Systems. The theoretical framework was grounded in social categorization theory to understand mechanisms driving DMP use in healthcare organizational contexts. The study reveals significant antecedents associated with hospital DMP use, including positive associations with a county diversity index and population. DMP maturity is found associated with patient experience metrics. The associations are often more pronounced in high-diversity counties.

**Future Research Agenda**

My future research plans include but are not limited to continuing the streams of research that I have been exploring throughout my master’s and doctoral studies. Although I was able to focus on supply chain management problems with a specific focus on network resilience and tackle a broad set of problems that arise in healthcare through scheduling and diversity related studies, there are many more promising directions within these areas that can further be explored. With the skills acquired and the perspective gained through graduate research experience, it is possible to extend the application areas to broader classes of problems and application areas that fall within operations research and supply chain management, such as disaster management, energy systems, logistics, and healthcare management. In addition to the methodologies I used so far during my graduate studies, I am planning to integrate reinforcement learning tools into my research in order to provide a new perspective to the challenges that are currently being studied. My plans for future research projects are summarized below along with the possible funding opportunities.

1. **Network Resilience in Disaster Management**

Network resilience has been gaining attention in the literature, especially in the context of infrastructure \citep{liu2022resilience}, road \citep{rivera2022road} and power \citep{bhusal2020power} networks. In the context of distribution networks, including critical infrastructure for water, power, gas, and communication, which are essential for everyday life \citep{karakoc2019community}, random perturbations arise in the form of unexpected events such as natural disasters that can reduce or eliminate the ability to function at one or more nodes. Such network disruptions caused notable economic, societal, and physical losses over the past years \citep{biswas2024review}.

The previously mentioned doctoral work primarily focused on the preparedness phase of the resilience planning, which consisted of node strengthening efforts subject to limited resources. In order to approach disaster management problems through a comprehensive lens, my research agenda includes exploring the response phase. Infrastructure recovery attempts incorporate timely allocation of scarce repair resources in affected nodes \citep{sharkey2019quantitative} as well as efficiently identifying the areas in need. These problems accentuate the challenges of disaster management as simultaneously optimizing all aspects of resilience is often considered impractical \citep{sharkey2021search}.

Funding Opportunities

Due to the severe impact of potential and uncertain service disruptions in a variety of infrastructure systems and distribution networks, insights derived from this stream of research can be applicable to many areas. This aspect enables collaboration opportunities with several organizations and funding agencies such as Department of Energy (DOE), Department of Transportation (DOT), and National Science Foundation (NSF). The Disaster Risk and Resilience focus of NSF, which promotes resilience against natural hazards, aligns with the goals of the intended research project. University Transportation Centers and Federal Transit Administration Grant Programs are some of such funding opportunities within DOT, whereas the Advanced Research Projects Agency of DOE could also provide support for the specific applications of network resilience problems.

1. **Healthcare Operations Management**

Increasing the efficiency and effectiveness of the healthcare system is a challenge faced by healthcare providers worldwide. This is an especially important issue in outpatient clinics due to increasing demand. Outpatient services consist of low-acuity medical services that do not require an overnight stay \citep{deceuninck2018outpatient}. Lower costs \citep{davis1972substitution,stgeorge2021}, improved patient experience, and the use of newer technologies \citep{vitikainen2010substituting, uncwo2021} are some of the factors that attract patients to outpatient services. Patient scheduling is a major factor that impacts efficiency in healthcare systems \citep{sun2021stochastic}. In particular, outpatient clinics need to develop appointment templates to balance minimizing provider idle time and overtime with reductions in patient waiting time \citep{zacharias2017managing}. Despite efforts in the literature to design an optimal appointment template that minimizes total costs, the solutions provided are often not adopted by outpatient clinics due to difficulties in implementation \citep{huang2012alternative}.

Outpatient services include but are not limited to imaging services, ambulatory surgery centers, specialized clinics, and primary care clinics, which each bring different structures, processes, and unique needs. Therefore, in order to be able to generalize the insights derived from the research conducted during doctoral studies, delving into these structures in more detail is crucial. Studying more dynamic and more realistic systems where the patient type is not known or determined upon initial examination and in the presence of walk-in patients could help provide a better understanding of these systems while designing efficient and practical appointment templates.

Funding Opportunities

The nature of the problem under consideration allows for collaboration with local outpatient clinics, hospitals, and National Cancer Institute-designated cancer centers. Additionally, the funding opportunities on programs such as disease prevention, women’s health, minority health and health disparities offered by the National Institutes of Health (NIH) can be applicable based on the specific problem setting of the research projects.

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**References**

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