LOCMED
Locating and Sizing Mobile Healthcare Units in Medical Deserts

This research project aims to develop an artificial intelligence (AI) tool capable of proposing solution scenarios for the problem of locating and sizing mobile healthcare units to improve access to care in medical deserts. The goal is to maximize territorial coverage while considering patient needs, caregiver availability, and uncertainty in healthcare service demand. The tool will deliver acceptable AI solutions by prioritizing population needs.

One of the most pressing issues in the French healthcare system today is the existence of medical deserts. The system struggles to provide equitable access to healthcare services across the country due to the uneven distribution of healthcare professionals, which creates underserved areas, often in rural or less attractive regions. This problem is exacerbated by the aging population. According to Santé Publique France, seniors make up one-quarter of the French population and could reach one-third by 2050. This demographic trend signifies increased demand for healthcare services and challenges the French healthcare system. The aging population further intensifies healthcare needs, necessitating improved medical services, particularly in underserved areas. Proximity hospitals and mobile units, as defined by law, can provide an effective solution by bridging primary and specialized care, and in some cases, enabling patients to remain at home. However, their location and staffing must be meticulously planned, considering available human resources and budget constraints.

From a managerial perspective, addressing healthcare coverage in medical deserts raises questions about the choice of infrastructure, their location, and their respective capacities in terms of healthcare personnel. These challenges must be addressed despite incomplete knowledge of healthcare needs (e.g., type, quantity, and location) and uncertainty regarding available human resources. The COVID-19 pandemic exemplified an unexpected surge in demand, likely impacting caregiver availability. At the same time, financial resources are limited, and solutions must work within budget constraints. Thus, the efficiency of the healthcare network is critical for ensuring the system's financial viability. This project aims to propose an integrated approach to these challenges.

The problems of facility location and sizing have been extensively studied in healthcare contexts but rarely in an integrated framework where location decisions are influenced by planning considerations. This integration is more common in supply chain management literature, though in that context, capacity is not tied to human resources.

A recent study addressing a similar healthcare issue is presented in [3]. The authors examined the location of COVID-19 testing facilities, integrating capacity sizing for test kits. Their two-phase approach determines locations and sizes in the first phase and dynamically adjusts poor decisions in the second phase. However, this approach is unsuitable for the current case, as increasing the number of doctors or nurses may not be feasible considering the chosen locations. The availability and needs of healthcare personnel must be considered from the outset for obtaining adaptable solutions.

While studies on healthcare infrastructure location exist, few integrate these decisions with human resource planning. This project proposes an integrated approach where the location of mobile health units and team sizing are jointly optimized to meet patient needs while respecting financial and human resource constraints. The project aims to develop a robust approach, providing feasible solutions under various future demand scenarios. These scenarios will be constructed predictively using machine learning (ML) tools, with the explicability of the predictive process being critical. Thus, developing explainable AI is an intrinsic part of this project.

Summary of Main Goals and Expected Outcomes:

- Integration of demographic and healthcare needs data to construct future demand and supply scenarios using explainable AI.
- Mathematical modeling of the joint problem of locating mobile health units and sizing teams, accounting for demand uncertainty.
- Development of an efficient algorithm to solve the mathematical problem.
- Case study in the Hauts-de-France region.

To Apply:
Send a CV, Master's grades, internship reports, and recommendation letters to:
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Host Laboratory
Laboratoire Modélisation, Information & Systèmes (UR UPJV MIS 4290)

The MIS Laboratory (Research Unit UPJV 4290) has been developing a cross-disciplinary focus across all its teams on e-Health topics since 2017. This focus already encompasses projects addressing healthcare organization (e.g., LORH, 3-PU), medical decision support (e.g., PSPC PIA3 Smart Angel, e-Moove, Autism Spectrum Disorder Characterization Support, GRECO), patient mobility (e.g., ANR ADAPT), and robotic surgery assistance (e.g., GRECO).Regarding robotic surgery, MIS is the founding STIC/SPI research unit of the *Group for Research and Studies in Robotic Surgery* (GRECO), in partnership with two Health Research Units (UR SSPC and UR CHIMERE) and the CPA SimUSanté Health Simulation Center. MIS is also one of the three core units of the recent PIA4 MAIA initiative, a laureate of Wave 2 in the AAP Excellences Under All Its Forms program. For this project, MIS is the lead organization for application domains involving AI in healthcare.The LOCMED PhD project is directly aligned with the MIS Laboratory's e-Health focus area.

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