A metaheuristic approach for integrated nurse routing and rerostering in hospital-at-home

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The global demographic shift toward an aging population has driven a rising demand for medical services. This trend requires adaptation and innovation within the healthcare sector to address the growing demand despite limited resources. One such innovation is the "hospital at home" (HaH), also known as "home hospitalization", which substitutes for inpatient care by delivering short-term treatment for acute illnesses directly at patients' homes. The expected benefits of HaH include: increased capacity of the institutional health care systems, potential cost savings, improved patient quality of life, and shorter length of stay [3].

Having an acute illness, patients in HaH need intensive care for a limited period. As a result, the fluctuations of the patient mix are greater than those observed in classical home health care systems. Since the availability of resources also evolves over time, it becomes a challenging task to match the available resources and the patient needs.

This study focuses on the operational planning decisions in HaH services over a one-week horizon, taking into account the information available at the beginning of the week regarding the patient list and the availability of nurses. Given a baseline roster and the actual availability of nurses, and considering the needs of new and existing patients, several operational decisions are taken simultaneously: select new patients to be admitted, decide whether and to what extent the baseline roster should be updated, and schedule the care visits to build the daily route of each nurse. Generally, the underlying task scheduling, nurse routing, and nurse rerostering subproblems are solved independently in the literature due to computational practicality [2]. However, this sequential decision-making approach may lead to suboptimal or even infeasible solutions, as these subproblems are strongly intertwined.

A lexicographic objective function is employed first to maximize the number of patients treated at home and second to minimize the total working duration of the nurses. A variety of complex real-world characteristics are considered, yielding a rich integrated problem. The routing subproblem addresses additional constraints associated with home healthcare services, including aligning the medical skills of nurses with the needs of patients and respecting time windows for treatment administrations [1]. When rerostering is necessary, compliance with institutional working hour regulations, including limits on working days and forbidden shift sequences, is essential [4]. Additionally, the continuity

of rostering constraints between consecutive weeks must be maintained and care for the existing patients must be ensured.

This work proposes a metaheuristic approach to solve the integrated nurse routing and rerostering problem. The approach allows exploration of infeasible solutions during the search by relaxing time windows, rostering, and rerostering constraints. The proposed algorithm iteratively improves incumbent solutions through embedded loops. The outer loop modifies the set of admitted patients. The inner loop improves the nurse roster and routes associated with the current patient set. Destroy-and-repair mechanisms are employed to modify the patient set and solve the routing subproblem. A guided local search is integrated into the metaheuristic to restore the roster feasibility and to refine its performance. In this talk, new benchmark instances for this integrated problem will be introduced. The effectiveness and performance of the proposed solution approach will be demonstrated by discussing some numerical results. Finally, practical insights will be provided through some managerial analyses.

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