

An integrated approach to operational scheduling in hospital-at-home

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Recent advances in digital health technologies have driven the emergence of hospital-at-home (HaH) programmes over the past decades. HaH programmes deliver short-term, hospital-level treatments in patients' homes for conditions that would otherwise require inpatient hospitalization. The benefits of such model ranging from improved hospital resource utilization to enhanced patient comfort and well-being [4].

HaH admissions depend not only on the medical conditions and home environment of each patient, but also on the hospital capacity. One of the factors constraining resource capacity is the work schedules, referred to as rosters, of hospital nurses responsible for delivering HaH services. These rosters are typically constructed several months in advance, taking into account anticipated patient demand and nurse availability, as well as legal constraints and contractual agreements. As real-time information on patient requests and nurse availability becomes available, the initial roster can be adjusted to allocate HaH resources more effectively and maintain a high level of service. In this work, the process of updating the baseline roster, referred to as rerostering, is triggered by the arrival of new patients at the beginning of each week.

Our study addresses the operational level complexities of HaH scheduling by simultaneously making the following weekly decisions: selecting eligible patients for HaH admission, adjusting the roster as needed, assigning nurses to specific care tasks, and scheduling daily care visits for each nurse. Specifically, the present work integrates the home health care routing and scheduling problem [1] and the nurse rerostering problem [2], giving rise to the nurse routing and rerostering problem. The objective of the problem is defined in lexicographic order: it first maximizes the number of admitted patients to HaH, and then minimize the total routing duration of all nurses. The routing subproblem explicitly considers the compatibility between nurses' skills and the skills required by patients. When rerostering is necessary, adherence to legal and contractual constraints must be preserved. In our work, deviations from each nurse's schedule in the baseline roster are limited. Furthermore, this study implements a stepping horizon approach [3] to maintain continuity in respecting rostering constraints and in delivering the treatment for ongoing patients.

Two neighborhood search-based solution algorithms are specifically designed to address the interplay among different decisions in this rich and highly integrated problem. During the course of the algorithms, infeasible solutions are

allowed to be visited by relaxing time window, rostering, and rostering constraints. Both algorithms have the same structure consisting of an outer loop that modifies the set of admitted patients and an inner loop that improves the performance of rostering and routing subproblems. The main difference between the proposed algorithms lies in how patient set is constructed and modified. Destroy-and-repair mechanisms, inspired by large neighborhood search, are employed for modifying the patient set and refine routing-related performance. Classical local search operators are employed to restore feasibility with regard to rostering and rostering constraints.

The talk will first introduce new benchmark instances specifically built to represent typical HaH cases. It will then present numerical results that demonstrate the effectiveness and performance of the proposed solution approaches. Finally, insights into the impact of several instance parameters will be discussed, with a particular focus on treatment characteristics that enable the admission of more patients to the HaH system.

References

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