Nurse Scheduling Problem under uncertainty

Salma MAKBOUL[1], Abderrahman ABBASSI[2], Adnane ELHILALI ALAOUI[3]

[1]Modeling and Scientific Computing Laboratory, Faculty of Sciences and Technologies, Sidi Mohammed Ben Abdellah University, Fez, Morocco

salma.makboul@usmba.ac.ma

[2] Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakech, Morocco

Abbassi.office@gmail.com

[3] ENSIAS CEDOC ST2I, Mohammed V University, Rabat, Morocco

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1. Introduction

In past years, scheduling problems have received a lot of attention as they are based on the effect concept that maximizes the profitability of organizations. Nurse Scheduling Problem (NSP) is the assignment of a number of nurses to a number of shifts. The scheduling must take account of financial considerations and the rules and guidelines on working practices, as well as attempting to meet the preferences and requests of each nurse, and the availability of nurses. The generation of high-quality schedules can lead to improve hospital resource efficiency, staff and patient safety and satisfaction, also administrative workload. The main target of NSP is to assign a number of nurses with different grades to each shift, while minimizing the hospital's cost, and maximizing the nurses' preferences. In this paper, we propose a new formulation of the NSP and a robust formulation for the problem using the worst-case criterion.

2. Problem description

The main target of NSP is to assign several nurses to each shift while minimizing the hospital's cost, and maximizing the nurses' preferences [1],[3].
Several factors are affecting the NSP: The governmental regulations, labor laws, hospital policy, in addition to the status and the preferences of nurses. In NSP, there are three main terms:

- **The planning horizon**: the time covered by a plan
- **Shift**: the day is divided into time slots called shifts
- **Day off:** a day when a nurse has no work.

The planning horizon is a certain number of days (usually considered as a week). In our work each day is divided into 12 shifts, and one shift is 2 hours. So, each day is 4-morning shifts, 4-afternoon shifts, and 4-night shifts. Moreover, each shift has several nurses that should be satisfied. We also consider three grades of nurses; the normal nurses (grade 1), the specialists'

nurses (grade 2) and the head nurses (grade 3). Due to hospitals standards, many constraints must be taken into consideration:

- Each nurse must work a specific number of afternoon and night shifts
- Each nurse must have a day off
- Each nurse has a minimum and maximum numbers of shifts to work in the planning horizon
- Each nurse should not work the next morning if he works night shift on a day.
- Each nurse should not work all night shifts of a day if he works morning/afternoon shifts on the same day

We have proposed a new mathematical formulation of the NSP taking into consideration all constraints cited above.

3. Robust Formulation

The worst-case criterion can be considered as the benchmark in robust optimization, when it comes to determining solutions before the realization of uncertainties. In general, its application to an uncertain problem determines the optimal solution in the worst-case scenario. The solution obtained is robust because it guarantees for all eventualities that it can be realized. The demand of nurses of each shift is subject to uncertainties. The constraints of demand of nurses in each shift can be formulated as follows: $\sum_{i=1}^{I} x_{ij} \geq M_j \quad \forall j \in \{1, \dots, J\}$, when J is the number of shifts, I is the number of nurses, M_j is the demand of nurses in shift j and x_{ij} is the decision variable that equals to 1 if the nurse i is assigned to shift j and 0 otherwise. We suppose that the right-hand side $M_j \ (j \in J)$ varies in the interval$[\underline{M_j}, \overline{M_j}]$, so our problem could be considered as a linear program in which the right-hand sides are interval numbers (Gabrel et al [2]).

4. Conclusion and perspectives

We have proposed a mathematical model for the nurse scheduling problem that aims to the minimization of the overall hospital cost, to maximize nurse's preferences and to satisfy the hospital demands. Thus, we have used the worst-case criterion to find the robust solution. We are working on a problem-solving approach based on the tabu search algorithm and our model will be applied to a real case study in a French hospital.

References

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