An integer programming approach to elective surgery scheduling
Analysis and comparison based on a real case

Inês Marques · M. Eugénia Captivo · Margarida Vaz Pato

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Abstract The scope of this work covers a real case of elective surgery planning in a Lisbon hospital. The aim is to employ more efficiently the resources installed in the surgical suite of the hospital in question besides improving the functioning of its surgical service. Such a planning sets out to schedule elective surgeries from the waiting list on a weekly time horizon with the objective of maximizing the use of the surgical suite. For this purpose, the authors develop an integer linear programming model. The model is tested using real data obtained from the hospital’s record. The non-optimal solutions are further improved by developing a custom-made, simple and efficient improvement heuristic. Application of this heuristic effectively improves almost all non-optimal solutions. The results are analyzed and compared with the actual performance of the surgical suite. This analysis reveals that the solutions obtained using this approach comply with the conditions imposed by the hospital and improve the use...
of the surgical suite. It also shows that in this case study the plans obtained from the proposed approach may be implemented in real life.

**Keywords** Health care · Operating rooms · Elective case scheduling · Integer programming

1 Introduction

The health sector has been progressively affected by restrictive budgets that, of necessity, not only call for an urgent need to promote a resource rationalization practice among hospitals but, above all, the demand for greater efficiency in the use of resources and the performance of each service.

The surgical suite is widely regarded as the hospital’s central engine as it has a direct impact in many other hospital departments, such as surgical wards and recovery units. As such, it is deemed a priority to improve the efficiency of this component.

Improvement of the surgical suite’s efficiency may lead to increased productivity, in terms of the number of surgeries undertaken, thus contributing to a reduction in surgery waiting lists. Costs involved in keeping a patient on the waiting list for surgery are high, both at the prevention and the maintenance level, even more so as considering the user’s quality of live. In addition, according to Portugal’s General Direction of Health (2004), reducing surgery waiting lists is one of the priorities of the National Health Service (SNS).

In the literature, operating room planning has been considered to be a three-stage process. Magerlein and Martin (1978), Przasnyski (1986), Blake and Carter (1997) and, recently, Cardoen et al. (2010) present literature reviews on operating room planning.

In a first stage, called *case mix planning*, operating room time is distributed among individual or groups of surgeons. At a strategic level of decision-taking, this stage defines the hospital’s supply for surgery and is usually conducted on an annual basis, together with the definition of the annual hospital budget. At this stage, there are some linear or integer linear programming approaches to solve the planning problem (Hughes and Soliman 1985; Kuo et al. 2003; Robbins and Tuntiwongpiboon 1989; Testi et al. 2007). Also a linear goal programming approach was presented by Blake and Carter (2002).

The second phase involves developing a surgery master schedule, a cyclic timetable that defines the number and type of operating rooms available, the hours that such rooms will be open, as well as determining the surgeons or surgical groups sharing priority in each operating room’s time periods. This phase is referred to as *master surgery planning* and is related to a tactical level of hospital management. There is a greater range of approaches for this stage of operating room planning. Literature varies from integer or mixed integer linear programming models solved by general solvers (Blake et al. 2002; Santibáñez et al. 2007; Testi et al. 2007; Vissers et al. 2005) or heuristic methods (Blake and Donald 2002), to a quadratic integer programming model solved by heuristic procedures, goal programming and