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Set Partitioning Methods for Robust Scheduling: an Application to Operating Theatres Optimisation

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Robust optimisation techniques and simulation models have been used with column generation methods within the framework of a set partitioning problem for the construction of a weekly operating theatre timetable, the Master Surgery Schedule (MSS). The model takes into account the preferences of surgical specialties for weekly theatre sessions, the stochastic nature of surgical demand and the availability of beds on wards for post-operative recovery.

Operating theatres are very expensive and resource-intensive facilities within modern hospitals; the efficiency of which has a significant impact on patient throughput and the patient experience. Operating theatres experience high demand and can also be seen as a driver of demand on wards and other departments in a hospital as surgical patients will often require other services during post-operative recovery.

Hospitals in the UK are increasingly facing the problem of a large proportion of elective operations being cancelled due to the unavailability of beds on hospital wards for post-operative recovery. The availability of post-operative beds is critical to the scheduling of surgical procedures and the throughput of patients in a hospital. The utilisation of the operating theatre schedule and the impact that it has on the demand for beds on hospital wards is investigated in order to better understand this important relationship. The insights gained from this relationship will aid the construction of a robust operating theatre schedule.

A large teaching hospital in Wales, UK, in which over 25,000 surgical operations are performed annually, is used as a case study. Around 18

A large amount of work has been published in both Operational Research and medical journals on the challenging problem of constructing a weekly MSS timetable which assigns surgical specialties to operating theatre sessions whilst taking account a range of restrictions on resources. These resources can be surgeons, skilled nurses, specialist theatre equipment and the operating

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theatres themselves. Other aspects to consider while constructing the MSS are the stochastic nature of the demand from hospital waiting lists and that of different surgical procedures; this includes both the occurrence of emergency patients and the duration of the procedures. The process of creating a theatre schedule can therefore be quite arduous and time-consuming, as often there is no systematic approach employed in hospitals that exploits Operational Research techniques.

The work to be presented includes the constraints of post-operative resource requirements, primarily beds on hospital wards, when constructing a practicable and efficient MSS. A set partitioning based optimisation model is used to assign specialties to operating theatres to construct a MSS, and a novel extension to the formulation is used to incorporate constraints on the demand for beds. Simulation of the resulting MSS is then performed in order to measure how robust the MSS is when different aspects of the uncertainty is realised.

A robust optimisation approach to the construction of the MSS is then developed and compared with the results from the nominal formulation in terms of the MSS satisfying the post-operative bed constraints. Initial results are presented to highlight the potential of these approaches to constructing the MSS.