A cloud-based decision support tool for data-driven strategic capacity planning and analysis in hospitals

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Abstract: Hospitals play a critical role in healthcare, and managing their capacity and productivity is a complex and essential task. Patients expect high-quality care within a short timeframe, and hospitals must have sufficient physical capacity and effective management to provide this. However, hospitals are large, integrated systems that operate around the clock and consist of numerous treatment spaces, staff, resources, and medical equipment. Access to hospital resources is competitive, creating issues with known elective patients versus unknown acute patients. Capacity planning is key to avoiding shortfalls in service, minimising expensive overruns and bloating of wait-lists. The challenge lies in matching assets, resources, and services to intended demand. Implementing adequate IT systems to support capacity planning is another significant challenge, as these systems must provide quality data, ease of access and appropriate analytical functionality to support decision making.

The focus of this presented research is on strategic hospital capacity planning. Rather than considering individual patient level decisions or dealing with variabilities day to day, strategic capacity planning has a horizon from several months to several years. The types of decisions to be made here relate to medium term alterations to the master surgical schedule template (in response to prolonged change in demand or case-mix, e.g. prolonged flu season, wait-list recovery post-covid, etc), out to long term decisions such as population growth and facility expansion. Burdett et al (2017) presented a mixed-integer programming (MIP) aiming to optimise allocation of a prescribed set of resources to hospital specialties and activities to maximise long term patient throughput for a given case-mix scenario. The aim of the research presented here is to determine how to put such an approach into the hands of hospital administrators, and to design and implement a solution to make this happen.

This project is a collaboration between QUT, Princess Alexandra Hospital, Queensland Children's Hospital, and Polymathian, a software company specialising in industrial mathematics. The hospitals have provided de-identified historical patient data spanning several years, providing information on admissions, diagnoses, procedures and timestamped location data for each patient. QUT has developed and provided Python code which replicates some of what is presented in Burdett et al (2017), along with the required data transformation from original de-identified data into input data required for the capacity assessment model. Polymathian trained a Masters student from QUT in use of their software development platform, and guided the student through development of a cloud-based SaaS implementation of the decision support tool. This included databases to manage the datasets provided by QUT, incorporation of QUT's Python model implementation, along with several data-visualisation functions, and the ability to conduct what-if analysis along with a scenario management system. One constraint on the tool was the requirement not to use a solver (due to cost and complexity considerations), and so the original models were modified to provide a what-if analysis capability. This is ultimately less risky and potentially more useful, since there are many complexities and qualitative considerations that make prescriptive capacity planning a fraught exercise.

The decision support tool is called FLOH, with development recently completed and partner hospitals currently trialling and evaluating the tool.

REFERENCES

Burdett, R., Kozan, E., Sinnott, M., Cook, D., Tian G., 2017, A mixed integer linear programming approach to perform hospital capacity assessments. Expert Systems with Applications, 77, 170–188.

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