Benefits of Mathematical Optimisation in Healthcare

Healthcare is playing catch-up with other industries – airline, retail, manufacturing – in terms of research and investment in artificial intelligence (AI), which has the potential to improve care delivery and patient outcomes. However, capturing this potential will require healthcare to first lay the foundation for the successful rollout of AI interventions (Reddy and Scheinker 2020).

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Long before the advent of AI (and its allied field: machine learning), non-healthcare companies have already digitised and streamlined their operations using rigorous methods such as mathematical optimisation. This 'optimisation first' strategy has enabled these companies to adopt AI applications with more success.

With mathematical optimisation, a family of algorithms are used for allocation of resources in order to minimise costs or maximise benefits even under difficult situations. These algorithms have enabled airlines to create efficient staff and flight schedules, while improving route packages and minimising delivery costs for retail giant Amazon.

Essentially, mathematical optimisation provided non-healthcare companies a basis of efficiency for deploying technologies later in AI. For instance, AI now allows airlines to predict which passengers won't show up, helping them to draw up contingency plans. Meanwhile, Amazon relies on AI to create personalised recommendations for each customer.

In contrast, the healthcare industry has largely ignored the use of mathematical optimisation. Despite healthcare's low levels of investment in optimisation, hospitals in particular have potential to benefit from developing sound optimisation practices.

Taking lessons from how airlines applied mathematical optimisation to solving problems on fleet assignment and crew scheduling, hospitals can use optimisation to improve the mostly manual process of matching nursing skills to the appropriate patient cases for the day. By matching nurses to surgical cases – similar to the optimisation model that matched flight crews to flight schedules – the manual burden of hospital managers would be eased while scheduling errors can be avoided.

Essentially, optimisation methods or solutions are aimed at solving specific mathematical problems. How the Massachusetts General Hospital (MGH) used optimisation to reduce overcrowding in patient beds is a good illustration. MGH's optimisation model took into account organisational constraints arising from a very specific problem: certain surgeons could not work particular days, or certain operating rooms would have different equipment from others.

Now, building on this improvement, AI can be employed for better estimation of future bed demand associated with operating room blocks. After systematic changes to inefficient healthcare workflows or processes have been made through mathematical optimisation, AI and machine learning can further enhance these systems – i.e. replacing tedious tasks currently performed by clinicians, thus reducing the risk of burnout.

One reason why hospitals have not fully embraced the use of mathematical optimisation, according to experts, is that optimisation models are more difficult to explain and conceptualise. AI models, in contrast, can be easily conceptualised because what AI tools do are intuitive – i.e. make diagnosis, predict risk of disease, or make operational predictions.

This lack of understanding of technical systems hinders progress on the use of various optimisation methods. To address this problem, hospitals need to work closely with mathematicians and engineers. Otherwise, investment in AI will not realise its full potential until it is based on a strong foundation of optimised care delivery.

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