Prioritising surgical cases deferred by the COVID-19 pandemic: an ethics-inspired algorithmic framework for health leaders

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ABSTRACT

Elective surgical suspension during the COVID-19 pandemic resulted in a sizeable surgical case backlog throughout the world. As we ramp back up, how do we decide which cases take priority? Potential future waves (or a future pandemic) may lead to additional surgical shutdown and subsequent reopening. Deciding which cases to prioritise in the face of limited health system capacity has emerged as a new challenge for healthcare leaders. Here we present an ethically grounded and operationally efficient surgical prioritisation framework for healthcare leaders and practitioners, drawing insights from decision analysis and organisational sciences.

INTRODUCTION

A 39-year-old man, recently recovered from COVID-19, requires an Achilles tendon repair. A 46-year-old woman, with no history of COVID-19 and a negative test result, requires lumpectomy. Despite both being 'elective', the respective surgeons rated their cases as 'high urgency'. Which patient should have higher priority? How do we choose? Historically, these questions were largely theoretical. However, elective surgery deferment during the peak of COVID-19 has resulted in an unprecedented backlog of surgical cases,[1] making dilemmas like above common place. Prioritisation of surgical cases has significant clinical, financial and operational implications, and is thus a pressing strategic decision that health leaders face.

COVID-19 has exposed our lack of preparedness for global health emergencies in many ways. Ethical choices in healthcare resource allocation are an important leadership dilemma that COVID-19 has magnified. Frequently, health leaders make decisions using their individual decision heuristics and what 'feels' intuitively right. However, intuition-guided decision-making under the current scenario is challenging, due to the simultaneity of vastly disparate goals: prioritising patients with worsening health conditions, maximising throughput, minimising risks of COVID-19 spread and mortality, and working within resource constraints.

Developing a surgical prioritisation strategy that leaders can implement is important both for addressing the surgical backlog, and for responding to a potential second wave of COVID-19 (or future emergencies). The aim of this work is to develop an ethically grounded and operationally efficient surgical prioritisation framework for healthcare leaders, drawing insights from the decision analysis and organisational sciences.

ETHICAL CONSIDERATIONS FOR SURGICAL PRIORITISATION

Non-maleficence, beneficence, justice and autonomy are the cornerstones of medical ethics.[2] Yet when prioritising elective surgical procedures, these broad, ephemeral concepts can be somewhat difficult to translate into concrete actions, requiring leaders to carefully consider how best to measure and account for each concern.

In most elective surgical contexts, 'elective' implies lower urgency, but does not mean 'optional'. Many elective operations such as spinal decompression or cataract extraction, if left untreated, may result in devastating consequences. *Non-maleficence* (doing no harm), as a guiding principle and prima facie duty of the physician, traditionally refers to reducing harm inflicted by clinicians from providing treatment, such as adverse events and complications. However, given the consequences of surgical deferment described above, an intentional delay in treatment may also result in harm, and ought to be avoided. Thus, surgical urgency (potential harm due to delayed surgery) is a key criterion.

At the same time, certain patient factors such as medical comorbidities and advanced age are known predictors of postoperative adverse events and COVID-19 mortality. Incorporating these in a prioritisation strategy may help balance the potential harm from delaying surgery against the potential harm with proceeding. Further, harm minimisation should focus not only on individual patients, but also on externalities to the community. Factors such as COVID-19 exposure risk (ie, risk of being a spreader) and case transmission risk (eg, cases requiring general endotracheal anaesthesia, which may present higher risk for COVID-19 spread) may be considered to protect other patients and healthcare providers. The risk a potentially COVID-19-positive patient presents to other patients and providers may decrease the priority of their surgery.

Beneficence refers to doing what is in the patient's best interest. In the elective surgical context, beneficence can be viewed in terms of the extent to which a person's life could be improved by receiving surgery, relative to another person. However, this is difficult to quantify and capture in a prioritisation framework. At the same time, in surgical triage, one patient's benefit may need to be prioritised over another's, creating an ethical dilemma of *justice*, which focuses on equitable distribution of benefits and burdens. Treatment for one subset of patients can potentially infringe on the rights of others, due to disproportionate consumption of resources.

Thus, criteria such as operating room (OR) time, blood and personal protective equipment (PPE) requirements, and hospital and intensive care unit (ICU) length of stay, may be considered in a prioritisation strategy.

Finally, health leaders need to be aware of and take into account the elasticity of the demand for elective surgery. Due to economic factors, such as employment status, and fear regarding infection risk, some patients may opt to defer or cancel surgery. Patients' *autonomy*, or the right to self-determination in their care ought to be upheld.

USING DECISION ANALYSIS TO OPERATIONALISE PRIORITISATION

Many healthcare decisions are based on some variation of a total point system, or simple additive weighting, due to ease of implementation and a lack of digital infrastructure required for implementing sophisticated algorithms. This is the decision method that most people use when making decisions such as purchasing a car. The process involves (a) making a list of positive and negative attributes (mileage, performance, price and so on), (b) assigning points to each alternative (on some arbitrary scale), (c) calculating weighted sums and (d) picking the choice with the best (eg, highest/lowest, depending on the scale) point score. Recently, this strategy has been proposed for prioritising critical care resources such as ventilators,[3] as well as for surgical prioritisation during the pandemic.[4] However, one limitation of the point system is that it does not optimise for multiple competing values and applies the same fixed criteria for all subgroups, some of which may not benefit from it.[5] For example, sicker patients may never receive ventilators under a point system, as they are 'too sick' and thus could never get good enough scores to qualify.

An alternative decision method used in allocating scarce care resources is the reserve system, whereby allocations are established for protected classes.[5] For example, a certain number of surgical cases per week may be reserved for particular groups, such as Good Samaritans, essential personnel and disabled individuals. Yet, the allocation decisions in the reserve system present their own set of ethical and implementation challenges. For example, within each protected class, patients may still have to be rank ordered and prioritised, and a clear tie-breaking mechanism may not always exist.

An alternative approach to decision-making is Multi-Criteria Decision Analysis (MCDA). The idea is that instead of using simple additive weighting, leaders ought to choose solutions from the set of possible alternatives that optimise under multiple criteria. Returning to the car-purchasing analogy, the total point system may lead to choosing a car with great performance and at a great price point, but poor mileage, while the MCDA approach may lead to an option with a reasonable mileage in addition to satisfactory quality and affordability, even though it may not have received the best score when adding up total points.

While a variety of MCDA algorithms exist, one that may be particularly relevant for surgical prioritisation is the Quantitative Entropy-Weighted Technique of Order Preference Similarity to Ideal Solution (QEWT).[6] This method prioritises alternatives that mathematically shorten the Euclidean distance from the ideal choice and elongate the distance from the least ideal choice. Thus, it does not just pick the solution with the highest or lowest point total, but rather aims to *simultaneously* maximise benefit and minimise harm for the cohort. For implementation, we suggest using Shannon's entropy to auto-calculate criteria weights with minimal subjectivity.[7]

TOWARD AN ETHICS-INSPIRED ALGORITHMIC FRAMEWORK

With ethical and operational principles in mind, we propose the following three-domain framework for surgical prioritisation that may couple well with MCDA. The first domain is surgical risk factors, which includes criteria such as patient age, American Society of Anesthesiologists (ASA) class and surgical urgency. In this framework, we place surgical urgency within the surgical risk factors domain. However, to account for the degree of disablement that the lack of elective surgery would produce (surgical urgency), and the relative effect on restoration of function resulting from elective surgery (surgical benefit), some centres may choose to make a separate patient-centric domain (surgical urgency+surgical benefit) or alternatively place additional weight on these criteria. The second domain is capacity requirement factors, which includes criteria such as OR time, OR staffing, blood requirement, PPE consumption, ICU needs and length of hospitalisation. The third domain is COVID-19 risk factors, which includes criteria such as COVID-19 status (1: tested negative and not exposed, 2: tested negative but possibly exposed, 3: tested positive and recovered), case transmission risk (eg, arising from the use of local anaesthesia vs regional/spinal block vs general anaesthesia) and COVID-19-specific comorbidities (eg, hypertension, obesity and diabetes). Except for age, ASA class and COVID-19 status, the aforementioned criteria can be scored as low (1), medium (2) or high (3), and the cut-offs for these can be personalised and defined at an individual centre level. For example, patients could be divided based on age cut-offs set at each centre, or using the following suggested criteria: 1: age ≤45, 2: age >45 and ≤65, and 3: age >65. For ASA, patients can be scored in the following manner: 1: for ASA 1, 2: for ASA 2, and 3: for ASA 3 and 4.

To illustrate the comparison of the various decision methods, we return to our two fictional patients described earlier (corresponding to patient #1 and #10 in table 1), and also consider eight other hypothetical patients with varying attributes, where lower scores on each criterion indicate higher priority for surgical scheduling (as detailed further in the online supplemental appendix). Table 1 shows how patient rankings vary across the three prioritisation strategies: a reserve system (with surgical slots reserved for high urgency cases), a total point system and our MCDA–QEWT model.

Comparing the overall prioritisation of the patients across the different systems reveals several superior elements of the MCDA–QEWT algorithm. For instance, since 5 of the 10 patients had high surgical urgency (as rated by the surgeon, despite the case being elective), in the reserve system all of them were assigned rank 1 and there was no tie-breaking mechanism. On the other hand, the point system prioritised based on the overall score, but it did not consider the merits of individual criteria. For example, the difference between low and medium surgical urgency was considered just as important as the difference between low and medium hospital length of stay. Thus, a point system may inadvertently select for healthier patients, such as those on an orthopaedic service, than relatively sicker and higher resource-consuming patients such as those on a cardiac service.

The MCDA algorithm, on the other hand, can provide an ordered rank list based on simultaneous consideration of all the criteria and thus, maximise net benefit and minimise net harm for the overall cohort. The specific criteria can be chosen within the broader framework based on institutional priorities. Further, while in this illustration we used entropy-generated weights to avoid bias, centres can decide on criteria weights based on local priorities. Additionally, because the MCDA algorithm

Table 1 Suggested criteria for surgical prioritisation and rankings based on various strategies

	Patient #									
Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Surgical risk factors										
Age	39	51	50	73	54	69	29	78	83	46
ASA class	2	2	1	3	1	2	1	3	2	1
Surgical urgency	1	3	3	1	2	1	3	3	1	1
Capacity requirement factors										
OR time	1	1	1	3	1	3	1	2	2	1
OR staffing	1	2	2	3	2	3	1	2	2	1
Blood requirement	1	1	1	2	1	3	1	3	3	1
PPE consumption	3	3	1	3	3	2	2	2	3	1
ICU requirement	1	1	1	3	1	3	1	3	2	1
Length of stay	1	2	2	3	2	3	1	3	3	2
COVID-19 risk factors										
COVID-19 status	3	2	2	1	3	3	1	3	1	1
COVID-19 comorbidities	1	1	1	3	1	3	1	3	3	1
Case transmission risk	2	3	2	3	1	3	1	2	2	3
Total points	18	23	19	31	20	32	15	32	27	16
Rankings based on various prioritisation strategies										
Reserve system	1	7	7	1	6	1	7	7	1	1
Point system	3	6	4	8	5	9	1	9	7	2
MCDA–QEWT	4	6	3	8	5	9	2	10	7	1

ASA, American Society of Anesthesiologists; ICU, intensive care unit; MCDA–QEWT, Multi-Criteria Decision Analysis–Quantitative Entropy-Weighted Technique of Order Preference Similarity to Ideal Solution; OR, operating room; PPE, personal protective equipment.

can be automated, customised and scaled, it can potentially be embedded in electronic surgical posting management system for an entire health system, and can be used to provide real-time, actionable information to physician and administrative healthcare leaders, empowering them to make data-driven, program-level decisions. Importantly, we note that this framework has not yet been tested in a real-life set of patients awaiting elective surgery, a limitation that should be addressed in future work extending this initial exploration of these sorts of surgical prioritisation algorithms.

CONCLUSIONS

A surgical prioritisation framework that reflects ethical principles while being operationally efficient is required for healthcare leaders to successfully navigate existing surgical backlog and be better prepared for future global health emergencies. Multicriteria decision analysis with appropriately selected criteria may aid in this effort.

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