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### Utilitarian Distribution of Scarce Surgical Capacity during the COVID-19 Crisis and Beyond: A Comparative Modelling Study

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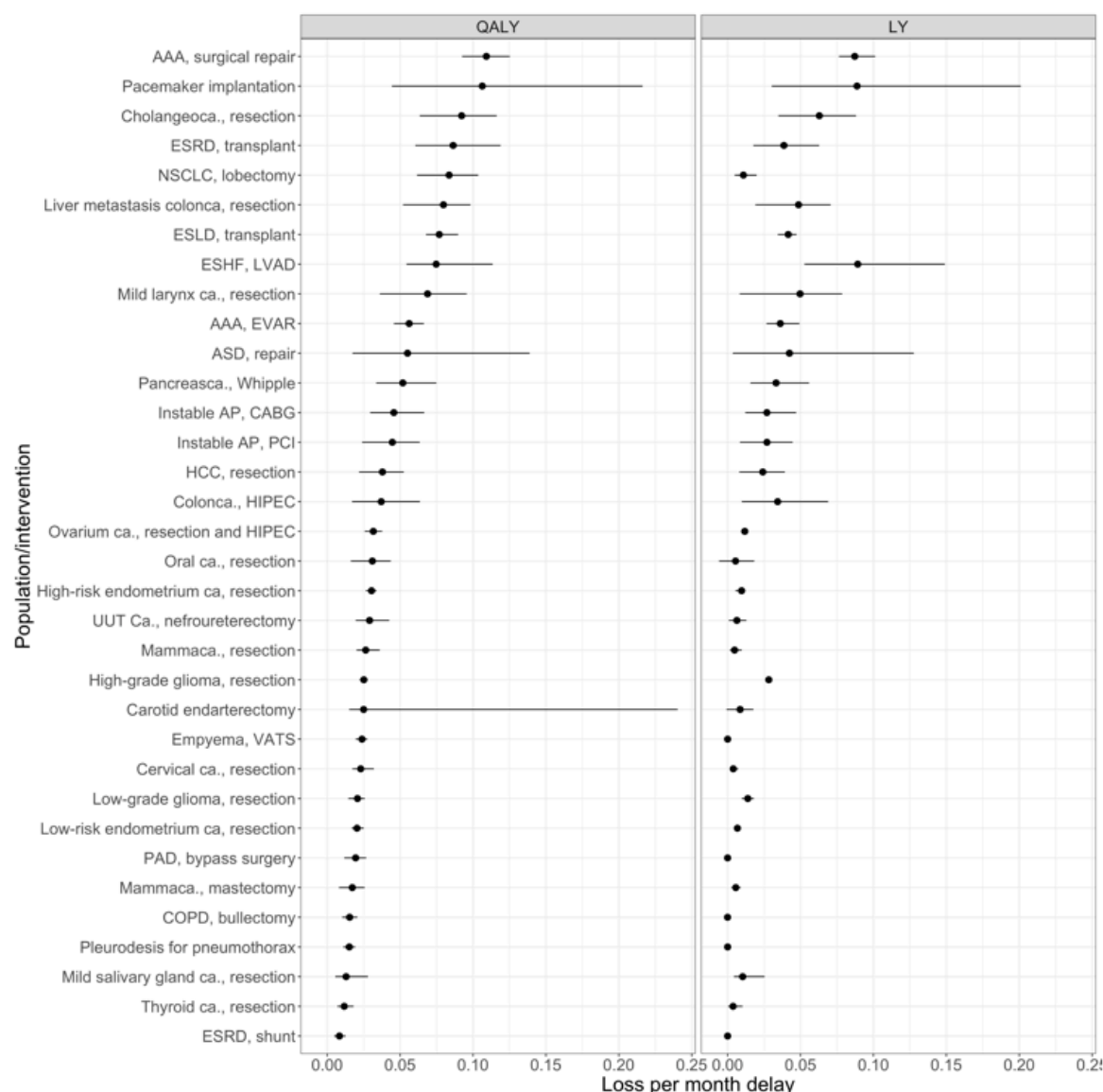
#### Abstract Text:

**Purpose:** COVID-19 has put unprecedented pressure on health care systems worldwide. This has led to a reduction of the health care capacity available for non-emergency surgical interventions. As a result, an accumulating number of patients is waiting for vital surgeries and societies face dilemmas about prioritization of patients. Therefore, our objective was to develop a decision model to estimate the effects of delay of surgical interventions on health and quality of life that can be used for prioritization.

**Method:** A cohort state-transition model was developed to simulate long-term implications of delaying surgery. The model was applied to 34 semi-elective (not necessarily performed within 3 days, but ideally performed within 3 weeks) surgeries on adults commonly performed in one of the eight Dutch academic hospitals. We compared scenarios of delaying surgery from two weeks up to one year (with 10-week intervals) and no surgery at all. Model parameters were based on Dutch and American registries, literature, and the global burden of disease study by the World Health Organization. For each surgical indication, we estimated the average expected Quality-Adjusted Life-Years (QALYs) for the different scenarios. Urgency was defined as expected health loss due to surgical delay, expressed in QALY loss per month (QALY/month). A probabilistic sensitivity analysis was performed to incorporate parameter uncertainty in the model estimates.

**Result:** The maximum QALYs gained varied between procedures, from 0.54 QALYs (95%-CI: 0.48–0.61) for resection of high-grade glioma to 10.3 QALYs (8.7–11.9) for kidney transplantation. The three most urgent interventions were surgically repairing an abdominal aorta aneurysm (-0.11 QALY/month, -0.13 – -0.09), pacemaker implantation (-0.11 QALY/month, -0.22 – -0.04), and resecting a cholangiocarcinoma (-0.09 QALY/month, -0.12 – -0.06). The three least urgent interventions were the placing of a shunt for dialysis (-0.01 QALY/month, -0.01 – -0.005), resecting thyroid carcinoma (-0.01 QALY/month, -0.02 – -0.01), and resecting mild salivary gland carcinoma (-0.01 QALY/month, -0.03 – -0.01).

**Conclusion:** Expected health loss due to surgical delay could reliably be quantified with our decision model and can guide prioritization of surgical care from a utilitarian perspective (i.e. minimizing health loss on population level) in times of scarcity (e.g. due to COVID-19). Placing this tool in the context of different ethical perspectives and combining it with capacity management tools is key to achieve large-scale implementation.



**Figure 1: The average loss of QALYs and LYs per month of delay for the investigated surgical interventions. These estimates are based on the results from the simulated scenario of surgery delay of 52 weeks. The dots are the mean estimates. The bars represent the 95% confidence intervals.**

Abbreviations: QALY: Quality-Adjusted Life-Years, LY: Life-years; AAA: aneurysm of the abdominal aorta; ASD: atrial septum defect; AP: angina pectoris; CABG: coronary artery bypass graft; ESHF: end-stage heart failure; ESLD: end-stage liver disease; ESRD: end-stage renal disease (kidney transplantation); EVAR: endovascular aortic repair; ca.: carcinoma; HCC: hepatocellular carcinoma; HIPEC: hyperthermic intraperitoneal chemotherapy; NSCLC: non-small cell lung carcinoma; UUT: upper urinary track; VATS: video assisted thoracoscopic surgery; PAD: peripheral arterial disease; PCI: percutaneous coronary intervention.

#### Title:

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