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Designing a clinical decision support algorithm for optimal ICU discharge decisions – A causal machine learning approach

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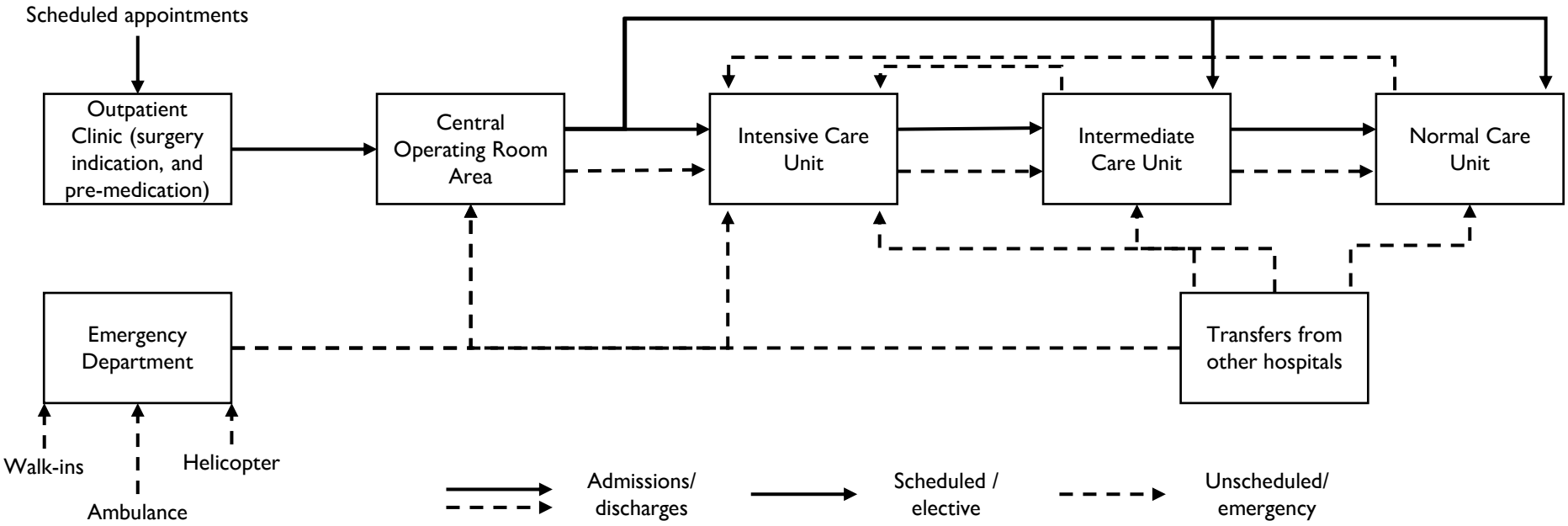
From insight to impact.

Patient flow through a (large) hospital is prone to uncertainties on the demand and supply side – where does uncertainty come from?



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Sources: Keskinocak, P., & Savva, N. (2019) [1]; Bai et al. (2018) [2]; Chan et al. (2012) [3]; Kramer et al. (2016) [4]; Niven et al. (2014) [5]

What are the conditional average treatment effects of discharging a patient from the ICU?

What policy can minimize readmissions to the ICU that are linked to ICU discharges?

How many readmissions and deaths can be avoided, how much ICU capacity saved with optimal decision policies?

Clinical decisions could potentially draw from vast amounts of data, but these data cannot be used comprehensively by humans

1. Approximately 10,000 admissions/ cases from the Cantonal Hospital of St. Gallen, including roughly 5% readmissions (2016-2023)

2. Hundreds of variables, e.g., age, gender, initial diagnosis, co-morbidities, procedures, laboratory test results, vital parameters, ventilation data, clinical risk scores, and administration of medication (time stamps available, where relevant)

3. Unbalanced dataset might be problematic, oversampling is potentially an option

Method for Research Question 1 | We estimate conditional average treatment effects using Causal Forest from the grf package in R

$$\tau(x) = E[Yi(1) - Yi(0) | Xi = x]$$

Causal Forest will help us to:

- Build patient profiles / subgroups with similar features influencing the treatment effect
- Identify the most influential features for treatment effect estimation

Some necessary assumptions (Rubin Causal Model):

- Stable unit treatment value assumption (SUTVA)
- Conditional Independence Assumption (CIA)
- Common Support (CS)
- Exogeneity

Sources: Wager & Athey (2018) [6]

We are facing two main challenges – any ideas?

1. (a) High-dimensional, sparse data and (b) continuous measurements (e.g., heart rate)

2. Method for optimal policy design: Policy tree? Comparison of CATEs? Timing essential!

Sources: Athey & Wager (2021) [7]

Our ultimate aim is to supply the basis for a clinical decision support algorithm – and not only for ICU discharge decisions!

1. Planning and scheduling of surgeries

2. Emergency Care Unit management

Sources: Diwas Singh et al. (2020) [8]

Literature

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Thanks!

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