AI for ambulance prioritization: From model to practice

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Background

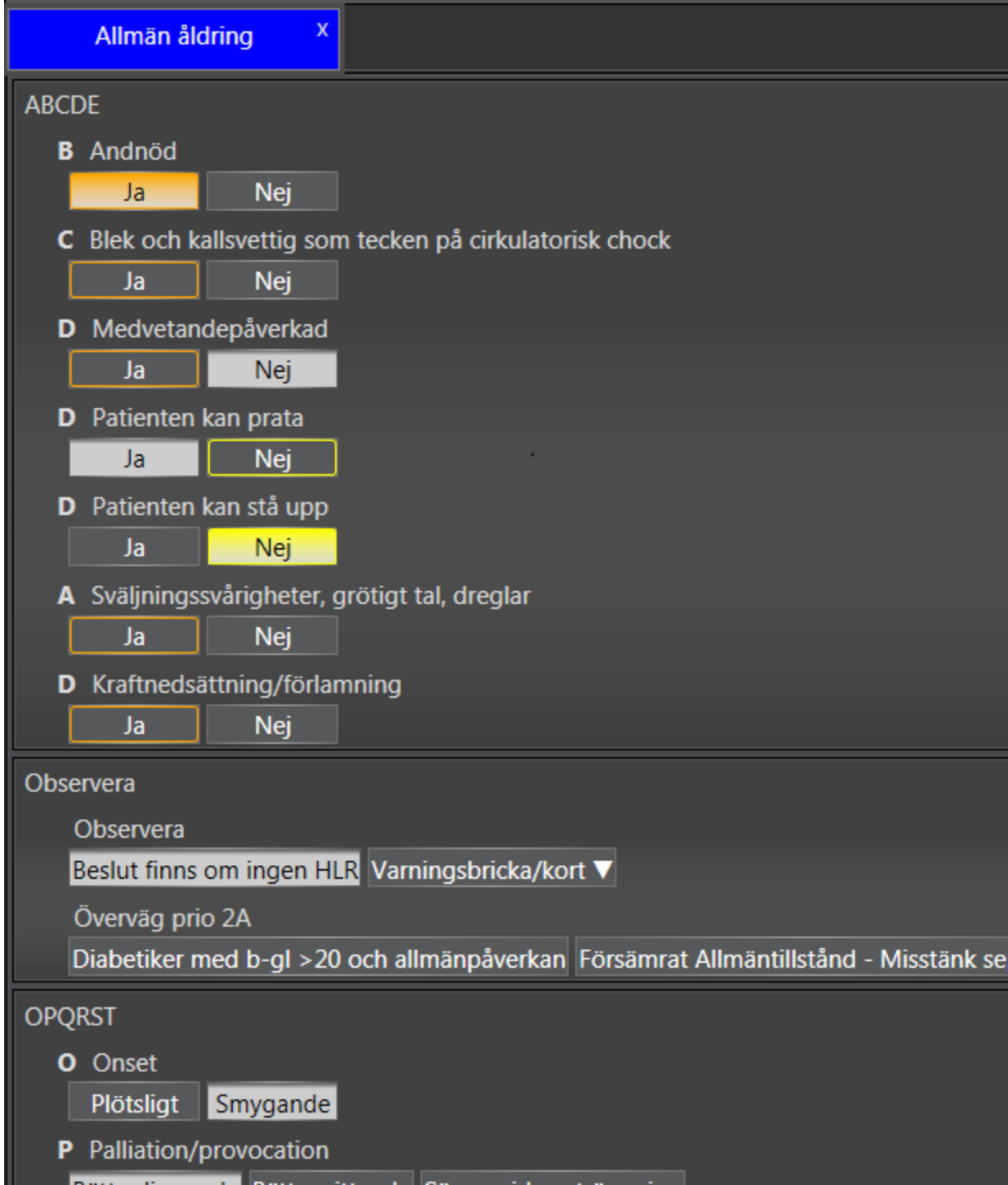
- Vinnova grant 2017 for development of ML models based on an existing decision support system

A validation of machine learning-based risk scores in the prehospital setting

Douglas Spangler, Thomas Hermansson, David Smekal, Hans Blomberg

Published: December 13, 2019 • https://doi.org/10.1371/journal.pone.0226518

- Project ended in 2021 – But still want to implement the model!
- Currently: Home stretch of RCT data collection

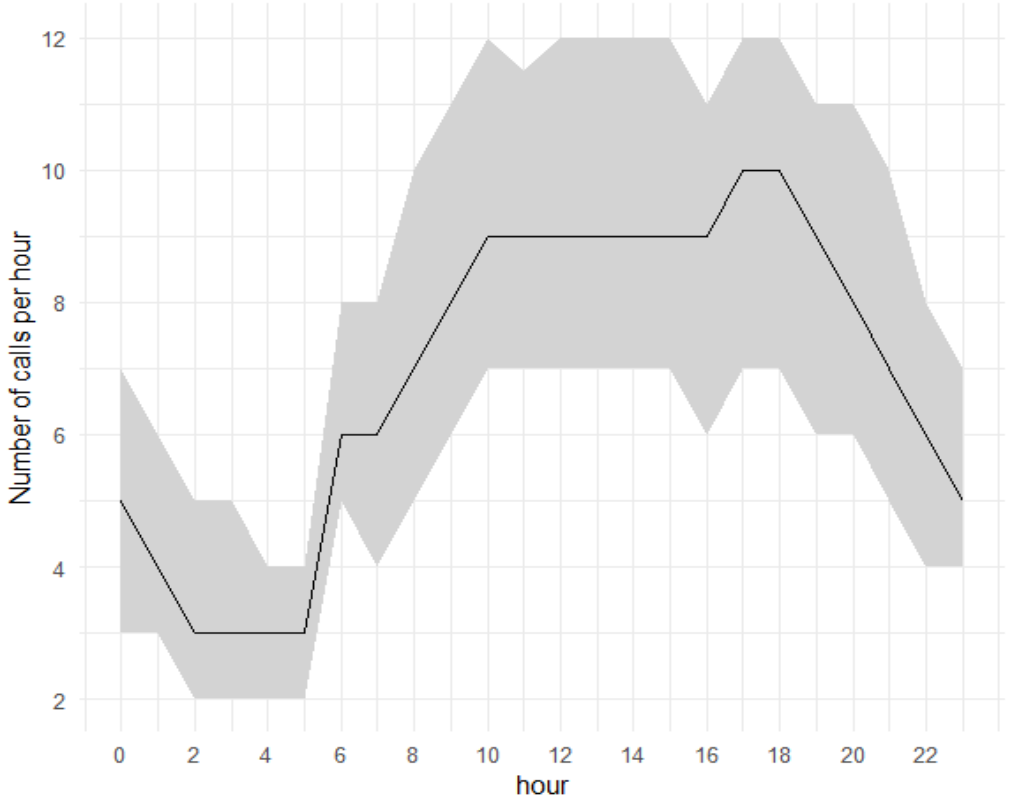


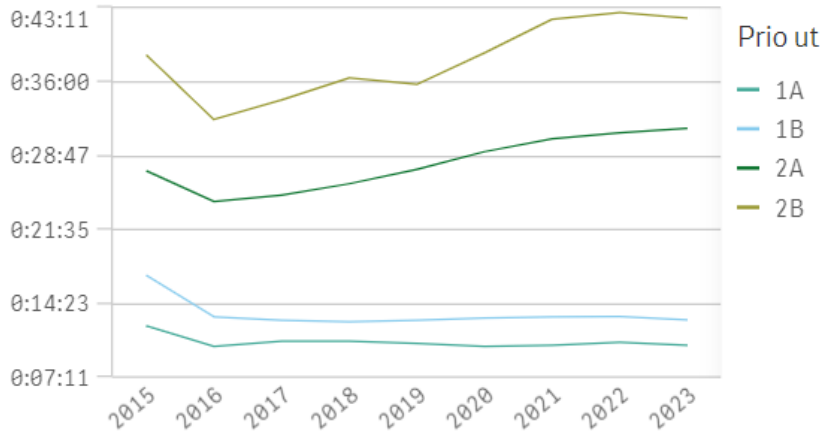
The problem

- Too many patients,
  not enough ambulances –
  Who should go first?

- Study goals:
  - Ensure patient safety
  - Generate high-quality evidence
  - Open source implementation

- How to clinically evaluate a novel triage algorithm with no budget?



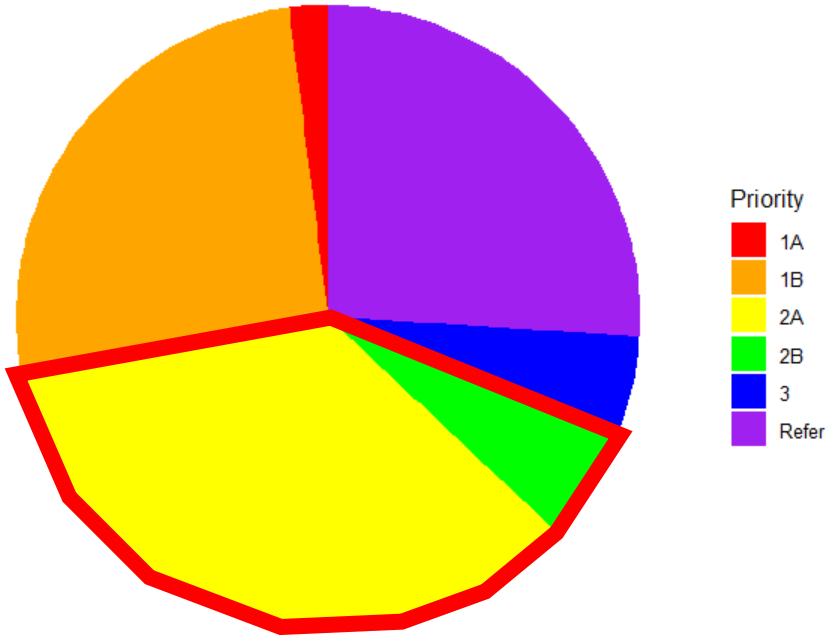


Some lessons

- Study population selection
- Outcome definition
- Intervention & study design
- Estimand selection & Power calculation
- Ethics & practice
- Future directions for development

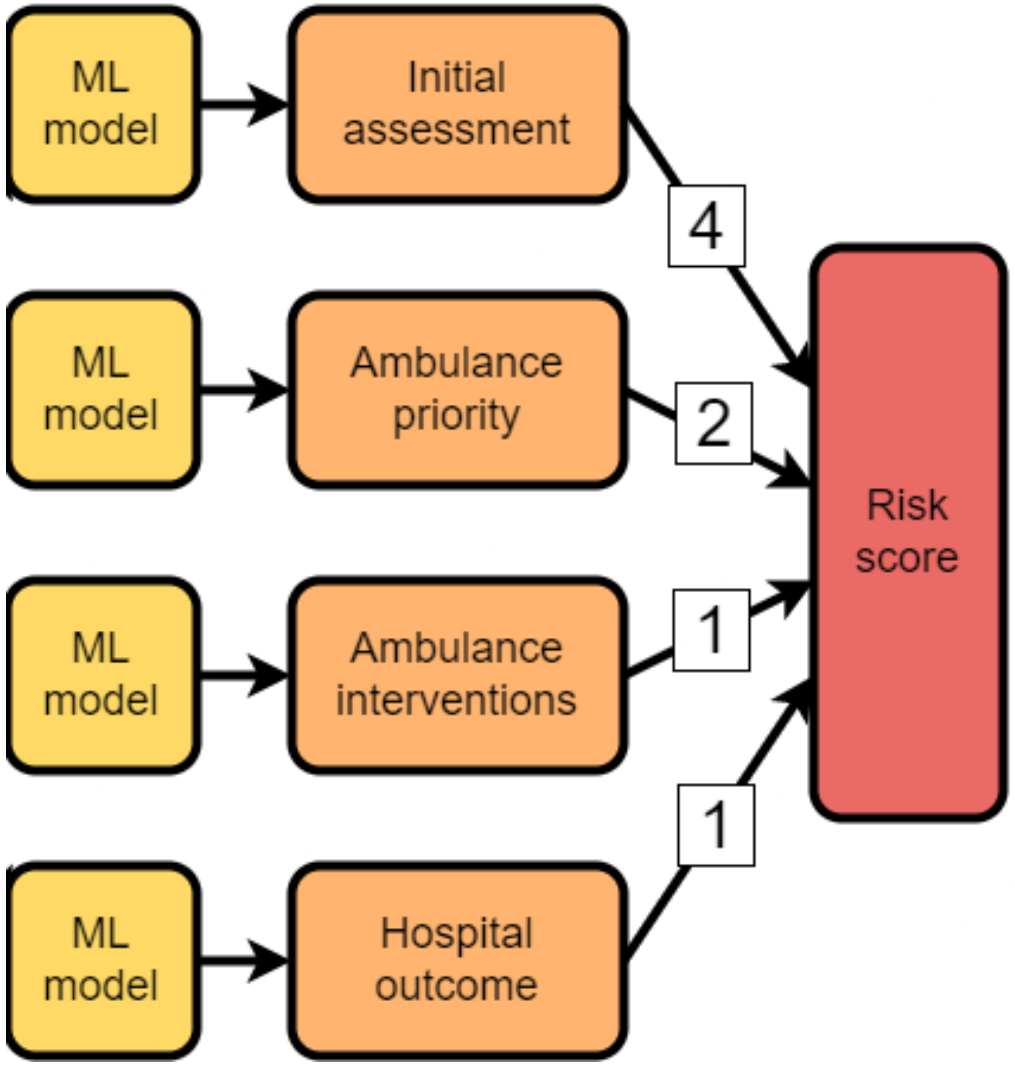
Prehospital populations

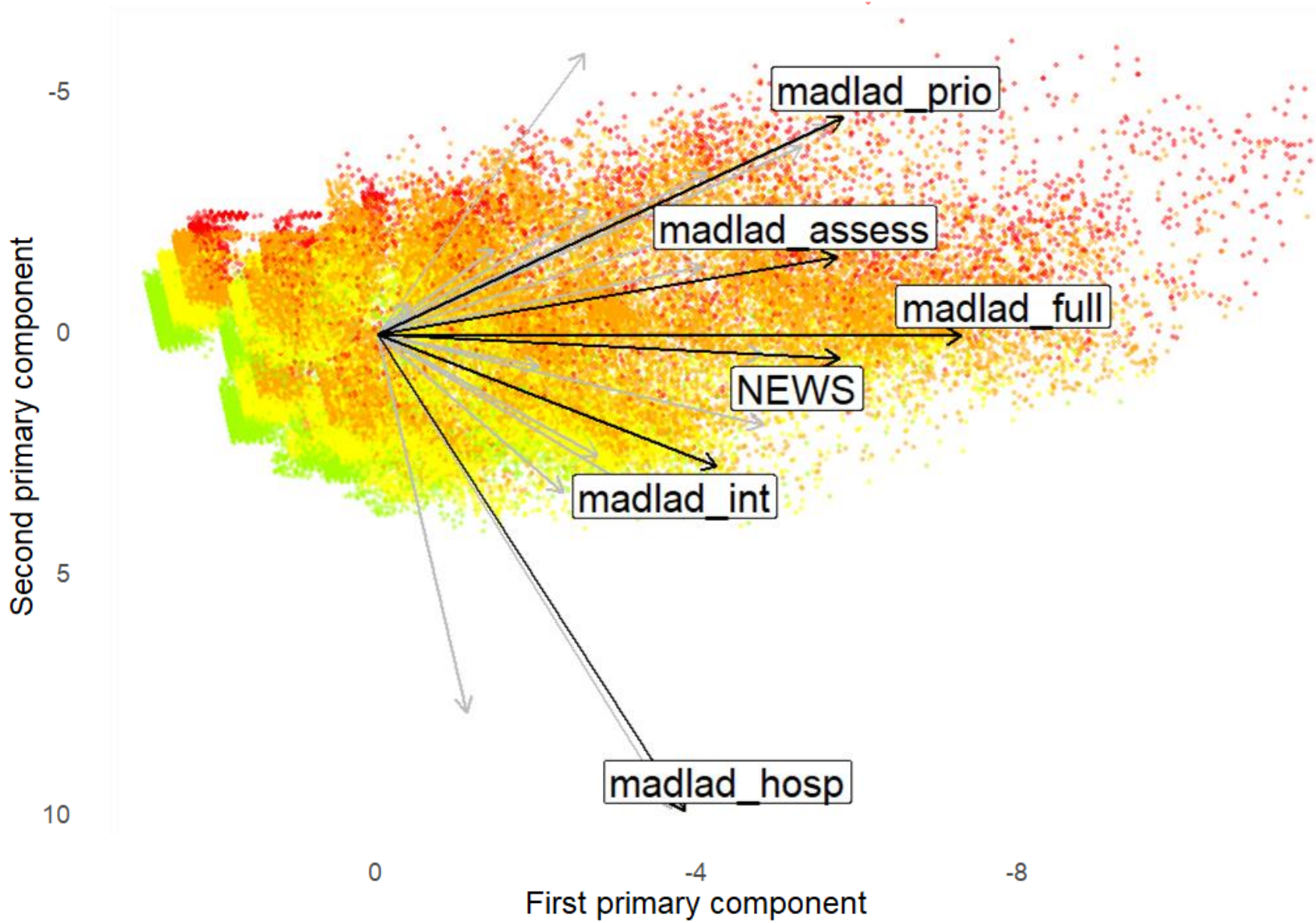
- Higher acuity
  - Rapid assessment
  - High sensitivity
  - Specific, rare syndromes
  - Simple outcome definitions
- Lower acuity
  - Looser time constraints
  - Need for differentiation
  - Comparisons across etiologies
  - Tricky to define relevant outcomes



Outcome definition

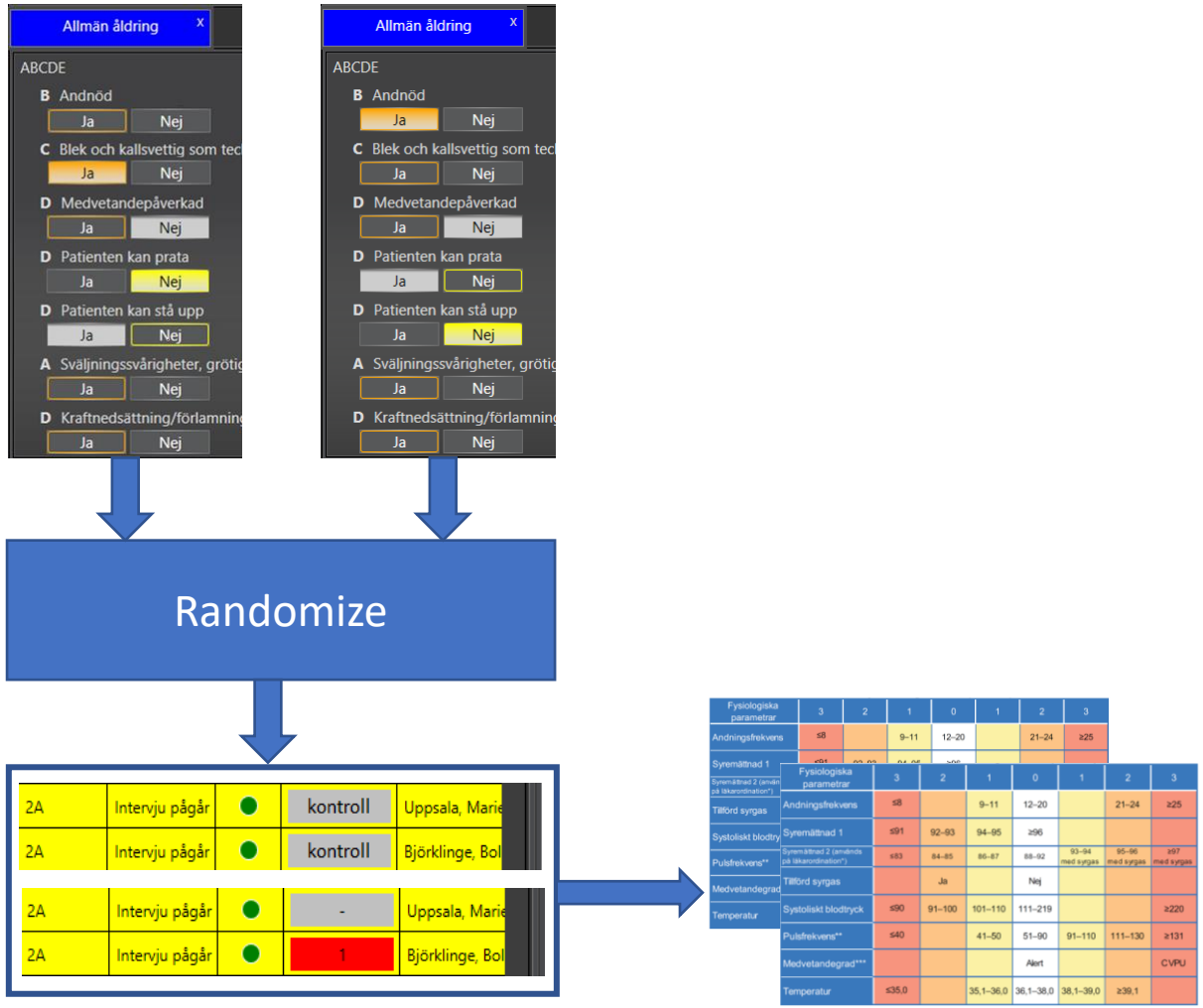
- Define a set of outcome measures which correspond with:
  - Qualitative, clinical domain knowlege
  - Existing patient risk scoring tools
- Study Outcome
  - Correlated with, but not caused by model outcomes




madlad_prio
madlad_assess
madlad_full
NEWS
madlad_int
madlad_hosp
-5
0
5
10
Second primary component
0
-4
-8
First primary component

Machine learning Assisted Differentiation of Low-Acuity patients at Dispatch (MADLAD): A Randomized Control Trial

- **Question**: Does information from a ML model improve triage accuracy at dispatch?
- **Sample**: 1500 ”resource constrained situations” in Uppsala and Västmanland
- **Method**: RCT – With or without information from the tool



Estimand definition

- Initially: Difference in NEWS score between prioritized vs. Non-prioritized patients
  - How to handle multiple non-priorizized patients?
  - Odd distribution of NEWS scores – Ratio scale? What does the difference mean?
- Finally: Dichotomized outcome
  - Loss of power to achieve more interpretable results

Power estimation

- Relatively simple to estimate model accuracy – But no data on historical nurse decisions!
- Simulate accuracy of comparisons between 2A and 2B assignments
- Assumed 100% compliance with model

Ethics approval

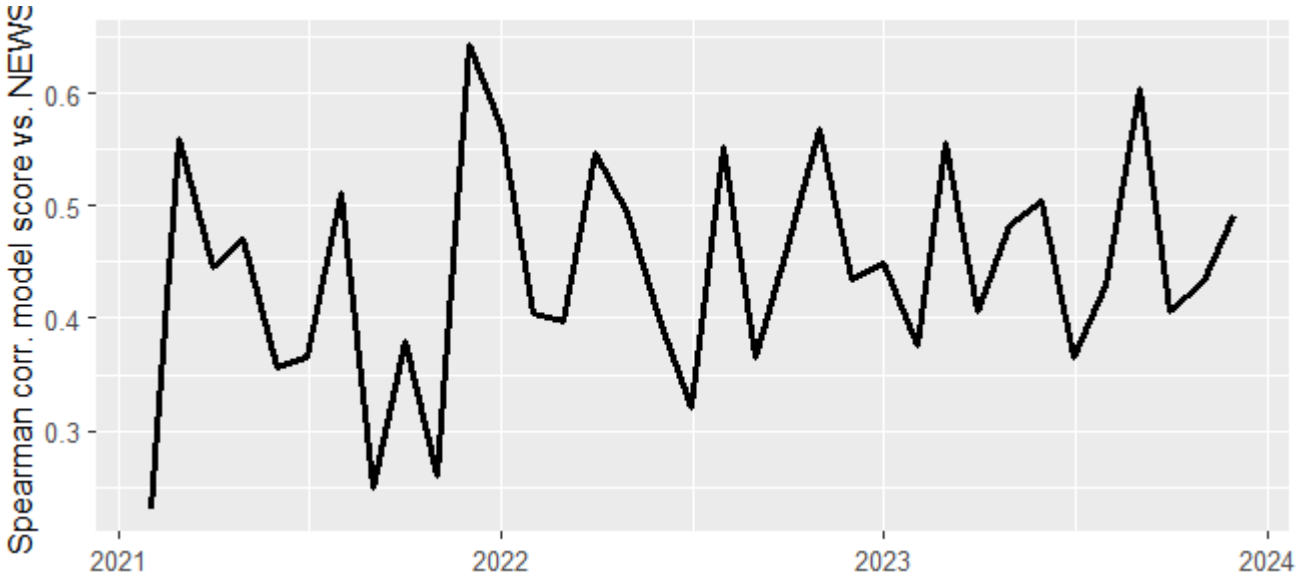
- Study design minimizes risk
  - All patients get an ambulance eventually!
  - … But also minimizes potential benefits

- Approval for ”Assumed consent”: Send patients information afterwards and provide an opportunituy to opt-out

- Initially high rates of opt-out – Reformulation of Informed consent letter & Form

Quality Assurance

- How to continuously ensure patient safety without exposing study results?
- Evaluate differentiation between **individuals** throughout study
- Evaluate compliance (ca 80%)



Further Development

- Model development
  - Additional structured data from patient history
  - Parsing audio data – Good open models now available (Whisper)
- Regulatory issues
  - How to handle regulatory approval without profit motive?
  - Continued use as ”Self developed medical device”:
    - In Sweden: Same documentation as CE marking, but no certification process
- Applications
  - Non-randomized implementation
  - Ambulance referral risk calculator (link)

Cheers!

- Source code: https://github.com/dnspangler/openTriage
- Demo: https://opentriage.net/ui/vitals

- Validation study: https://doi.org/10.1371/journal.pone.0226518
- RCT protocol: https://clinicaltrials.gov/study/NCT04757194

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