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INFORMS 2018

Michael Freeman
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Gatekeeping under Congestion:
An Empirical Study of Referral Errors in the Emergency Department

Joint work with:
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Decision making in the ED

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- Emergency providers make disposition decisions ~350,000 times/day in US EDs
  - Option 1: admit patient to hospital
  - Option 2: discharge patient home

    → ED physicians act as **gatekeepers** to inpatient beds

- Significant variation in admission rates (gatekeeping referral rates) across EDs:
  - Pines at al. (2013 MCRR): US ED admission rate varied from 9.8% to 25.8% at the 10th and 90th percentiles

MCRR: Medical Care Research and Review

Challenges for ED gatekeeping

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- Emergency medicine: High levels of clinical uncertainty and variation in diagnostic accuracy

- Decision density high → can lead to elevated cognitive loading
  - Graber et al. (AIM 2005): cognitive factors contributed in 74% of cases of diagnostic error in the ED

- ED physicians under increasing time and workload induced pressure
  - US (1997 to 2007): ED visits grew at almost twice the rate of population growth
  - UK (1997 to 2012): ED visits grew by 47% compared to population growth of 10%

AIM: Archives of Internal Medicine

Research question

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RQ1: How does congestion affect the accuracy of ED gatekeeping decisions?

- **Wrongful discharges** (false negative)
- **Unnecessary hospitalizations** (false positive)

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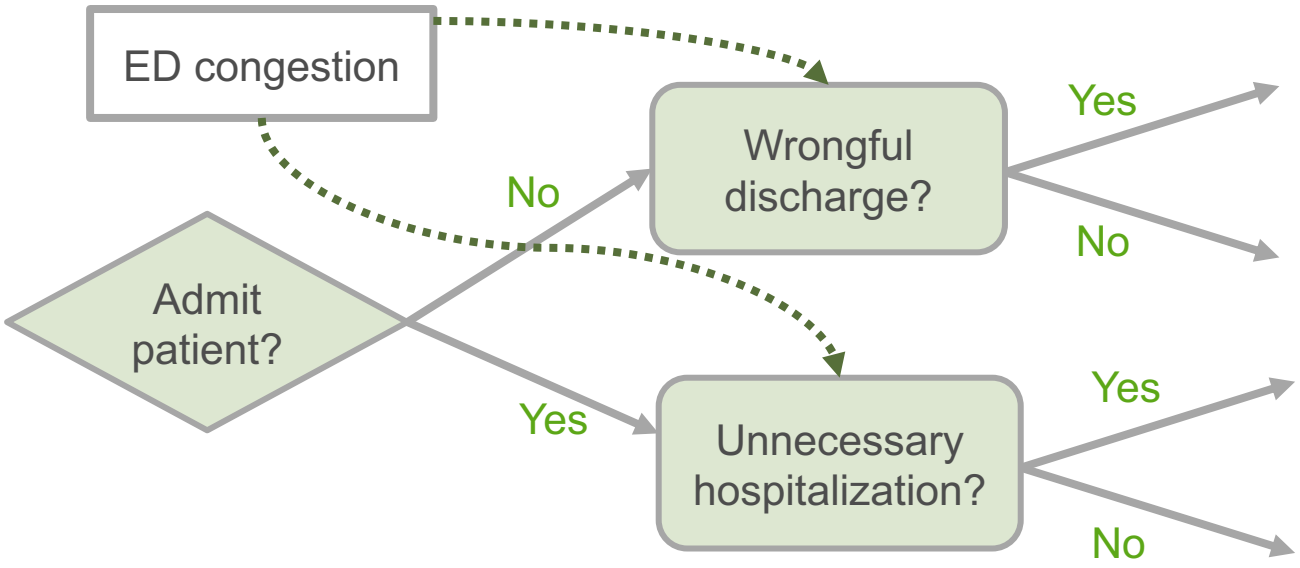

Data

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- Data from a large UK-based teaching hospital (2008-2013)
- Analysis sample includes all **adult** ED visits that resulted in admission or discharge
  - ~375,000 ED visits
  - ~250 patient visits per day
- Also have inpatient data corresponding to emergency admissions
  - ~ 110,000 admissions
  - 30% admission rate

Key variables

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- **Congestion**
  - Percentage of capacity used
  - ”Used” is equal to the ED census, time weighted over the hour after a patient arrives
  - “Capacity” is proxied by 95th %tile of the ED census, predicted using quantile regression
- **Wrongful discharges**
  - Patient discharged but revisits ED within 7 days and is then admitted to the hospital
  - *Revisits with a condition in the same diagnosis category as the previous visit*
  - Rare! 0.7% of ED visits and 1.0% of all patients discharged
- **Unnecessary hospitalizations**
  - Patient admitted to an inpatient unit and discharged within 24hrs without treatment
  - 4.3% of ED visits and 13.7% of all admissions
  - Change in rate indicative of change in likelihood of false admissions

The ED bullwhip

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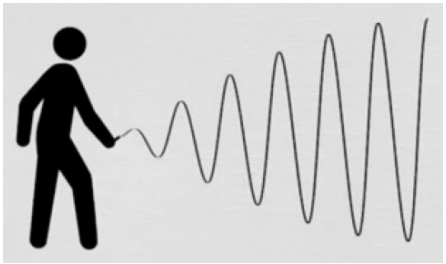
- **Moving from low congestion (-2s) to high congestion (+2s):**
  - Relative **increase** in both errors by 15%
  - Relative **increase** in unnecessary hospitalizations by 21%
  - Relative **decrease** in wrongful discharges by 17%

- **Bullwhip-type effect**
  - A surge in ED demand will lead to a relatively larger surge in unnecessary hospital admissions.



Why? Misaligned incentives

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"No-one has ever been sued for admitting a patient to the hospital"

- The gatekeepers incentives are **misaligned** with the goal of protecting the specialist resource from overuse
- Congestion creates time pressure, and in cases of doubt ED physicians choose a policy of "safety first", and admit rather than discharge

This has severe consequences!

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- Hospitals are dangerous places
  - Lack of mobility → physical and mental deterioration
  - Adverse events → infections, falls, medication errors
- Hospital admission is expensive
- Capacity (e.g. beds) is limited
- Unnecessary admission exposes other patients to risk

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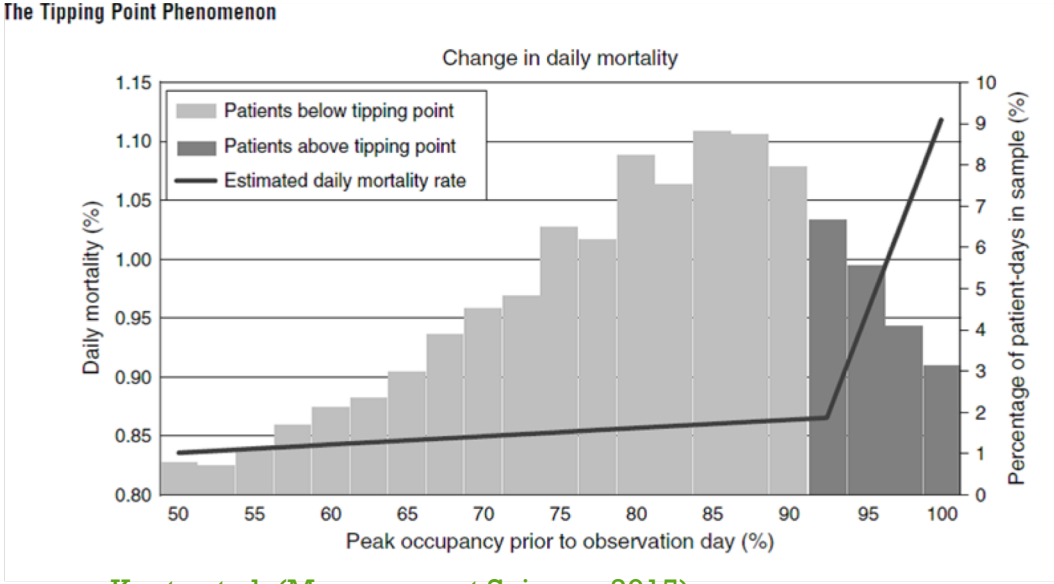

Kuntz et al. (Management Science 2015)
[~80,000 patients with STR,AMI,CHF,GIH,PNE,NOF]

Research question

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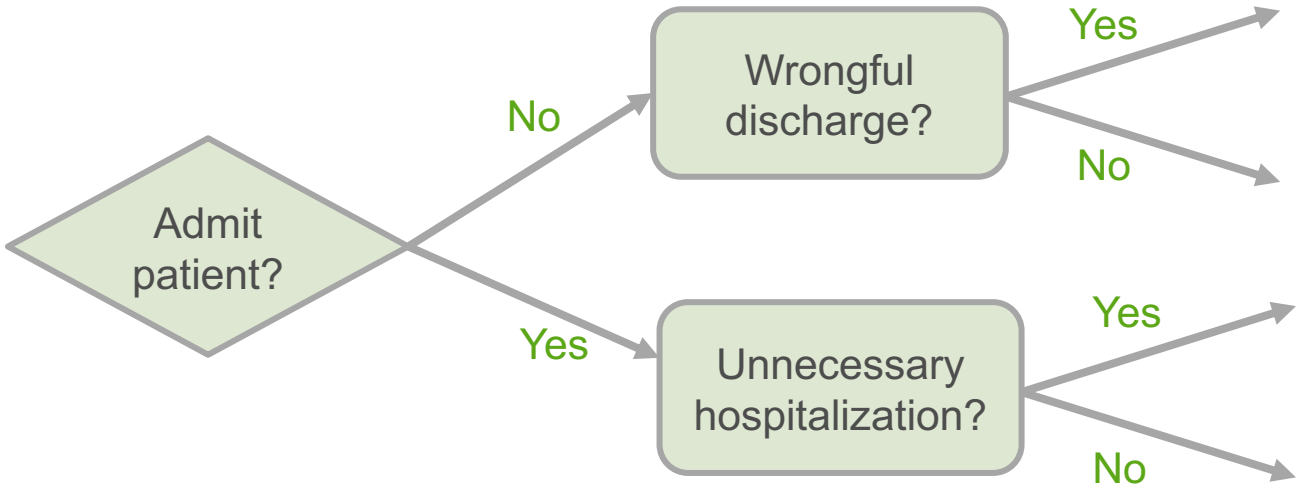
RQ2: How can admission decisions be improved?



Single-stage gatekeeping system

Research question

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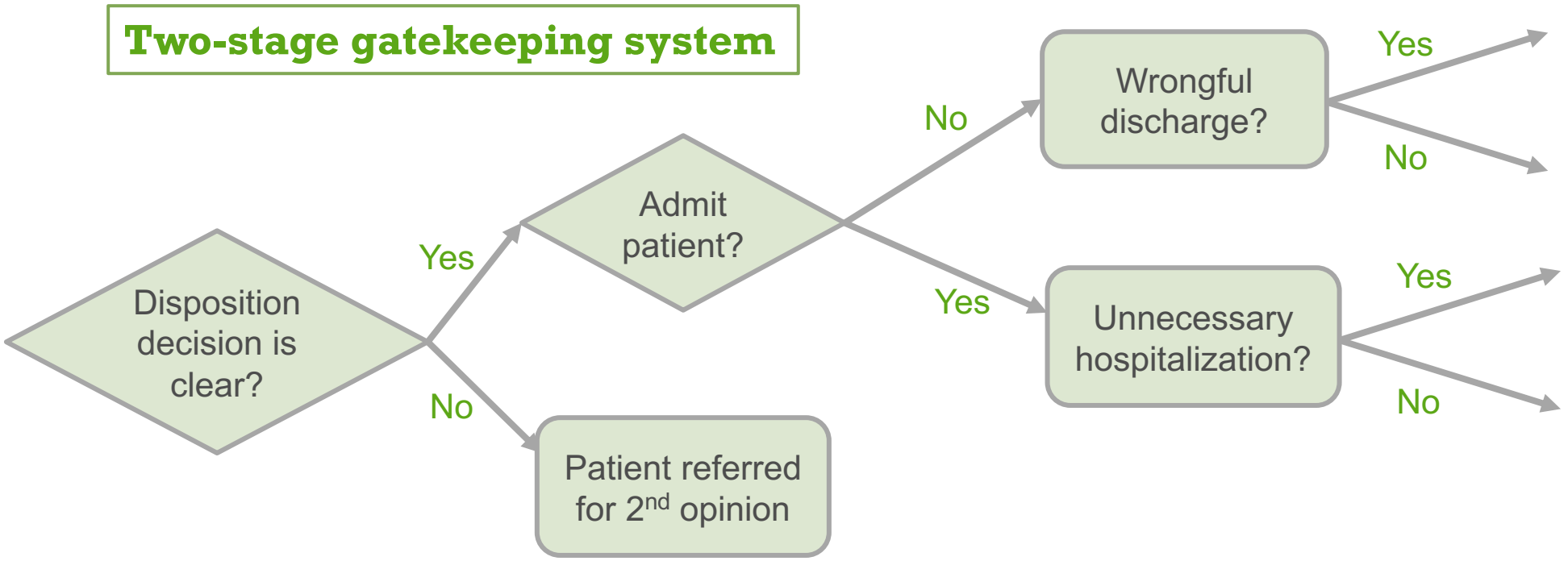

The Clinical Decisions Unit

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- Dedicated bedded area, separated from the ED but organizationally integrated within the ED and staffed by emergency physicians and nurses
- Designed to provide further diagnostic evaluation, additional testing, and continuation of therapy for patients who require extra care
- Patients admitted to the CDU are expected to have symptom complexes that can be resolved within 6-24 hours
- At the end of their CDU stay, patients are either admitted or discharged
  - 10% of patients in our sample admitted to the CDU
  - 35% of patients admitted to CDU are subsequently admitted

AIM: Archives of Internal Medicine

Modeling challenge

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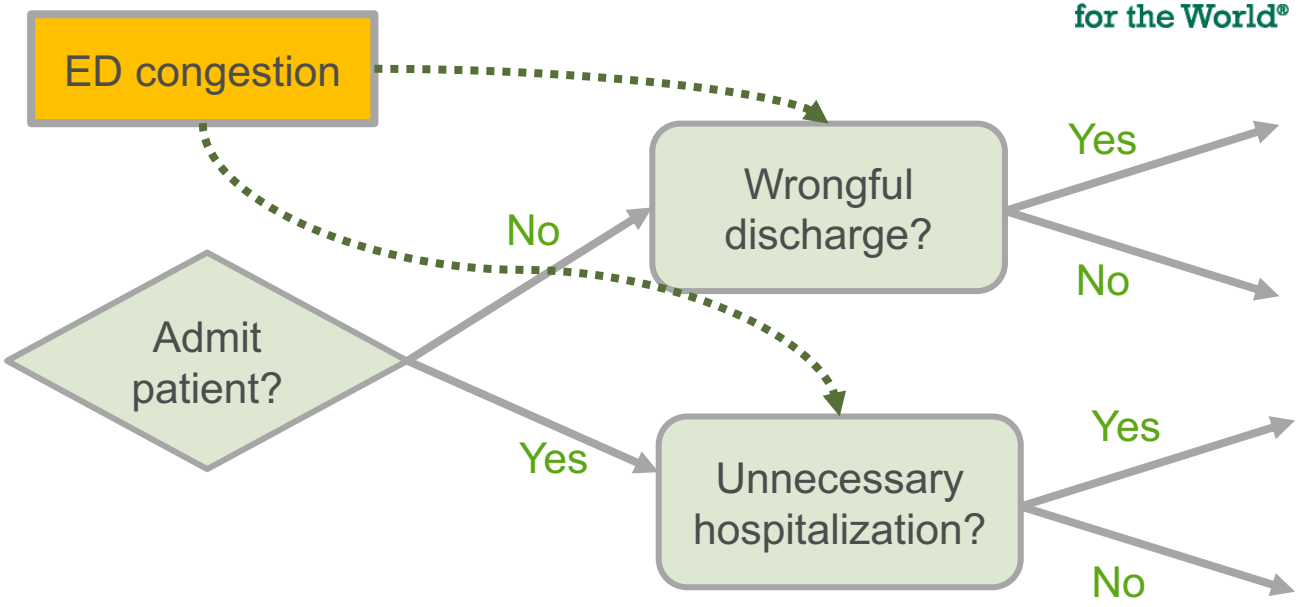

Modeling challenge

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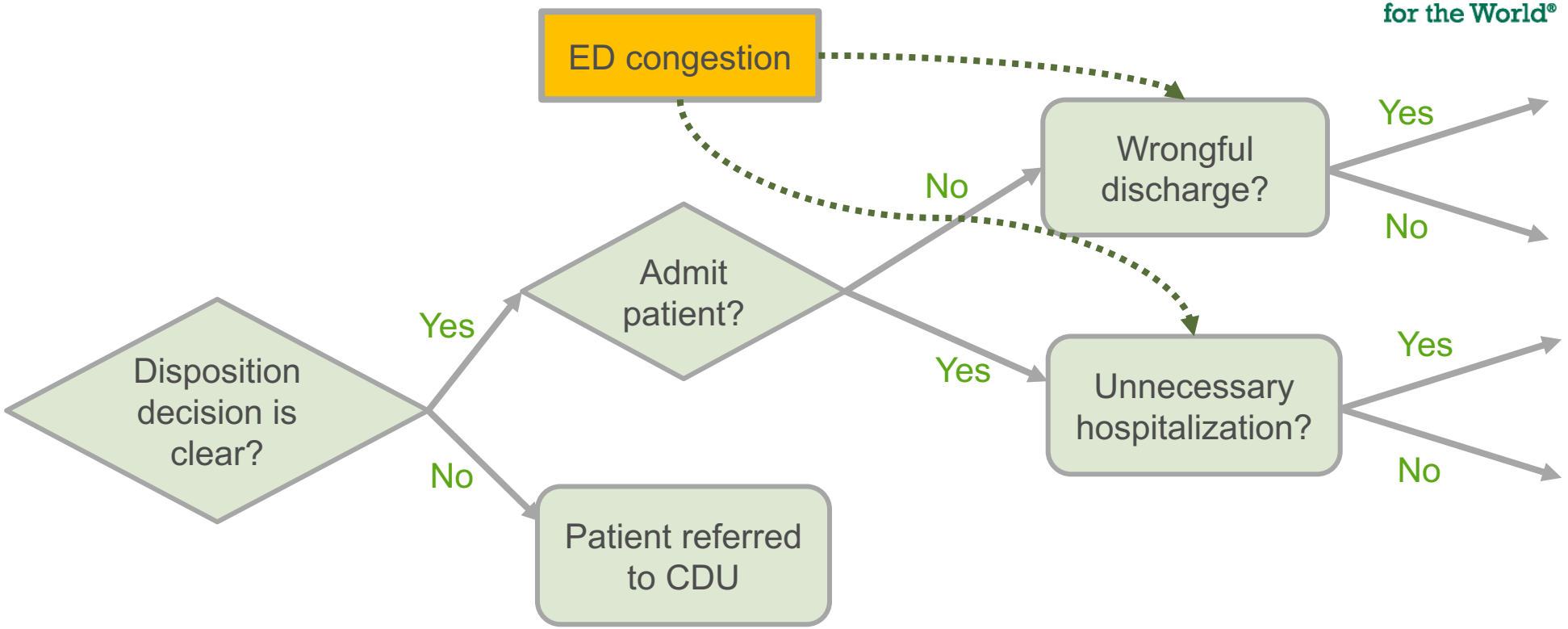

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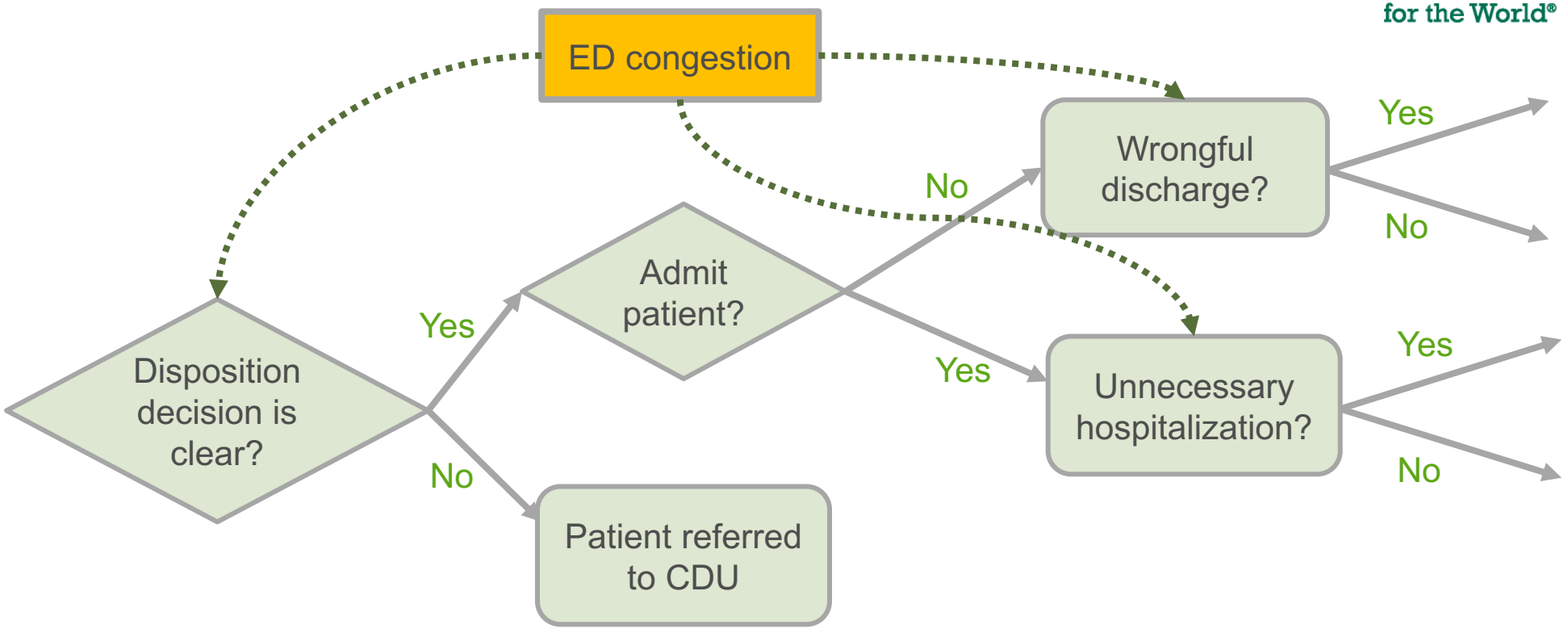

Modeling challenge

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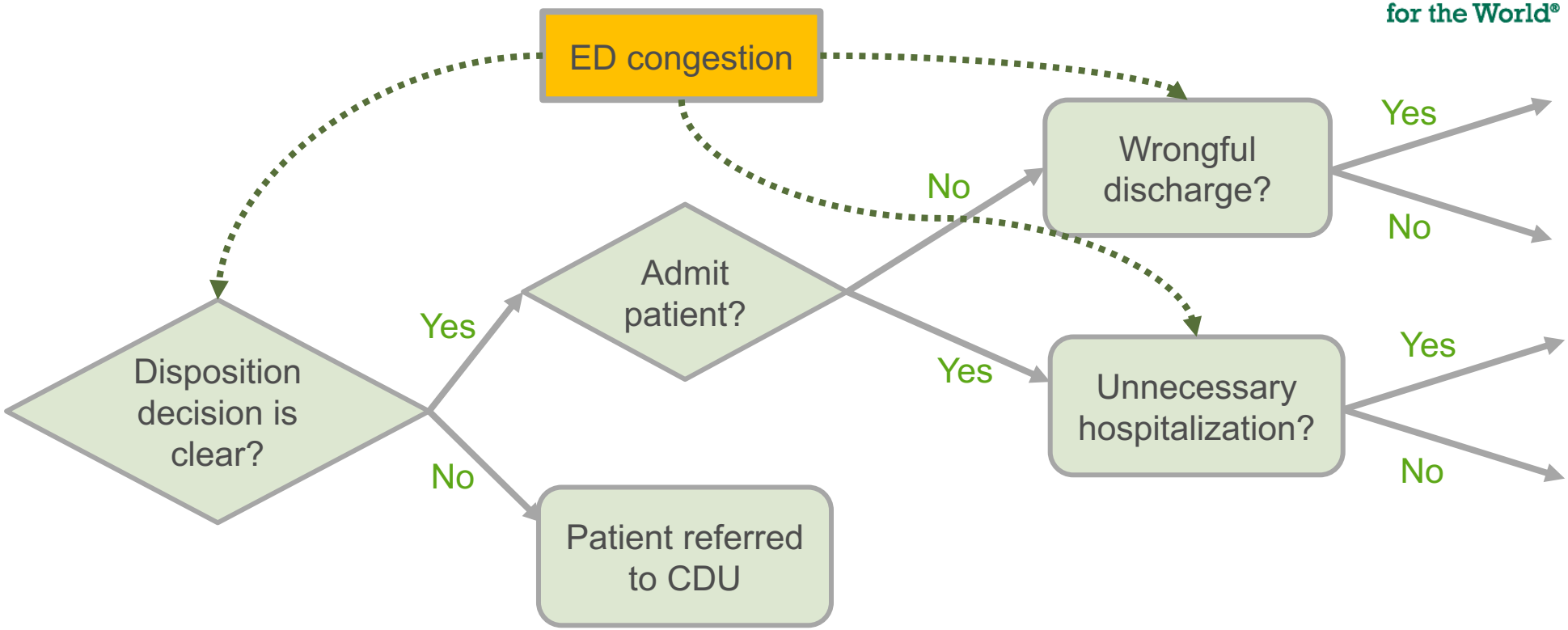
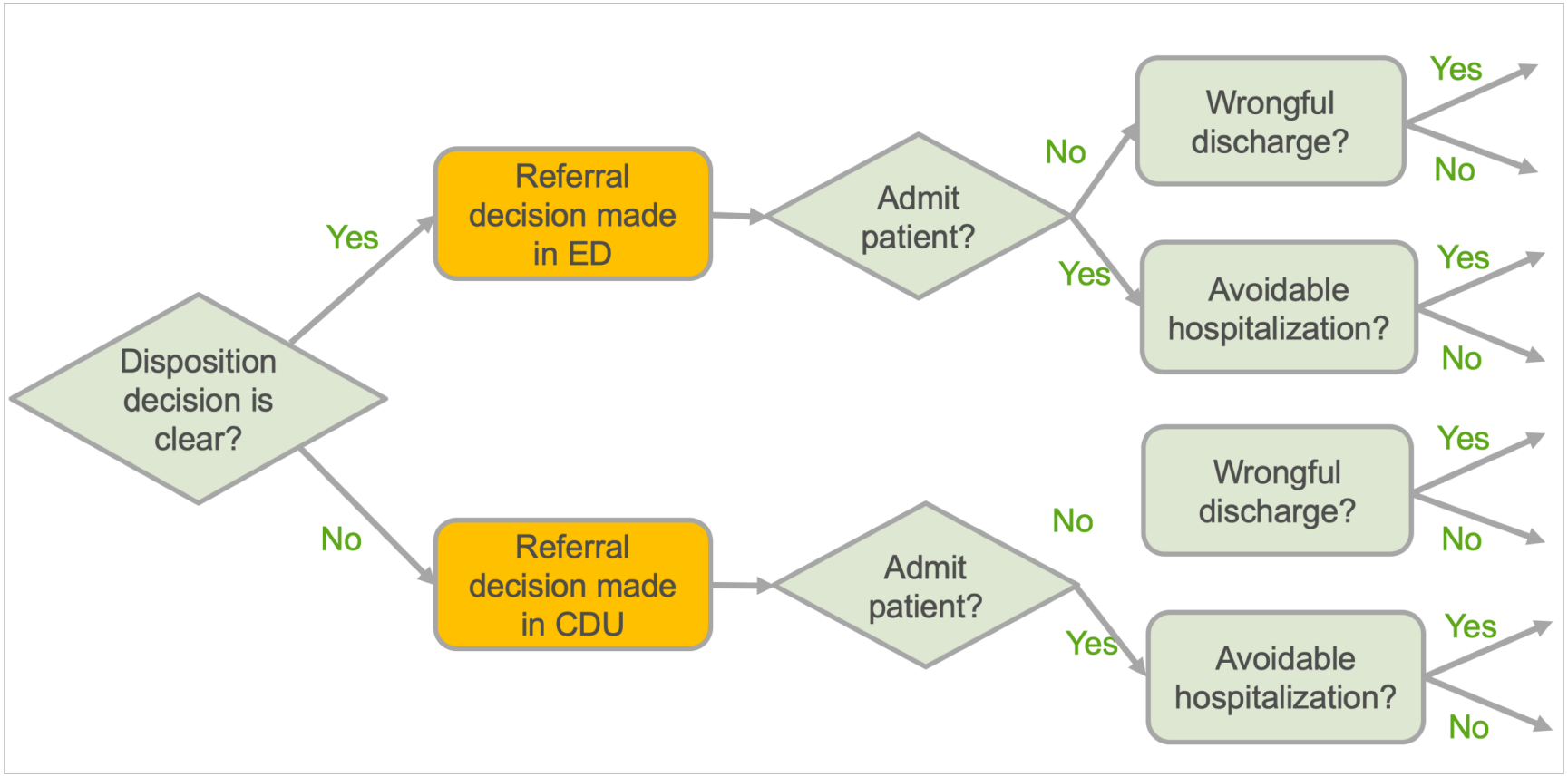


Heckman probit model estimates the effect of congestion as if there were no CDU

$$y_i^{\text{outcome}} = 1(\alpha + u_i\beta + x_i\gamma + \varepsilon_i > 0)$$
$$y_i^{\text{select}} = 1(\alpha' + u_i\beta' + x_i\gamma' + z_i\delta' + \varepsilon_i' > 0)$$
$$(\varepsilon_i, \varepsilon_i') \sim N\begin{pmatrix}1 & \rho\\ \rho & 1\end{pmatrix}.$$

Two-stage gatekeeping system



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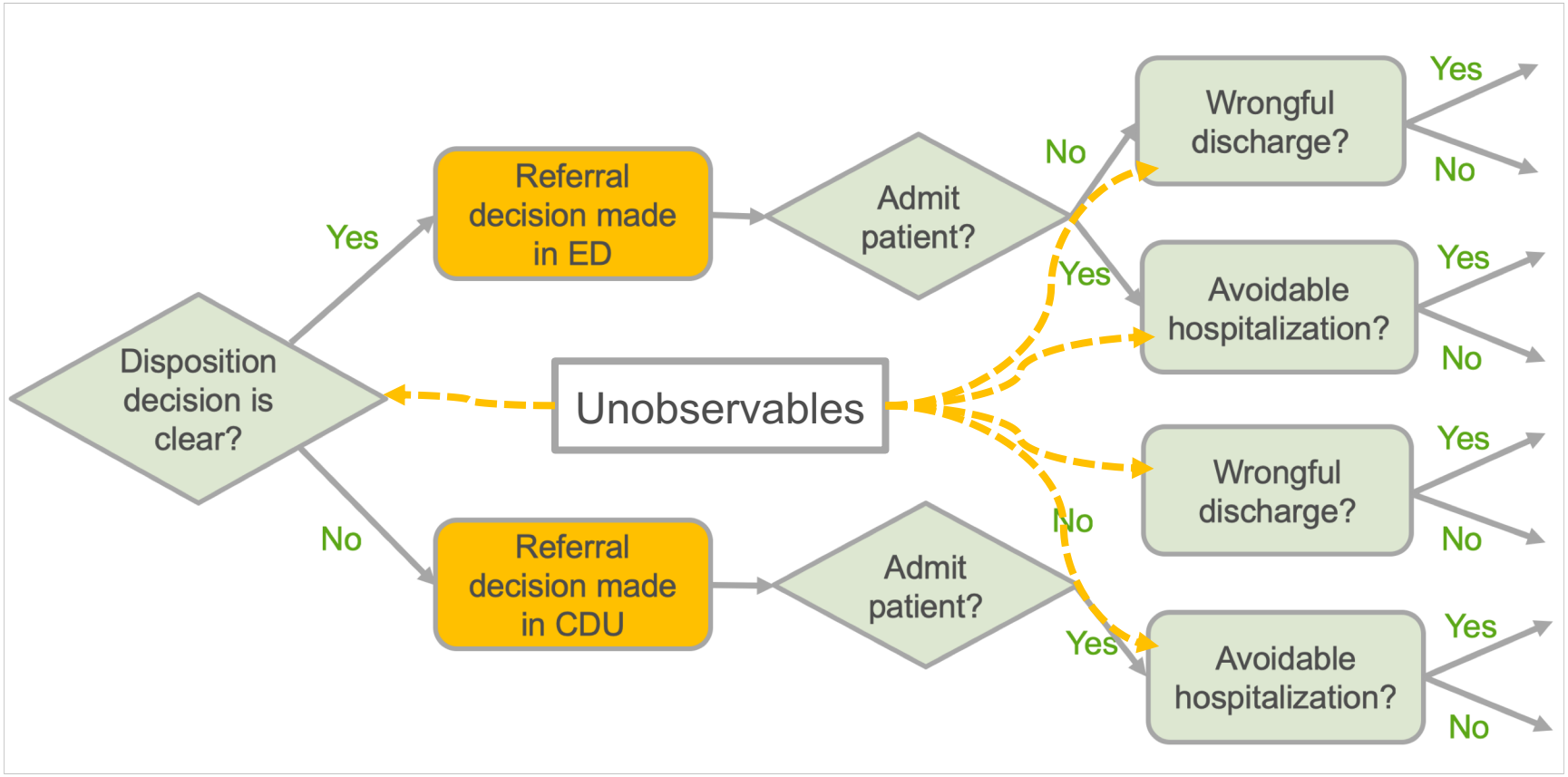

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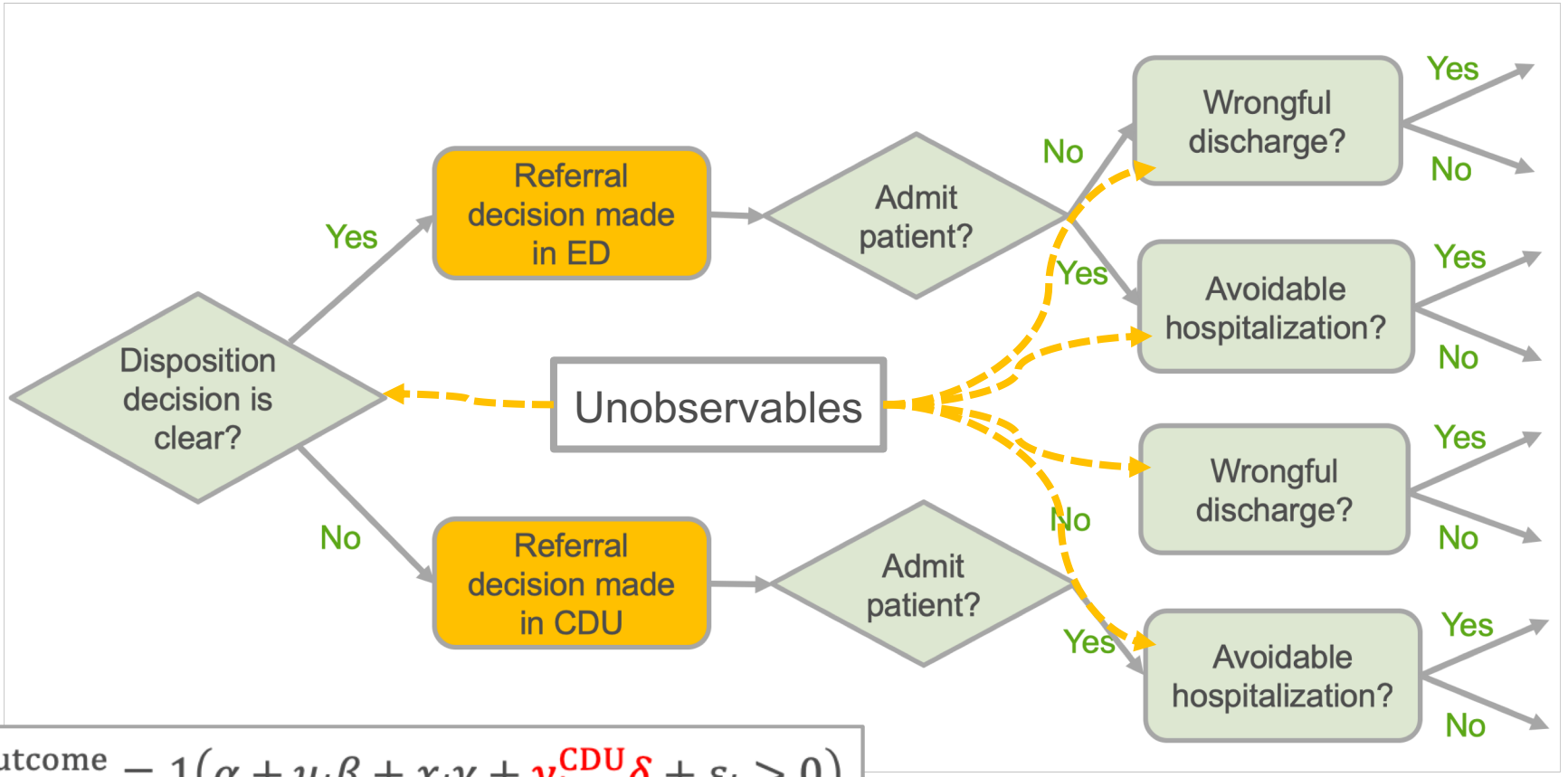

$$y_i^{\text{outcome}} = 1(\alpha + u_i\beta + x_i\gamma + y_i^{\text{CDU}}\delta + \varepsilon_i > 0)$$

$$y_i^{\text{CDU}} = 1(\alpha' + u_i\beta' + x_i\gamma' + z_i\delta' + \varepsilon_i' > 0)$$

$$(\varepsilon_i, \varepsilon_i') \sim N\begin{pmatrix}1 & \rho \\ \rho & 1\end{pmatrix}.$$

Bivariate probit model estimates the effect of the CDU on errors

Benefits of 2-stage gatekeeping

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	No patient routed through CDU	All patients routed through CDU
Avoidable hospitalizations	4.9%	2.3%
Wrongful discharges	0.8%	0.5%

Avg. treatment effect (**ATE**)

- Avoidable hosp. = -2.7%
- Wrongful discharges = -0.33%

→ When patients routed through the two-stage system *both* errors go down

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→ When patients routed through the two-stage system *both* errors go down

Avg. treatment effect on the treated (**ATT**)

- Avoidable hosp. = -5.7%
- Wrongful discharges = -0.8%

→ ED physicians especially good at identifying patients who would benefit most from CDU second opinion

Accounting for the opportunity cost of CDU capacity

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- **Counterfactual**
  - Closing CDU would increase unnecessary hospitalizations from 4.3% to 4.9%
  - But, could reallocate resources from the closed CDU to the ED
    - Would result in an approx. 20% decrease in congestion in the ED
    - And we also divert more experienced physicians to the ED
    - ➢ Unnecessary hospitalizations would reduce from 4.9% to 4.6%
- **Why is CDU better than commensurate increase in ED capacity?**
  - Extra capacity in ED is only useful during busy periods; CDU improves decisions all the time
  - Extended service time in the CDU is provided only to those patients who benefit from it the most

Robustness

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- **Congestion effect**
  - As congestion increases, risk profile of patients changes (endogeneity)
  - Measuring congestion over different time windows *(2h, 4h, -1h)*
  - Alternative definitions of unnecessary hospitalization *(12h, 48h, no diagnosis, a stay significantly shorter than other patients with same ED diagnosis).*
  - Wrongful discharges measured over *3 days* (instead of 7 days)
  - Different Heckprobit model, where first stage is to make either an admit, refer to the CDU, or discharge decision.
- **Two-stage gatekeeping**
  - 1:1 nearest neighbor matching
  - Alternative definitions of unnecessary hospitalization and wrongful discharge, as above.

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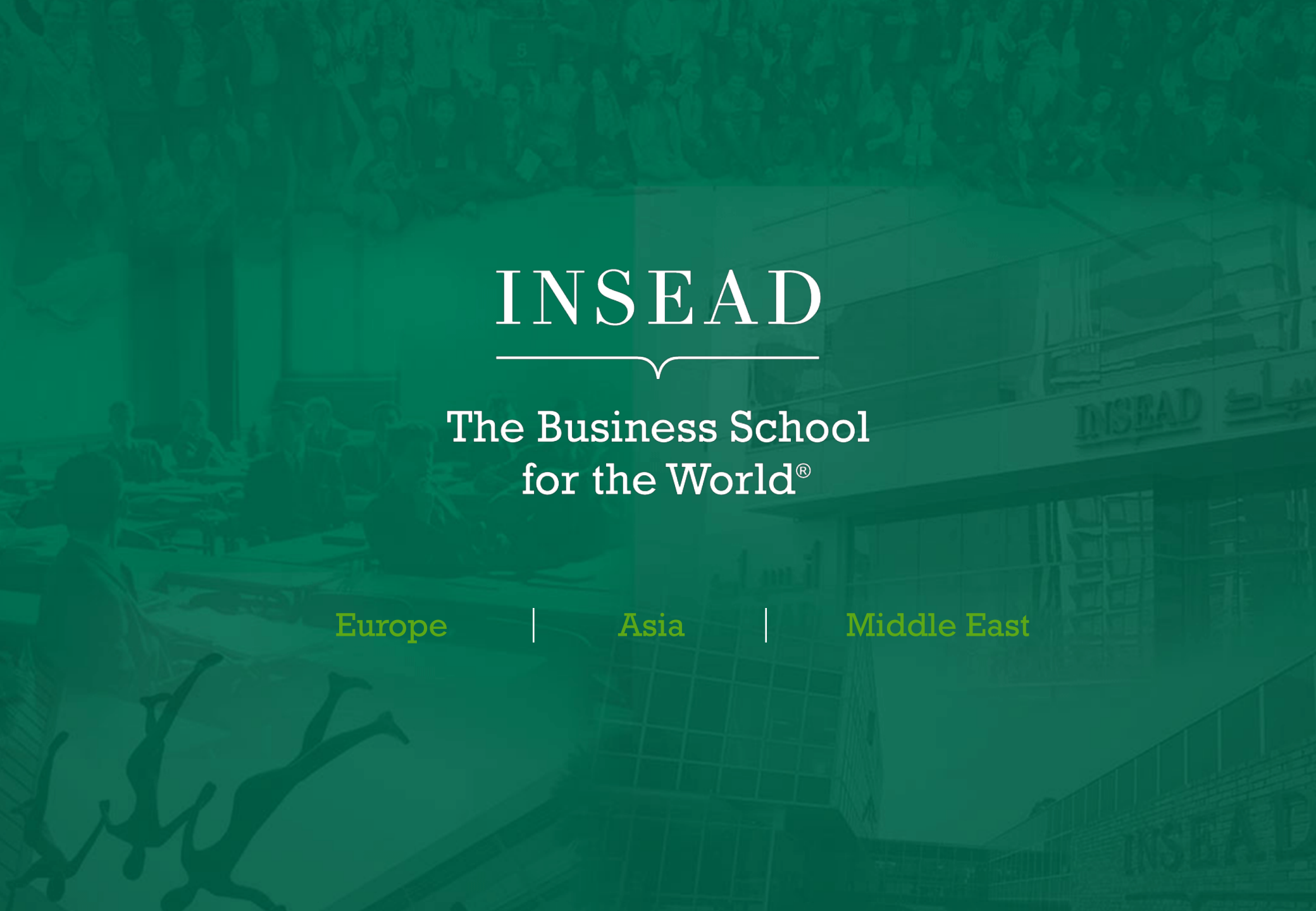
Thank you!

Questions?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