The effect of predicted hemoglobin trajectories on anemia outcomes

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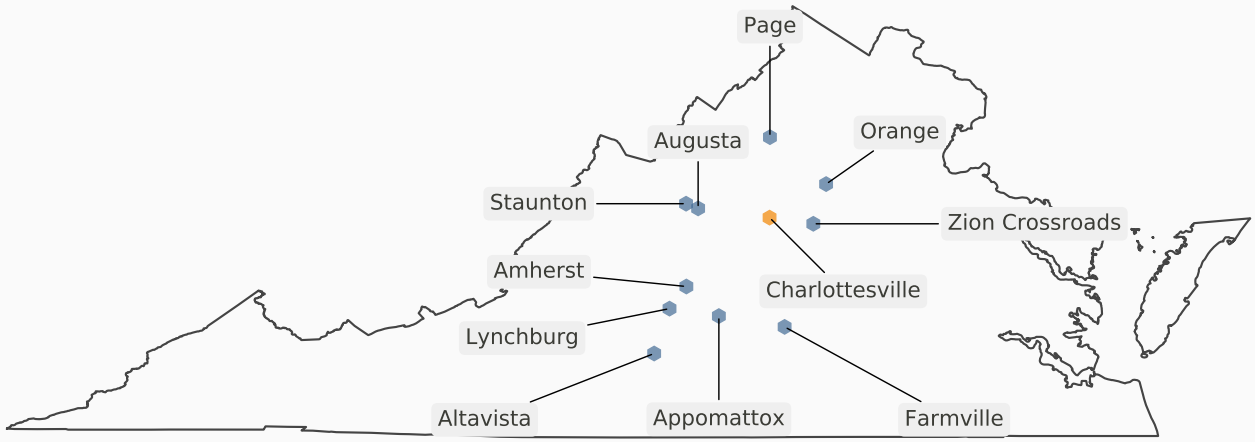
KIDNEY DISEASE

- There are over 30 million Americans with some form of kidney disease
- End-Stage Renal Disease (ESRD) is the most severe form, affects over 650,000 individuals, and affects minorities more than whites[6]
- Diagnosed when the kidney's abilities to cleanse toxins from the blood fall below 15%
- Treatment options are
    1. Dialysis
    2. Kidney transplant

UVA DIALYSIS

- The UVA owns its dialysis system
  - 11 clinics across Virginia
  - ~930 patients



- Not an extremely large patient population...
  - Dialysis patients account for 1% of the Medicare population but 7% of the budget

ESRD-INDUCED ANEMIA

- Patients with End-Stage Renal Disease (ESRD) typically have ESRD-induced anemia (a low red blood cell count)
- Erythropoiesis stimulating agents (ESAs): main class of drugs administered in order to obtain the target red blood cell levels 治疗贫血的一种药
- Medicare guidelines suggest a goal where 90% of dialysis patients achieve target red blood cell levels (hemoglobin [Hgb] levels) of 10–12 g/dL
- Medications, like the ESAs used to treat anemia, are costly and used by ~80% of all patients

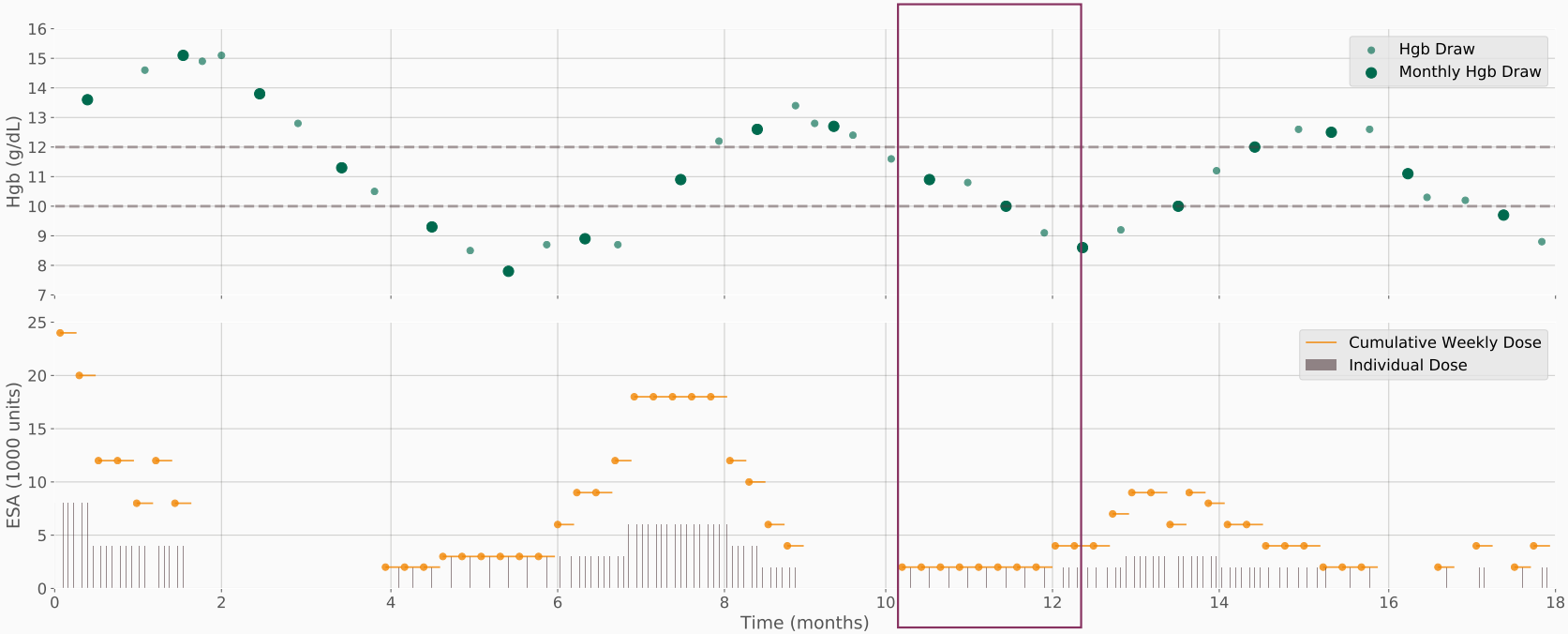
CURRENT PROTOCOL

- Paper protocol with monthly dosing decisions
- Every patient is treated the same - dosing decisions are based on
  - The current Hgb level, and
  - The direction and magnitude of the change in Hgb level between the current and 1 month prior Hgb levels
- Anemia nurse managers make changes based on the paper protocol
- Clinician gets involved if a patient needs a non-protocol change based on clinical indications

ISSUES WITH CURRENT APPROACH

- Patient response to ESAs is highly variable
  - Raw materials (e.g., iron) must be present to produce red blood cells
  - Red blood cell production seems to shut down when a patient is sick (inflammation, etc.)
  - Presence of other co-morbidities 并发症
- It takes 2–3 months[5] for the effects of a dosing decision to be fully realized, but dosing decisions are made monthly
- Time mismatch drives hemoglobin cycling[1]
  - Sinusoidal pattern of Hgb values with peaks and valleys outside of target range

CLASSIC HEMOGLOBIN CYCLING



- High doses of ESA may increase risks of death and cardiovascular events[4]

PROPOSED NEW APPROACH

- Root cause of issues:
  - Timing mismatch
  - Protocol suggests changing weekly ESA dose unless patient Hgb level is between 10.0 and 11.5 g/dL
- Would like to:
  - Keep patient Hgb “in range”: 10.0 – 12.0 g/dL[2]
  - Minimize the use of ESA
- How to accomplish this? Provide information that would allow nurse managers or clinicians to override the protocol and “do nothing”

PREDICTIVE DOSING

- Built a predictive dosing model[3]
  - Given a future ESA dosing profile, predicts the Hgb level using the patient's history
- Built a dosing recommendation algorithm
  - Incorporates UVA dialysis business rules
  - Iterates over a large number of possible future dosing profiles
- Given target criteria, the dosing recommendation algorithm provides the
  1. Recommended future dosing profile over the next 3 months
  2. Expected Hgb level trajectory over the next 3 months

INTERVENTION

Each month

- We held a conference call with the anemia nurse manager
- They would go through each patient and state what they would do based on current (paper) protocol
- We would then provide them the expected Hgb trajectory
- They were able to change their dosing decision if desired (they had final say)

INTERVENTION ISSUES

1. The form of information presented changed during the pilot
    - Initially provided the 3 month Hgb level prediction over the phone
    - Then began sending them a visualization with the 3 month prediction
    - Finally ended up providing a visualization with the 1, 2, and 3 month Hgb trajectory

2. We did not simply give them the information - we sat down and went through each patient
    - The nurse manager likely spent more time and placed more thought on each patient than they would normally

ANALYSIS GOAL

Evaluate whether the intervention

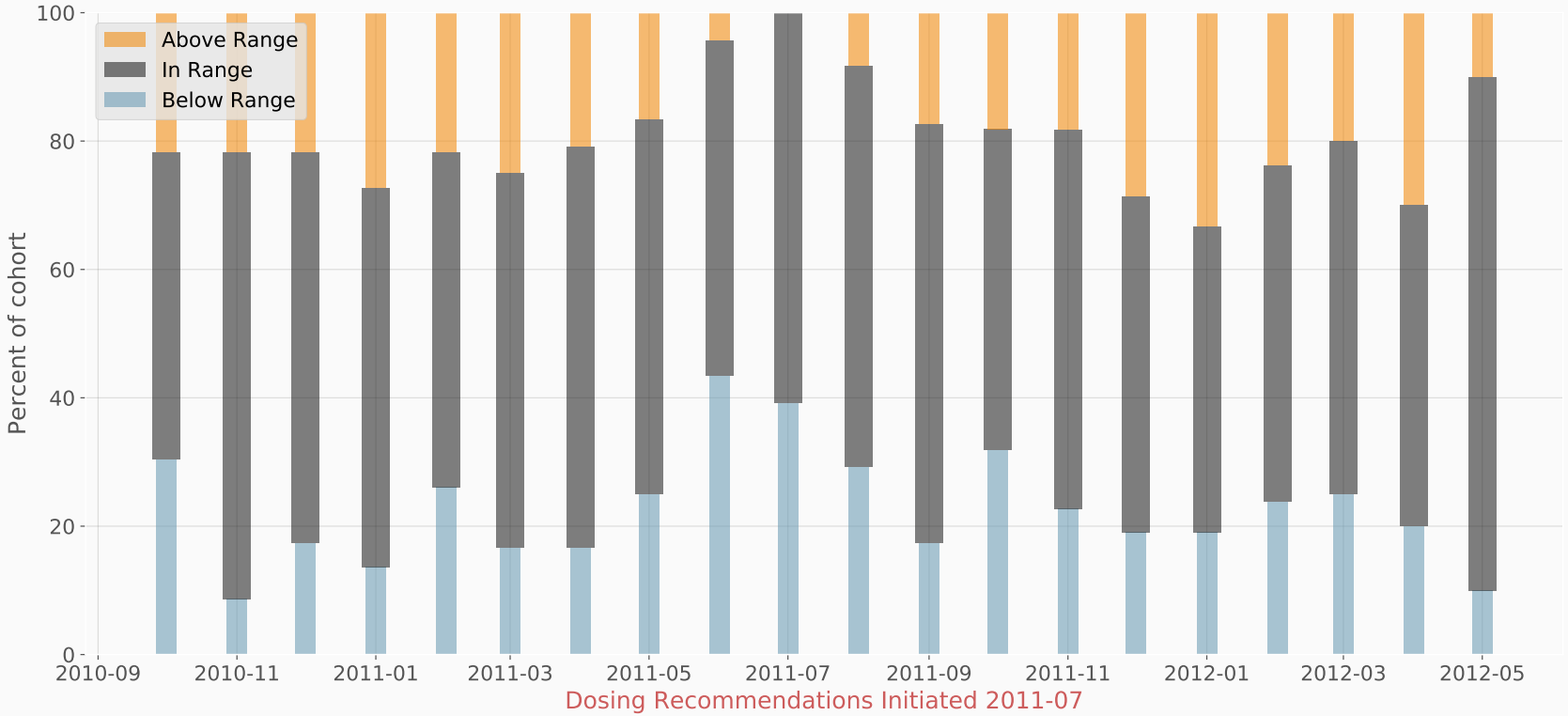
1. Improved patient outcomes
   - 1.1 Percent of time in range (Medicare goal)
   - 1.2 Reduction in cycling / severity of cycling
   - 1.3 Minimizing time below 10.0 g/dL
   - 1.4 Individual vs. group improvement?

2. Decreased ESA usage
   - 2.1 Average ESA dose per treatment
   - 2.2 Average weekly ESA dose

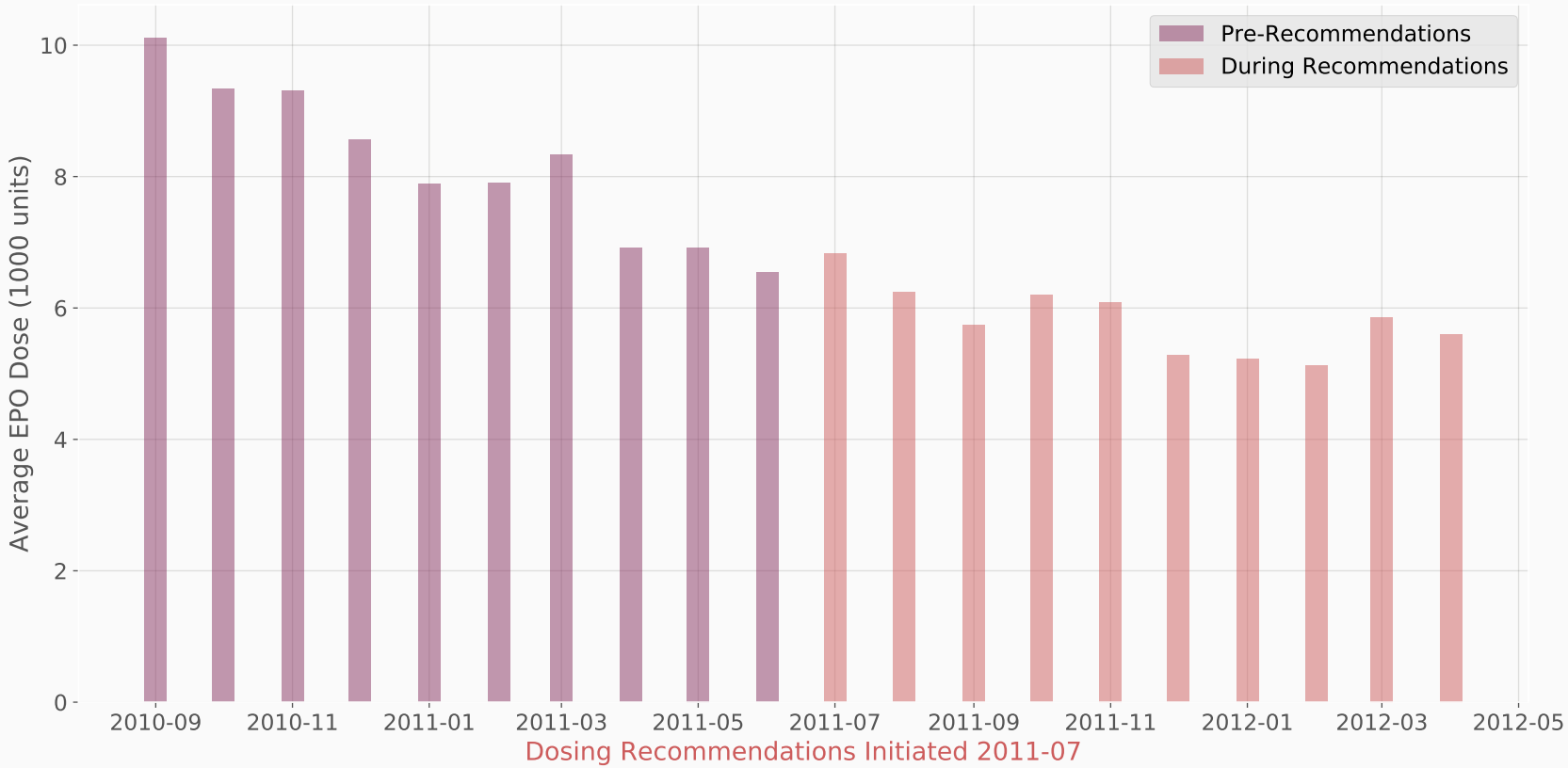
DATA

- 25 patients over 20 months
  - 10 months pre-initiation of intervention
  - 10 months post-initiation of intervention
- Monthly Hgb values (monthly_HGB_dosing.csv)
  - PatientID, Year, Month, HGB, Post-Intervention
- Per treatment ESA doses (monthly_EPO_dosing.csv)
  - PatientID, Year, Month, EPO_Dose, Post-Intervention

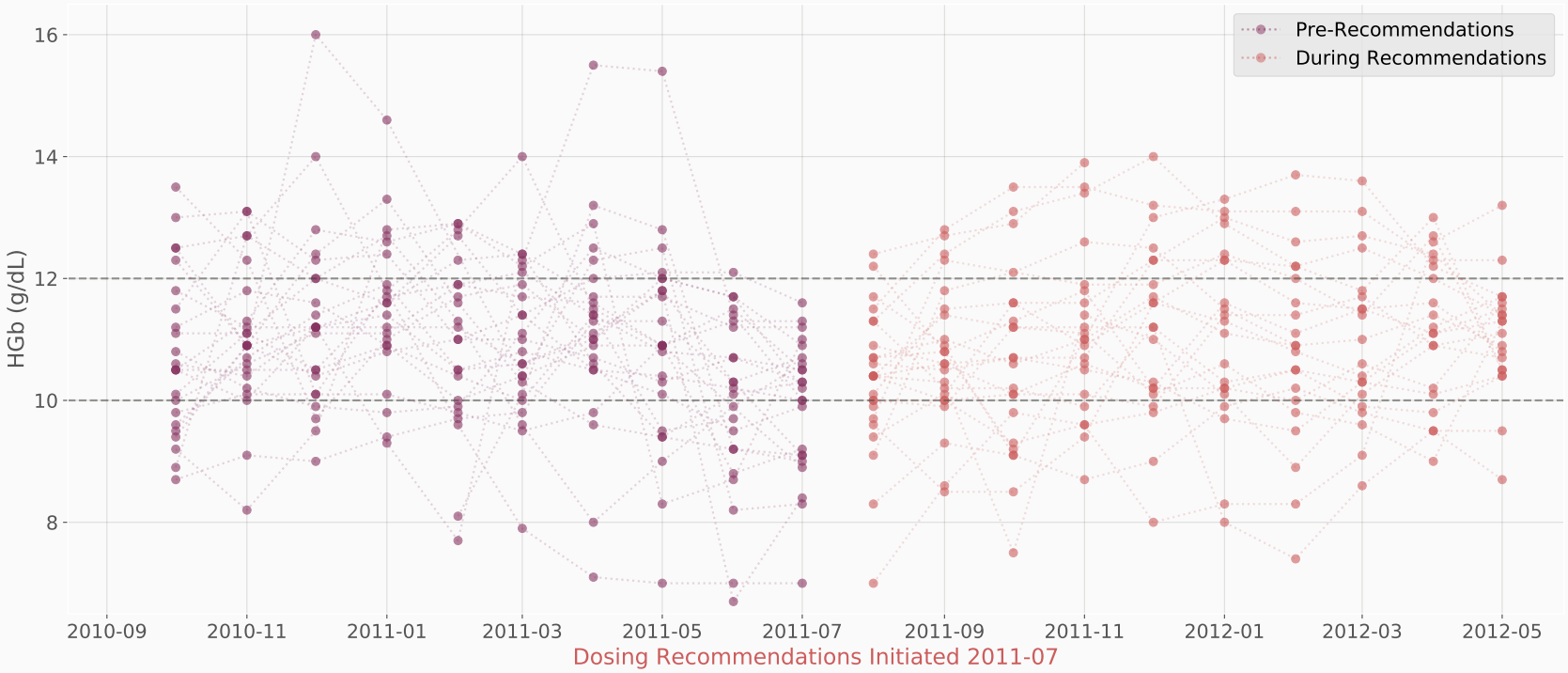
PERCENT OF TIME IN RANGE



AVERAGE ESA TREATMENT



MONTHLY HEMOGLOBIN VALUES



Questions?

References

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