Predicting Transfusion Risks Among Hemodialysis Patients

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Introduction

- Patients with chronic kidney disease who undergo dialysis are at risk of persistent anemia. Transfusion is an option of last resort for anemia management and may adversely impact dialysis patients' survival, well being, and transplant candidacy.[1] The ability to prospectively predict which patients are at risk for transfusions may facilitate implementation of avoidance strategies.
- Predictions through risk models may help increase efficiency, reduce costs, and improve health outcomes.[2]

Objective

The goal of this study was to develop a prediction algorithm enabling prospective identification of patients who are at high risk of transfusion.

Methods

- Demographic, biochemical, clinical, and transfusion data were abstracted from the DaVita Clinical Data Warehouse. In the training set, predictor variables Q4 2010 were used to predict transfusion risk in Q1 2011. Bivariable associations with outcomes were used to guide specification and prioritize potential predictors. A multivariable logistic model was built by sequentially adding variables and assessing the impact on prediction. Validation sets evaluated the quality of prediction at subsequent time periods (Q1 2011-Q2 2011; Q2 2011-Q3 2011; Q3 2011-Q4 2011). Discrimination was assessed by C-statistic and calibration by comparison of observed versus predicted transfusion risk.
- Patients:
  - Received in-center hemodialysis at DaVita
    - During predictor assessment period
    - During transfusion at-risk period
  - Had visibility into receipt of red blood cell transfusion
  - Excluded US Veterans Affairs patients (n = 2,124)
  - N=101,135
- Transfusion data were collected from hospital medical records by independent data services.

Logistic model

- Outcome: red blood cell transfusion in subsequent 3 months
- Predictors: demographic, comorbidity, laboratory, clinical data over prior 3 months

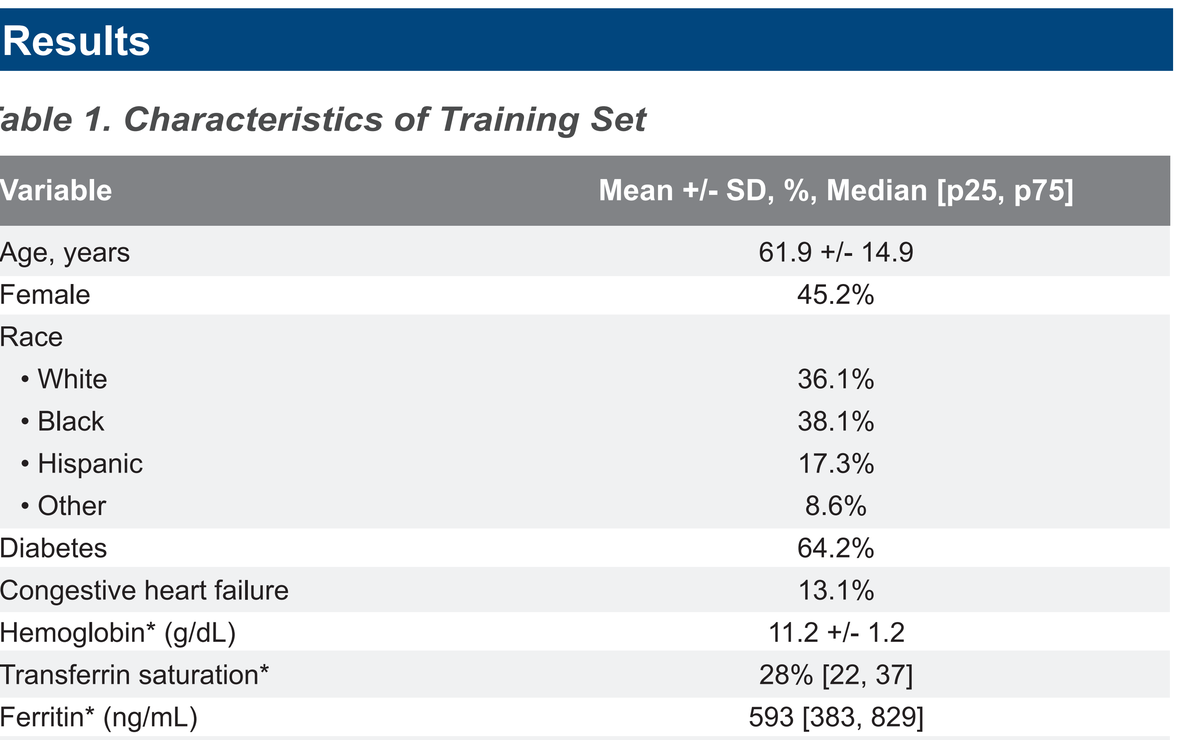
Results

Table 1. Characteristics of Training Set

Variable	Mean +/- SD, %, Median [p25, p75]
Age, years	61.9 +/- 14.9
Female	45.2%
Race	
• White	36.1%
• Black	38.1%
• Hispanic	17.3%
• Other	8.6%
Diabetes	64.2%
Congestive heart failure	13.1%
Hemoglobin* (g/dL)	11.2 +/- 1.2
Transferrin saturation*	28% [22, 37]
Ferritin* (ng/mL)	593 [383, 829]
Epogen dose* (units/treatment)	4,714 [2,475, 9,054]
Intravenous iron dose* (mg cumulative)	200 [100, 400]

*Over prior month

Figure 1. Approach



- The training set contained 103,350 patients (mean age 62 years, 45% female, 38% black, 45% diabetic) of whom 1,756 had a transfusion in Q1 2011.
- Thirty-two variables were identified and included in the final model; each variable incrementally improved prediction (C-statistic, 0.73; Figure 2).
- The model demonstrated excellent calibration over the full 20-fold range of risk observed (Figure 3).
- In the 3 validation cohorts, discrimination (Table 2) and calibration (not shown) were similar.

Table 2. Discrimination in Training and Validation Sets

Models	Area Under the Curve
Internal validation: Q1 2011	0.7343
External validation 1: Q2 2011	0.7359
External validation 2: Q3 2011	0.7119*
External validation 3: Q4 2011	0.7355

* There was a marked increase in transfusion rates from July - Oct 2011 that likely changed the clinical parameter transfusion relationship temporarily.

Figure 2. Discrimination in Training Set

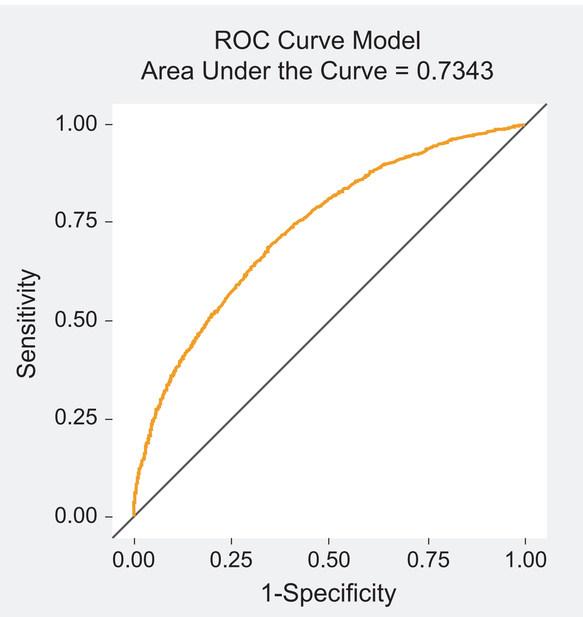
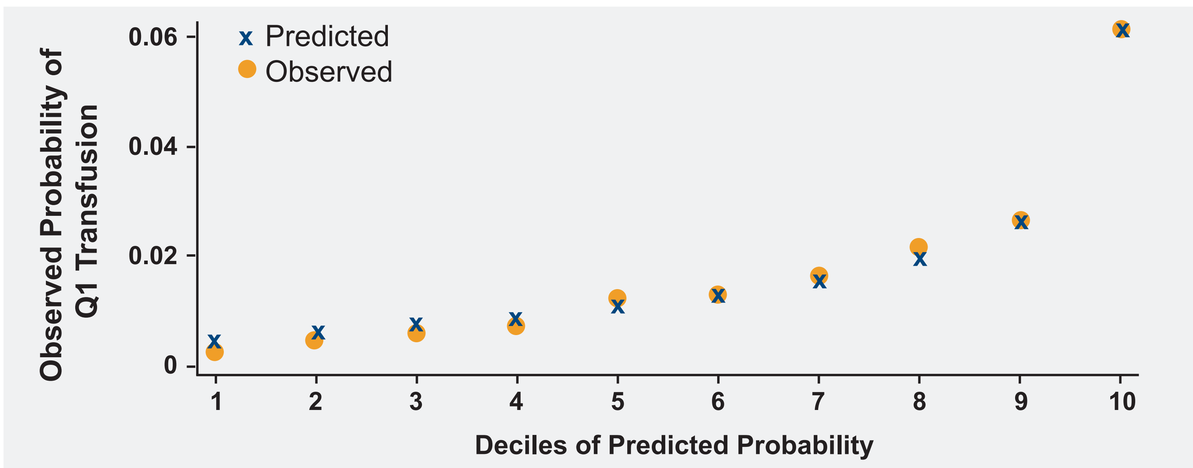


Figure 3. Observed vs Predicted Probability of Transfusion in Training Set



Conclusions

We developed a predictive model that is able to accurately and reproducibly risk-stratify patients on the basis of future transfusion risk. This model:

- Uses data elements that are commonly available in electronic health records
- Is flexible with respect to risk threshold (ie, can turn up or down the gain)
- Enables:
  - Real-time clinical assessment of patient risk
  - Opportunity for prevention efforts
  - Identification of high-risk population in which prophylactic interventions can be tested

Because of the proprietary and confidential nature of the model, we are not able to share it at this time.

References

1. Lawler EV, Bradbury BD, Fona JR, Gaziano JM, Gagnon DR. Transfusion burden among patients with chronic kidney disease and anemia. Clin J Am Soc Nephrol. 2010;5(4):667-672.
2. Claus EB. Risk models used to counsel women for breast and ovarian cancer: a guide for clinicians. Fam Cancer. 2001;1(3-4):197-206.

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