

# Simulated Risk Model

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September 5, 2022

## Data Generation and Estimation Equations

### Data Generation

The data for observed patient outcomes of readmission, home health care (HHC) assignment, patient demographics, prior hospitalization, diagnosis, and payer type come from a single hospital in the READI study (Weiss, et al., 2019).

The challenge is simulating the patient's latent "risk" for the adverse outcome of readmission. We propose that this is not the same as the *ex post likelihood* of readmission. We also propose that patients with higher risk of adverse outcomes - including readmission - will be more likely to receive HHC assignments. Hence, there will be a bias in the using the observed likelihood to measure risk, and therefore a bias in the observed effectiveness of the intervention of assigning HHC. To simulate this bias, we randomly assign ten percent of the patients who received HHC assignment but were not eventually readmitted a positive readmission risk value. The remaining risk values remain the same as the observed readmission outcome.

### Estimation Equations

The equations to estimate the *observed* rate of readmission and home health assignment, respectively, are:

$$\begin{aligned} HHC = & \beta_{10} + \beta_{11}Female + \beta_{12}Married + \beta_{13}Hispanic + \beta_{14}Prior + \beta_{15}Surgical \\ & + \beta_{16}ICU + \beta_{17}LengthOfStay + \sum_{t=1}^T \tau_{1t}Age_t + \sum_{r=1}^R \rho_{1r}Race_r + \sum_{d=1}^D \delta_{1d}Diagnosis_d \\ & + \sum_{s=1}^S \sigma_{1s}Severity_s + \sum_{m=1}^M \mu_{1m}Mortality_m + \alpha_{1j} + \epsilon_{1i}, \end{aligned}$$

$$\begin{aligned} Risk = & \beta_{20} + \beta_{21}Female + \beta_{22}Married + \beta_{23}Hispanic + \beta_{24}Prior + \beta_{25}Surgical \\ & + \beta_{26}ICU + \beta_{27}LengthOfStay + \sum_{t=1}^T \tau_{2t}Age_t + \sum_{r=1}^R \rho_{2r}Race_r + \sum_{d=1}^D \delta_{2d}Diagnosis_d \\ & + \sum_{s=1}^S \sigma_{2s}Severity_s + \sum_{m=1}^M \mu_{2m}Mortality_m + \alpha_{2j} + \epsilon_{2i}, \end{aligned}$$

and

$$\begin{aligned} Readmission = & \beta_{30} + \beta_{31}Female + \beta_{32}Married + \beta_{33}Hispanic + \beta_{34}Prior + \beta_{35}Surgical \\ & + \beta_{36}ICU + \beta_{37}LengthOfStay + \sum_{t=1}^T \tau_{3t}Age_t + \sum_{r=1}^R \rho_{3r}Race_r + \sum_{d=1}^D \delta_{3d}Diagnosis_d \\ & + \sum_{s=1}^S \sigma_{3s}Severity_s + \sum_{m=1}^M \mu_{3m}Mortality_m + \alpha_{3j} + \epsilon_{3i}, \end{aligned}$$

where  $\alpha_j$  represents the fixed effect for hospital  $j$ .

## Simulation Results.

We simulated the model 1000 times using 1000 observations randomly selected from the dataset described above in each iteration. We present the coefficients for these results for the impact of the various risk factors on the likelihood of receiving a referral to home health and on the *outcome* of readmission in Table 1.

We present the results for the impact of the various risk factors on *risk* of readmission and the *likelihood* of readmission in Table 2.

Figure 1 presents a kernel density plot of the distributions of the coefficient for age on the raw outcome as well as the adjusted risk after accounting for provider intervention bias.

Table 1:

	<i>Dependent variable:</i>		
	hh	read30_01	
	(1)	(2)	(3)
medsugptSurgical	0.168 (0.295)	−0.529* (0.277)	−0.533** (0.263)
icustayICU Stay	0.345 (0.285)	−0.242 (0.266)	−0.247 (0.252)
genderFemale	0.222 (0.229)	−0.074 (0.215)	−0.076 (0.207)
raceAsian	0.102 (0.295)	0.172 (0.284)	0.172 (0.273)
raceBlack	−0.290 (0.303)	0.014 (0.293)	0.016 (0.287)
ethnicityHispanic	−0.335 (0.400)	0.405 (0.388)	0.406 (0.383)
maritalsMarried	−0.188 (0.228)	−0.098 (0.215)	−0.097 (0.210)
hosp30d30-day Prior Hosp.	0.615** (0.263)	1.182*** (0.253)	1.179*** (0.251)
mortriskModerate	0.356 (0.326)	0.292 (0.314)	0.290 (0.304)
mortriskMajor	0.389 (0.416)	0.432 (0.398)	0.428 (0.384)
severityModerate	0.413 (0.346)	0.253 (0.334)	0.250 (0.321)
severityMajor	0.667 (0.417)	0.462 (0.406)	0.456 (0.395)
age_cats45-54	0.468 (0.382)	0.113 (0.373)	0.111 (0.365)
age_cats55-64	0.831** (0.352)	0.015 (0.341)	0.010 (0.331)
age_cats65-74	1.218*** (0.372)	0.020 (0.364)	0.010 (0.352)
age_cats75+	1.745*** (0.377)	0.043 (0.363)	0.027 (0.351)
lnlos	0.854*** (0.149)	0.335** (0.142)	0.329** (0.138)
hhHHC			0.065
Constant	−4.755*** (0.624)	−3.326*** (0.600)	−3.318*** (0.569)
Observations	1,000	1,000	1,000
Log Likelihood	−336.145	−315.280	−315.020
Akaike Inf. Crit.	738.291	696.560	698.040

*Note:*

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

Table 2:

	<i>Dependent variable:</i>			
	risk			
	(1)	(2)	(3)	(4)
medsugptSurgical	−0.441 (0.295)	−0.370 (0.277)	−0.314 (0.263)	−0.267 (0.252)
icustayICU Stay	−0.184 (0.285)	−0.128 (0.266)	−0.086 (0.252)	−0.050 (0.240)
genderFemale	−0.043 (0.229)	−0.018 (0.215)	0.001 (0.207)	0.019 (0.200)
raceAsian	0.162 (0.295)	0.158 (0.284)	0.152 (0.273)	0.146 (0.264)
raceBlack	−0.011 (0.303)	−0.034 (0.293)	−0.052 (0.287)	−0.071 (0.280)
ethnicityHispanic	0.348 (0.400)	0.308 (0.388)	0.274 (0.383)	0.243 (0.382)
maritalsMarried	−0.104 (0.228)	−0.114 (0.215)	−0.122 (0.210)	−0.129 (0.203)
hosp30d30-day Prior Hosp.	1.129*** (0.263)	1.091*** (0.253)	1.064*** (0.251)	1.045*** (0.246)
mortriskModerate	0.294 (0.326)	0.299 (0.314)	0.304 (0.304)	0.311 (0.290)
mortriskMajor	0.412 (0.416)	0.406 (0.398)	0.404 (0.384)	0.400 (0.369)
severityModerate	0.261 (0.346)	0.276 (0.334)	0.285 (0.321)	0.295 (0.310)
severityMajor	0.473 (0.417)	0.484 (0.406)	0.498 (0.395)	0.509 (0.379)
age_cats45-54	0.127 (0.382)	0.146 (0.373)	0.160 (0.365)	0.176 (0.352)
age_cats55-64	0.069 (0.352)	0.121 (0.341)	0.162 (0.331)	0.207 (0.322)
age_cats65-74	0.107 (0.372)	0.183 (0.364)	0.259 (0.352)	0.327 (0.339)
age_cats75+	0.194 (0.377)	0.326 (0.363)	0.438 (0.351)	0.533 (0.341)
lnlos	0.383** (0.149)	0.420*** (0.142)	0.454*** (0.138)	0.491*** (0.134)
Constant	−3.302*** (0.624)	−3.286*** (0.600)	−3.266*** (0.569)	−3.261*** (0.552)
Observations	1,000	1,000	1,000	1,000
Log Likelihood	−329.406	−351.435	−381.769	−398.965
Akaike Inf. Crit.	724.812	768.869	829.539	863.931

Note:

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01