5.4.4a Risk/Case-mix Adjustment Modeling Specifications Attachment

30-Day Unplanned Readmissions for Cancer Patients Measure

Method

To risk-adjust for variation in patient cohorts across hospitals and allow for clustering of outcomes at a given hospital, we fit a hierarchical logistic regression model with random intercepts for each hospital. The data source is CMS's Standard Analytic File (SAF) Limited Data Sets (LDS). The hierarchical logistic regression model was estimated via the **glmer** function of the *lme4* package (1.1-35.5) in *R*(4.4.2)/*Rstudio*(2024.4.0.735).

Y_{ij} gives the outcome of the *i*-th index admission at the *j*-th hospital, where 0 indicates that there was no unplanned readmission in the 30 days following discharge and 1 indicates that there was an unplanned readmission during that period. N_j indicates the number of index admissions at hospital *j*, $o_j = \frac{\sum_1^{N_j} Y_{ij}}{N_j}$ gives the observed (unadjusted) rate of unplanned readmissions at that hospital, and o_U is the 30-day unplanned readmission rate for the United States.

The outcomes Y_{ij} are assumed to be Binomially distributed, linked to the covariates through the logit function:

$$logit\left(P\left(Y_{ij}=1\right)\right) = \alpha_j + \beta * Z_{ij} + \epsilon_{ij}$$

$$\alpha_j = \mu + \omega_j \; ; \omega_j \sim N(0, \tau^2)$$

where:

- α_j is the hospital specific random intercept
- $\boldsymbol{\beta}$ gives the parameter estimates for the patient-level covariates
- $\mathbf{Z}_{ij} = (Z_1, Z_2, \ldots, Z_m)$ indicates the values of the set of *m* patient-level covariates
- μ is the average outcome estimated by the model across all index admissions
- ω_j gives the offset from μ for hospital *j,* drawn from a Normal distribution centered at 0
- τ^2 gives the variance of the distribution which the hospital-level random intercepts are drawn from

To then estimate hospital *j*'s risk-adjusted performance for the measure, we calculate the ratio of the sum the predicted probabilities and the sum of expected probabilities for all patients at that hospital, which include and omit the hospital-level effects, respectively.

The predicted probability (p_{ij}) of an unplanned readmission for patient *i* at hospital *j* is given by

$$p_{ij} = \frac{\exp(\alpha_j + \boldsymbol{\beta} * \boldsymbol{Z_{ij}})}{1 + \exp(\alpha_j + \boldsymbol{\beta} * \boldsymbol{Z_{ij}})}$$

and the expected probability (e_{ij}) of an unplanned readmission for patient *i* at hospital *j* is given by

$$e_{ij} = \frac{\exp(\mu + \boldsymbol{\beta} * \boldsymbol{Z_{ij}})}{1 + \exp(\mu + \boldsymbol{\beta} * \boldsymbol{Z_{ij}})}$$

Then hospital *j*'s risk-standardized readmission rate is given by multiplying this ratio by the unplanned readmission rate for all eligible index admissions with a cancer diagnosis code in the US:

$$RSRR_j = \frac{\sum_1^{N_j} p_{ij}}{\sum_1^{N_j} e_{ij}} * o_U$$

Data Source

See Data Dictionary attachment for details and codes.

Variable Distribution

Descriptive statistics regarding distribution of all risk variables tested are in Table 5.4.3.

Table 5.4.3 Variable Distribution Across Measured Entities

Risk Covariate	Mean	Minimum	Maximum	25th Percentile	Median	75th Percentile
Male	53.5%	0.0%	100.0%	48.7%	53.6%	58.9%
Admission Via ER	63.0%	0.0%	100.0%	44.4%	76.0%	88.1%
Bone Marrow Transplant	0.3%	0.0%	25.0%	0.0%	0.0%	0.2%
2 or More Comorbidities	81.3%	0.0%	100.0%	77.8%	85.8%	90.6%
Length of Stay longer than 3 days	50.9%	0.0%	100.0%	42.9%	53.9%	61.7%
Metastatic Disease	25.0%	0.0%	100.0%	19.4%	26.1%	31.1%
Any admissions in prior 60 days	27.8%	0.0%	100.0%	22.2%	28.9%	33.5%
Age between 65 and 69	19.9%	0.0%	100.0%	14.3%	19.9%	25.0%
Age between 70 and 74	22.9%	0.0%	100.0%	17.7%	23.1%	27.1%
Age between 75 and 79	20.9%	0.0%	100.0%	16.7%	20.8%	24.4%
Age between 80 and 84	17.5%	0.0%	100.0%	12.5%	16.7%	20.5%
Age 85 or greater	18.8%	0.0%	100.0%	12.3%	16.8%	23.1%
ICU admission	21.9%	0.0%	100.0%	3.6%	16.4%	32.6%
Solid Tumor vs Hematologic Cancer	60.7%	0.0%	100.0%	53.2%	60.0%	67.6%
Dual-Eligible	16.7%	0.0%	100.0%	6.5%	12.1%	21.4%
Surgical Admission	19.5%	0.0%	100.0%	3.7%	18.2%	27.8%
1 or More Comorbidities	94.6%	0.0%	100.0%	94.2%	97.1%	99.1%

Risk Adjustment Modeling Results

All parameters below were included in the risk adjustment model.

Table 5.4.4 Risk/Case-Mix Adjustment Modeling Results

	Estimate	Std. Error	P value	Odds ratio point estimate	Odds ratio Wald lower bound	Odds ratio Wald upper bound
Intercept	-2.454	0.01	<0.0001	0.086	0.084	0.088
Male	0.076	0.005	<0.0001	1.079	1.068	1.089
Admission Via ER	0.324	0.006	<0.0001	1.383	1.368	1.399
Bone Marrow Transplant	0.061	0.036	0.0934	1.063	0.99	1.141
2 or More Comorbidities	0.304	0.008	<0.0001	1.355	1.334	1.377
Length of Stay longer than 3 days	0.299	0.005	<0.0001	1.348	1.334	1.361
Metastatic Disease	0.027	0.005	<0.0001	1.027	1.016	1.038
Any admissions in prior 60 days	0.389	0.005	<0.0001	1.475	1.461	1.49
Age between 65 and 69	Ref. Age					
Age between 70 and 74	0.006	0.007	0.3528	1.006	0.993	1.02
Age between 75 and 79	0.023	0.007	0.001	1.024	1.009	1.038
Age between 80 and 84	-0.016	0.008	0.0363	0.984	0.969	0.999
Age 85 or greater	-0.138	0.008	<0.0001	0.871	0.857	0.885
ICU admission	-0.001	0.005	0.8705	0.999	0.989	1.01
Solid Tumor vs Hematologic Cancer	0.007	0.005	0.1768	1.007	0.997	1.017