Association Between Opioid Prescription Propensity and Medicare Patient Panels' Mean HCC Risk Scores

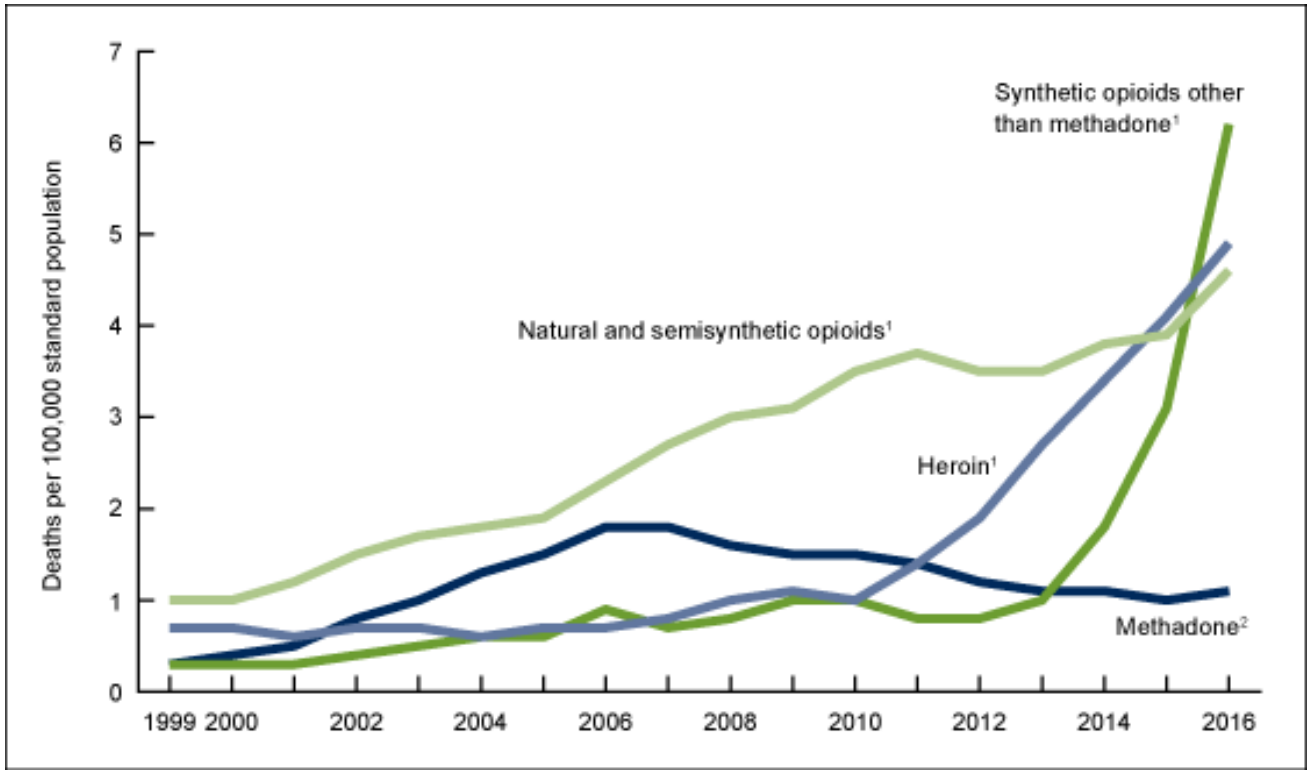
Carlo Duffy

Department of Statistics & Data Science

Carnegie Mellon University

14 December 2020

Opioid overdose deaths have risen (1999-2016)



Opioid addiction has crippled the US

Opioids are pain-relievers, whether they come from

- doctors' prescriptions (oxycodone, hydrocodone, synthetic opioids) or
- black markets (heroin, synthetic opioids)

Opioid overdose deaths persist: 46,802 in 2018; 50,042 in 2019

Purdue Pharma reached an $8B settlement w. the Dept. of Justice for

- paying doctors to promote and increase prescriptions of its drugs
- failing to prevent prescriptions from entering black markets

Physician prescriptions might contribute

Patients covered by Medicare are **six** times more likely to suffer from opioid addiction, compared to those covered by commercial health insurance (Lembke & Chen, 2016)

Barnett et al. (2017) discovered that patients who were prescribed high-intensity opioids, without previous opioid treatment, were more likely to use opioids in the long term

North et al. (2017)

- found a positive association between average patient case complexity and physician propensity to prescribe opioids
- provided preliminary results using a convenient sample

North et al.’s approach is narrow

Their population: physicians at the Mayo Clinic in Rochester, MN

Their sample size: 100

Their physician specialties studied: family practice & internal medicine

North et al. motivate using richer data

I study 2016 Medicare Part D physician data, which captures prescriptions spanning from Jan. 1, 2016 to June 30, 2017

This dataset has ~1.13M rows (*i.e.* physicians) and 84 columns

Variables include

- physician demographics (state, specialty, gender)
- claim types (opioids, antibiotics, antipsychotics)
- aggregate patient panel demographics (age, gender, race)

Key terms and variables

Part D: optional prescription drug coverage for Medicare patients

Patient panel: a physician's entire group of patients (beneficiaries) seen

SLOB: a physician's total supply length (in days) of all opioid prescriptions per opioid beneficiary

Key terms and variables

Hierarchical Condition Category (HCC) risk score

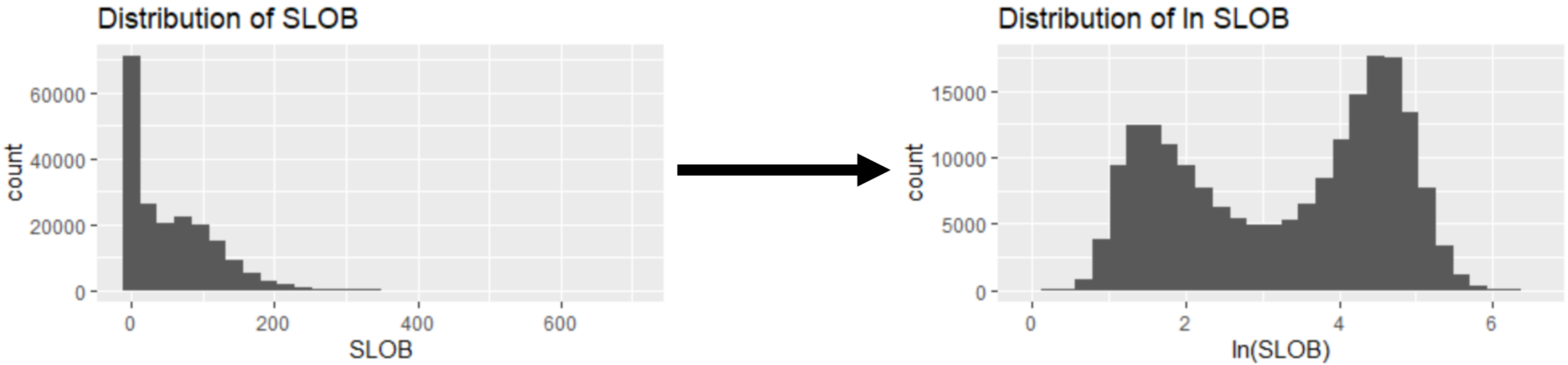
- compares a patient's estimated medical expenditures to the Medicare population's average medical spending
- higher scores = higher medical spending = higher case complexity

Mean HCC risk score: a patient panel's average case complexity

North et al. motivate the following approach

I model the relationship between mean HCC score and SLOB

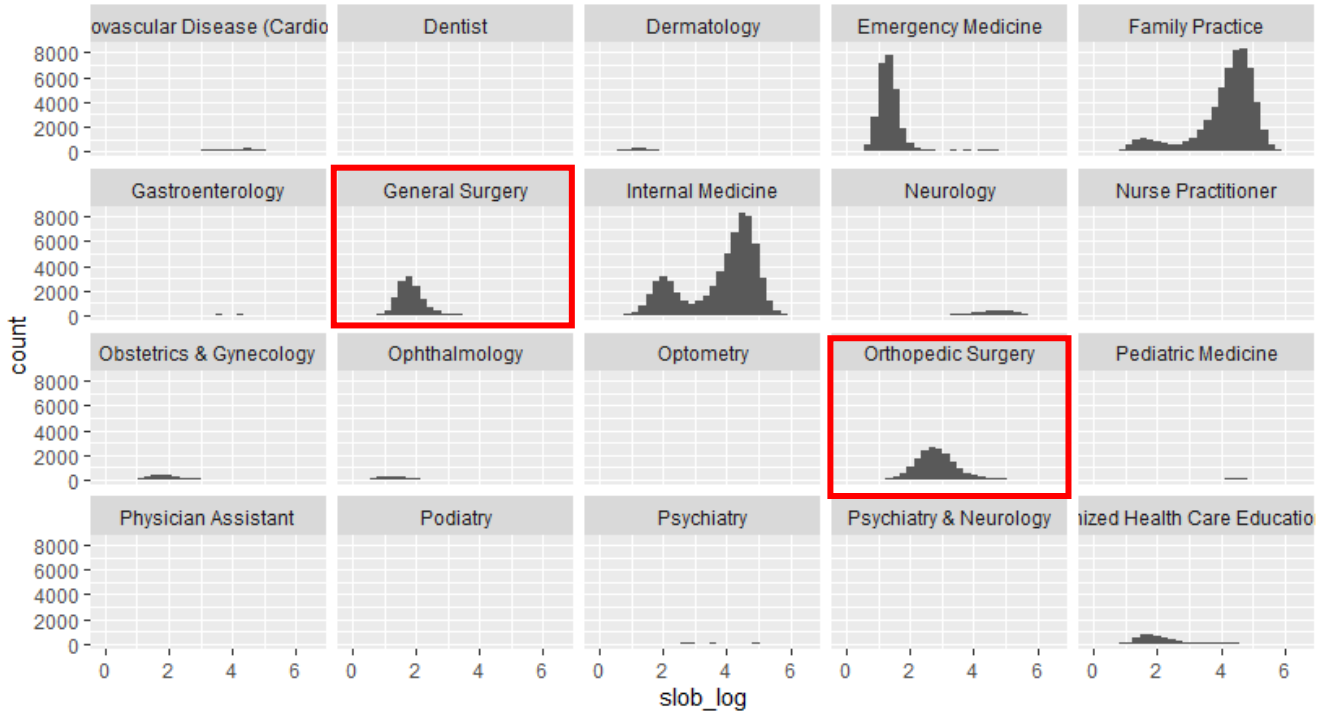
SLOB must be log-transformed



North et al. motivate the following approach

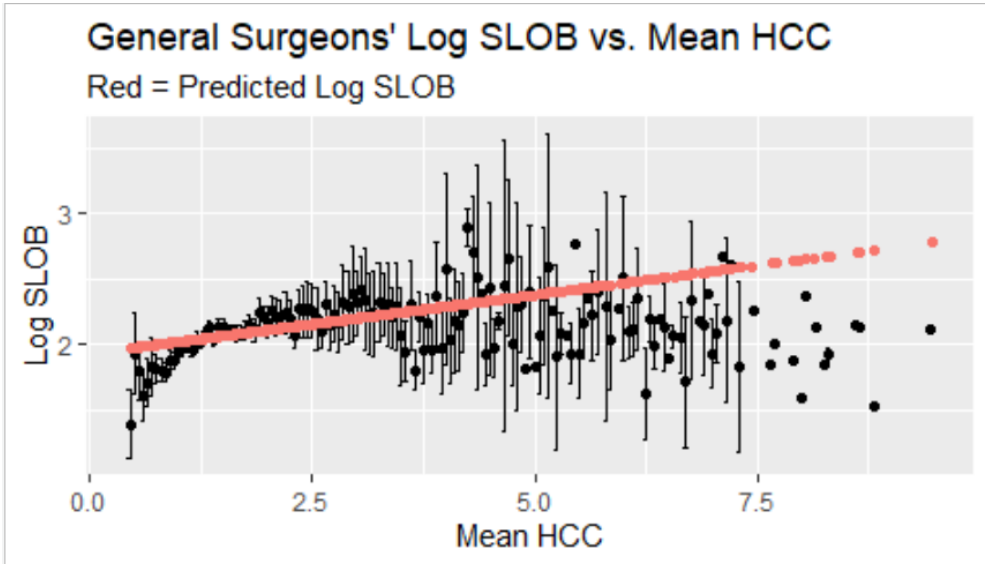
The distribution of log SLOB varies by physician specialty

I first study two specialties with roughly normal distributions

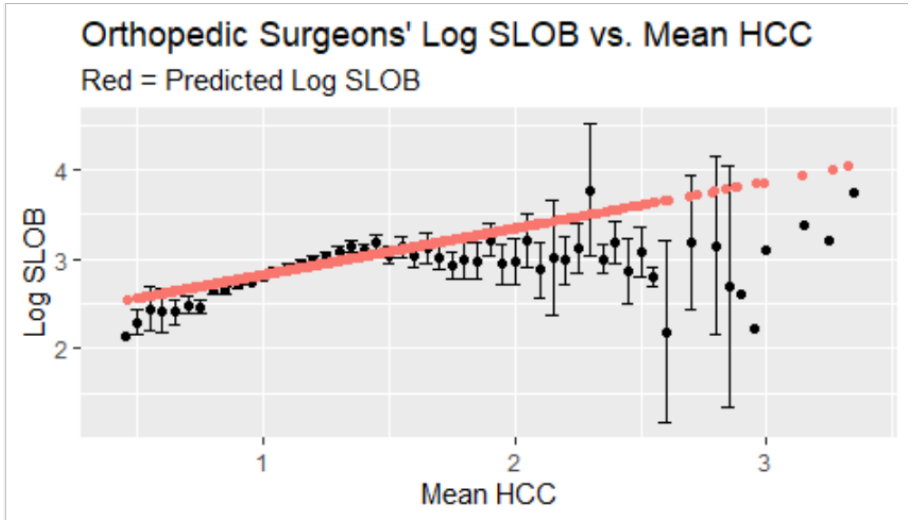


Simple linear regressions are insufficient

$$\ln SLOB = \beta_0 + \beta_1 \overline{HCC} + \varepsilon$$
$$\varepsilon \sim N(0, \sigma^2)$$



RMSE: 0.527



RMSE: 0.582

Splines can better fit nonlinearity

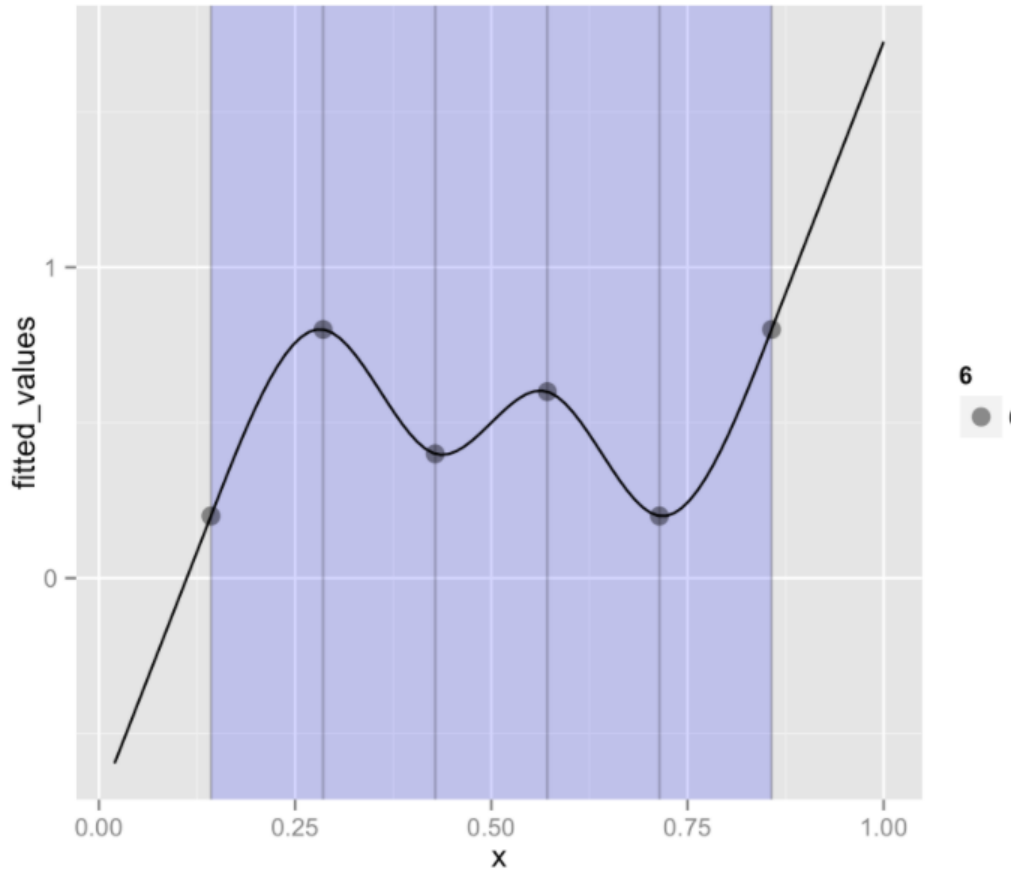
$$y = S(x)$$

where

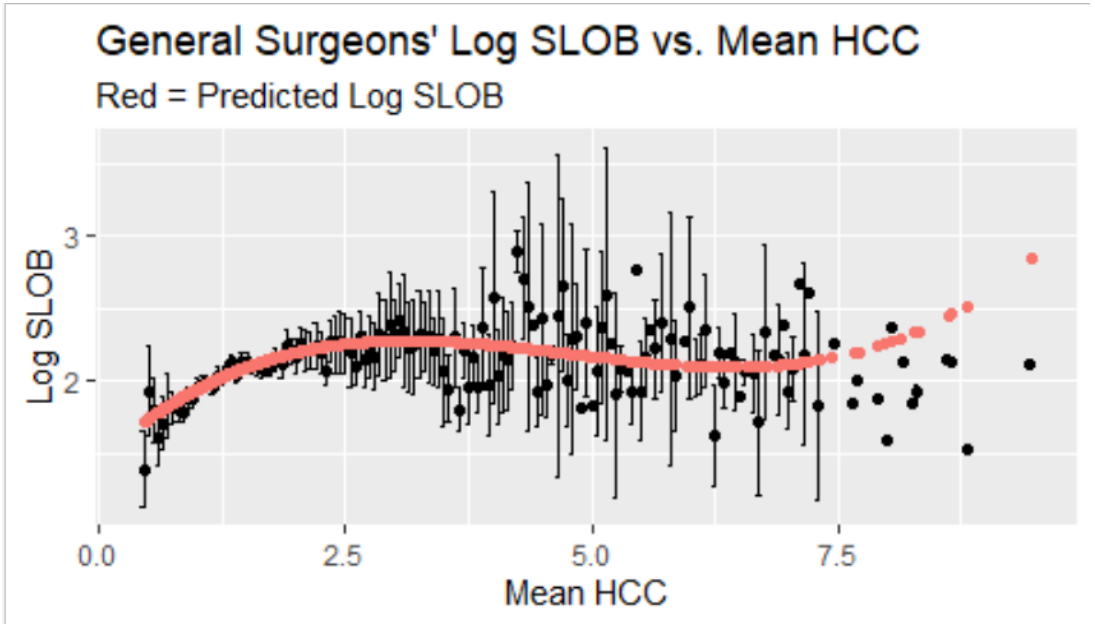
$$S(x) = \begin{cases} S_0(x) = \sum_{i=0}^{k} \beta_{0i} x^i, & t_0 \le x \le t_1 \\ \vdots & \\ S_{n-1}(x) = \sum_{i=0}^{k} \beta_{(n-1)i} x^i, & t_{n-1} \le x \le t_n \end{cases}$$

for n knots $t_1, \ldots, t_n$

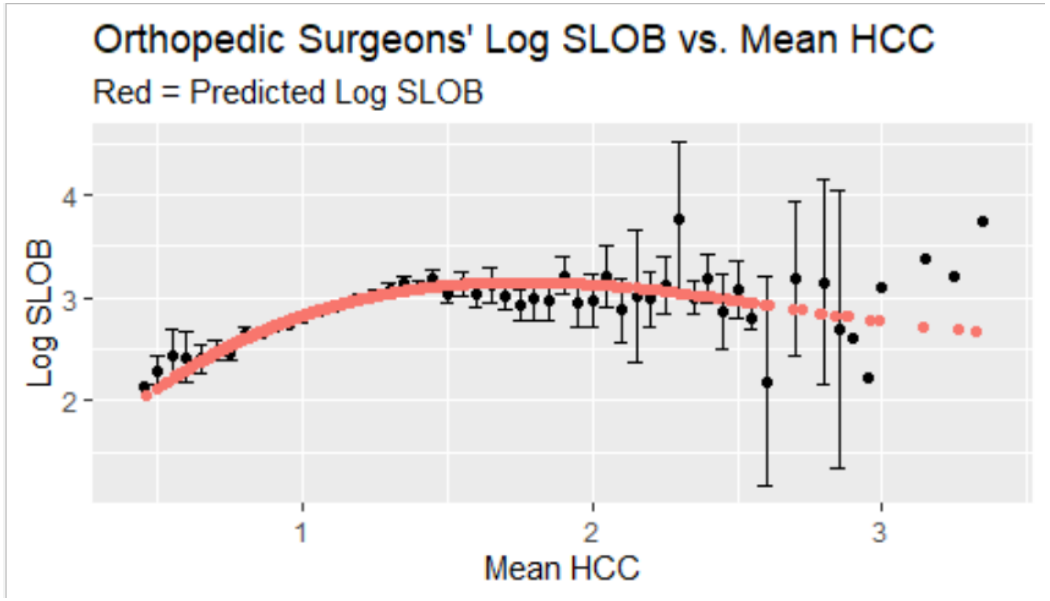
See Cosma Shalizi's "Advanced Data Analysis from an Elementary Point of View" for more background



Cubic B-splines (w. 0 internal knots) fit better

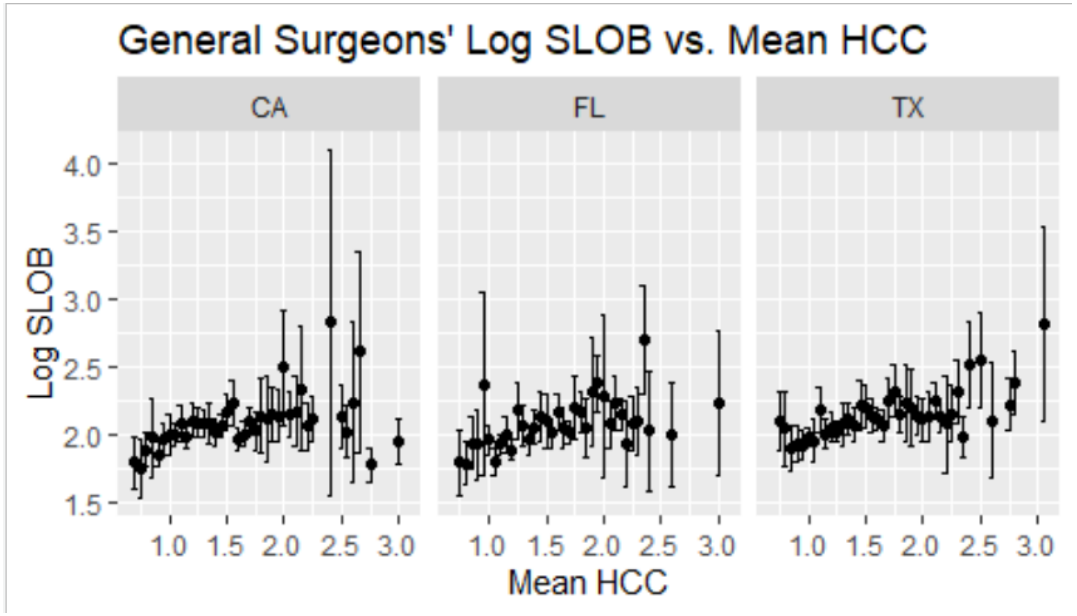


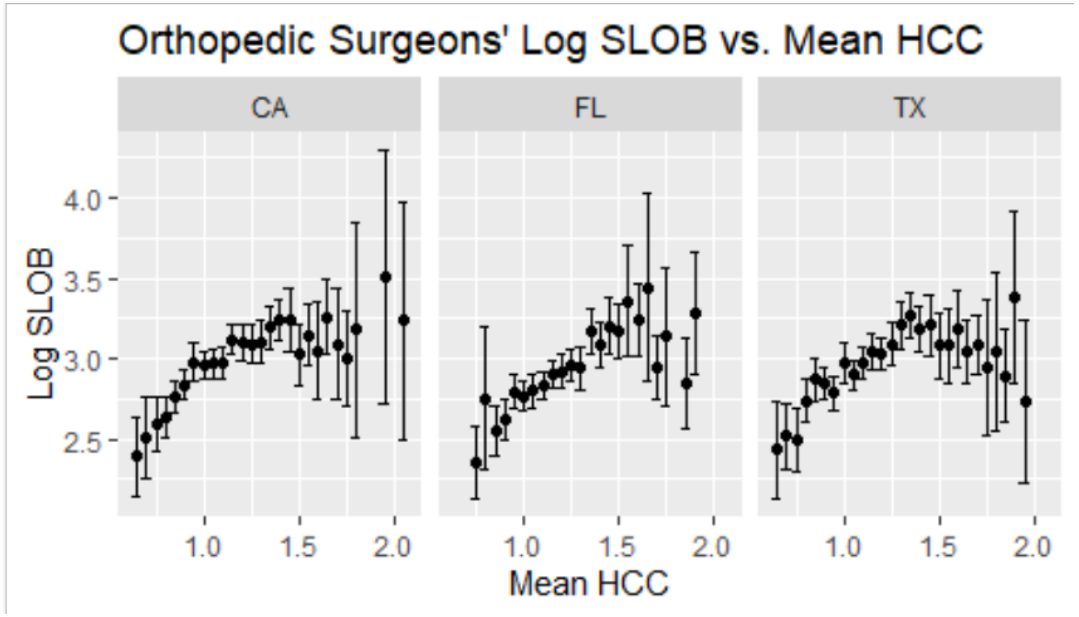
RMSE: 0.521



RMSE: 0.575

Geographic variation motivates hierarchical modelling





A simple hierarchical model

For each physician i, and state j,

$$\ln(SLOB_{ij}) = (\beta_0 + u_{0j}) + (\beta_1 + u_{1j})\overline{HCC}_{ij} + \varepsilon_{ij}$$

where

$$u_{0j} \sim \mathrm{N}(0, {\sigma_0}^2), u_{1j} \sim \mathrm{N}(0, {\sigma_1}^2), \varepsilon_{ij} \sim \mathrm{N}(0, \sigma^2)$$

$\widehat{u_{0j}}$ is state j's deviation from the average random intercept (0)

$\widehat{u_{1j}}$ is state j's deviation from the average random slope (0)

Hierarchical Model Results

General Surgery

```
Random effects:
 Groups                Name        Variance  Std.Dev. Corr
 nppes_provider_state (Intercept) 0.0116682 0.10802
                      mean_hcc    0.0002295 0.01515  -0.33
 Residual                         0.2862741 0.53505
Number of obs: 7772, groups:  nppes_provider_state, 52

Fixed effects:
            Estimate Std. Error t value
(Intercept) 1.923985   0.020988  91.672
mean_hcc    0.075871   0.007824   9.698

Correlation of Fixed Effects:
         (Intr)
mean_hcc -0.614
```

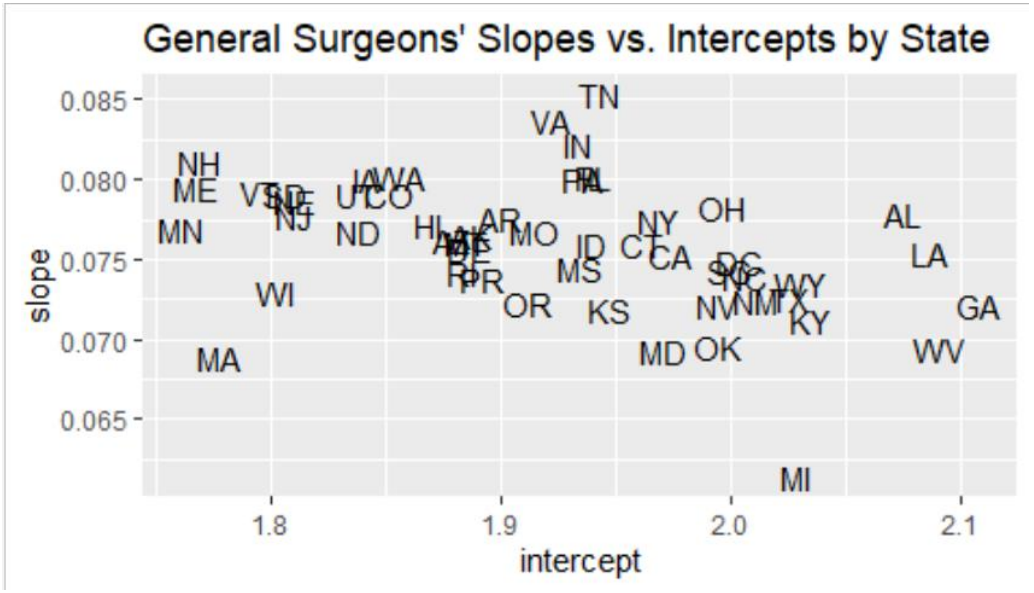
Orthopedic Surgery

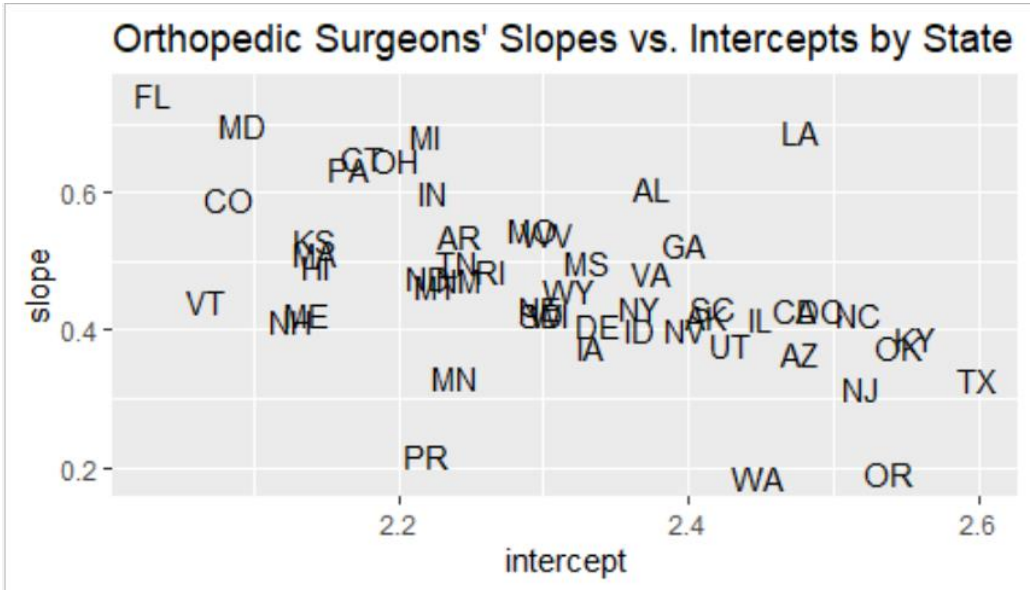
```
Random effects:
 Groups                Name        Variance Std.Dev. Corr
 nppes_provider_state (Intercept) 0.04402  0.2098
                      mean_hcc    0.03265  0.1807   -0.74
 Residual                         0.32153  0.5670
Number of obs: 9503, groups:  nppes_provider_state, 52

Fixed effects:
            Estimate Std. Error t value
(Intercept)  2.31322    0.04385   52.76
mean_hcc     0.46702    0.03816   12.24

Correlation of Fixed Effects:
         (Intr)
mean_hcc -0.868
```

States' Predicted Random Effects





Key Interpretations

Both specialties' fixed slopes alone suggest a positive relationship

A 95% CI for the general surgeons' state slopes: [0.069, 0.083]

A 95% CI for the orthopedic surgeons' state slopes: [0.199, 0.695]

No clear patterns emerge wrt states (so far . . .)

Next Steps

Improving the general and orthopedic surgeons' models

- *e.g.* using splines of mean HCC, more random effects

Moving to the specialties with trickier log SLOB distributions

- *e.g.* family practice, internal medicine

References

Barnett, M. L., Olenski, A. R., & Jena, A. B. (2017). Opioid-Prescribing Patterns of Emergency Physicians and Risk of Long-Term Use. *The New England Journal of Medicine*, 376(7), 663-673.

Lembke, A., & Chen, J. H. (2016). Use of Opioid Agonist Therapy for Medicare Patients in 2013. *JAMA Psychiatry*, 73(9), 990-992.

North, F., Tulledge-Scheitel, S. M., & Crane, S. J. (2017). Association of provider opioid prescribing practices and the Centers for Medicare and Medicaid Services hierarchical condition category score: A retrospective examination of correlation between the volume of provider-prescribed opioid medications and provider panel complexity. *SAGE Open Medicine*, 5, 1-7.

Thank you!