Hospital Peer Groups, Reliability, and Stabilization: Shrinking to the Right Mean

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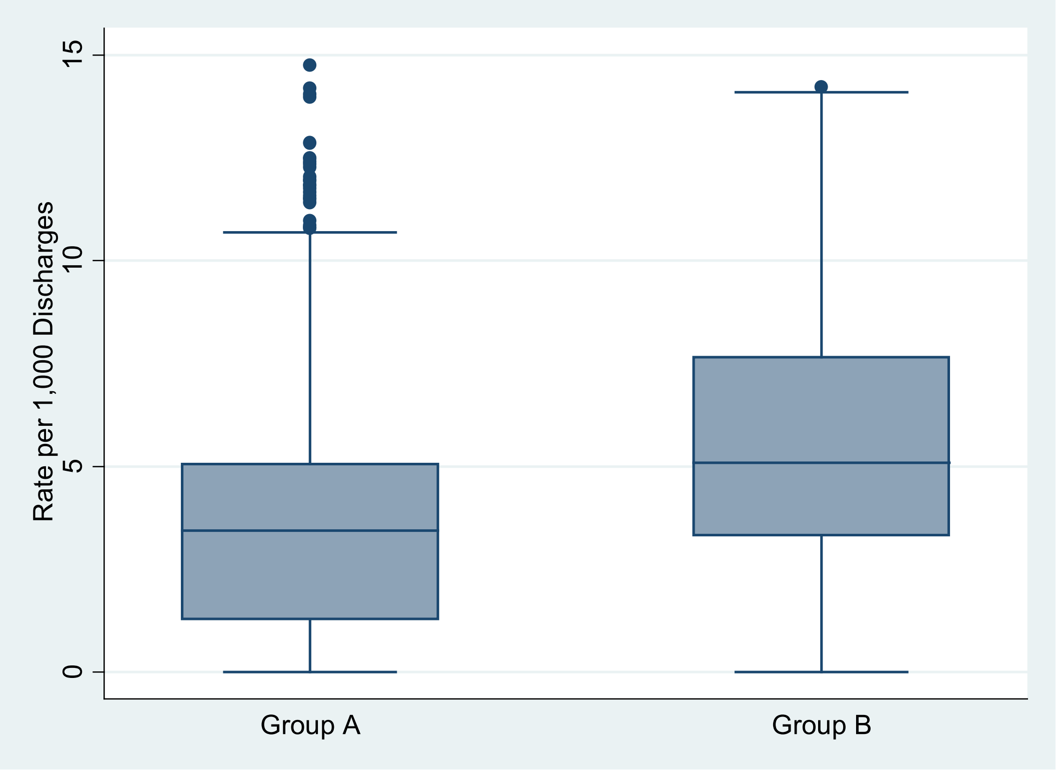
Agenda

- **Including Peer Groups in Hospital Comparisons**
  - Rationale
  - Technical Approaches
- **Empirical Example**
- **Challenges and Next Steps**

Stabilizing the Quality Indicators

- **Hospital Risk-Adjusted Rates (RARs) are often unstable**
  - **Small sample sizes**
  - **Rare events**

- **Smoothing stabilizes RARs by using information from the entire sample of hospitals**



What’s the Correct Smoothing Target?

- **Including hospital characteristics to create peer groups is controversial**
  - Influences hospital ranking (Austin et al. 2004)
  - Changes the interpretation (Romano 2004)
- **Volume is the most common characteristic considered**
  - Strong empirical volume-outcome relationship for mortality (Silber et al. 2010)
- **The ultimate choice of peer group**
  - Needs conceptual and empirical backing
  - Depends on the outcome of interest
  - Should be precise

Technical Approaches to Peer Grouping

Hospital characteristics can enter risk- or reliability-adjustment models (or both)

- **Risk-Adjustment Model**
  - **Peer group fixed effects, and/or**
- **Reliability-Adjustment Model**
  - **One-part or unified: Smooth to peer group rates**
    - Peer group random effects
    - With or without risk adjustment for hospital-level factors
  - **Two-part shrinkage model: Standardize to peer group rate**
    - Estimate reliability as signal-to-noise ratio
    - Smooth to the peer group target

Illustrative Example

- Aim: Incorporate peer group targets into the AHRQ QI model
- Peer grouping: Teaching vs. Non-Teaching Affiliation
- Measure: PSI 12 (Postoperative Pulmonary Embolism or Deep Vein Thrombosis Rate)
- Approach:
  - Base case: Current QI methodology
  - Alternative: Two-part approach smoothing to teaching peer group target rates
- Evaluation criteria:
  - Change in reliability (signal variance/total variance)
  - Correlation of hospital ranking across approaches
  - Proportion of hospitals moving above/below national average

Methods

- Calculate reliability weights and shrinkage targets for two scenarios:
  - Base Case ("Overall")
  - Alternative ("Peer Group")
- Reliability weights vary for each approach
  - Recalculate signal and noise
- Changes in smoothed rate estimates is therefore a function of
  - The new shrinkage target
  - The change in reliability weight

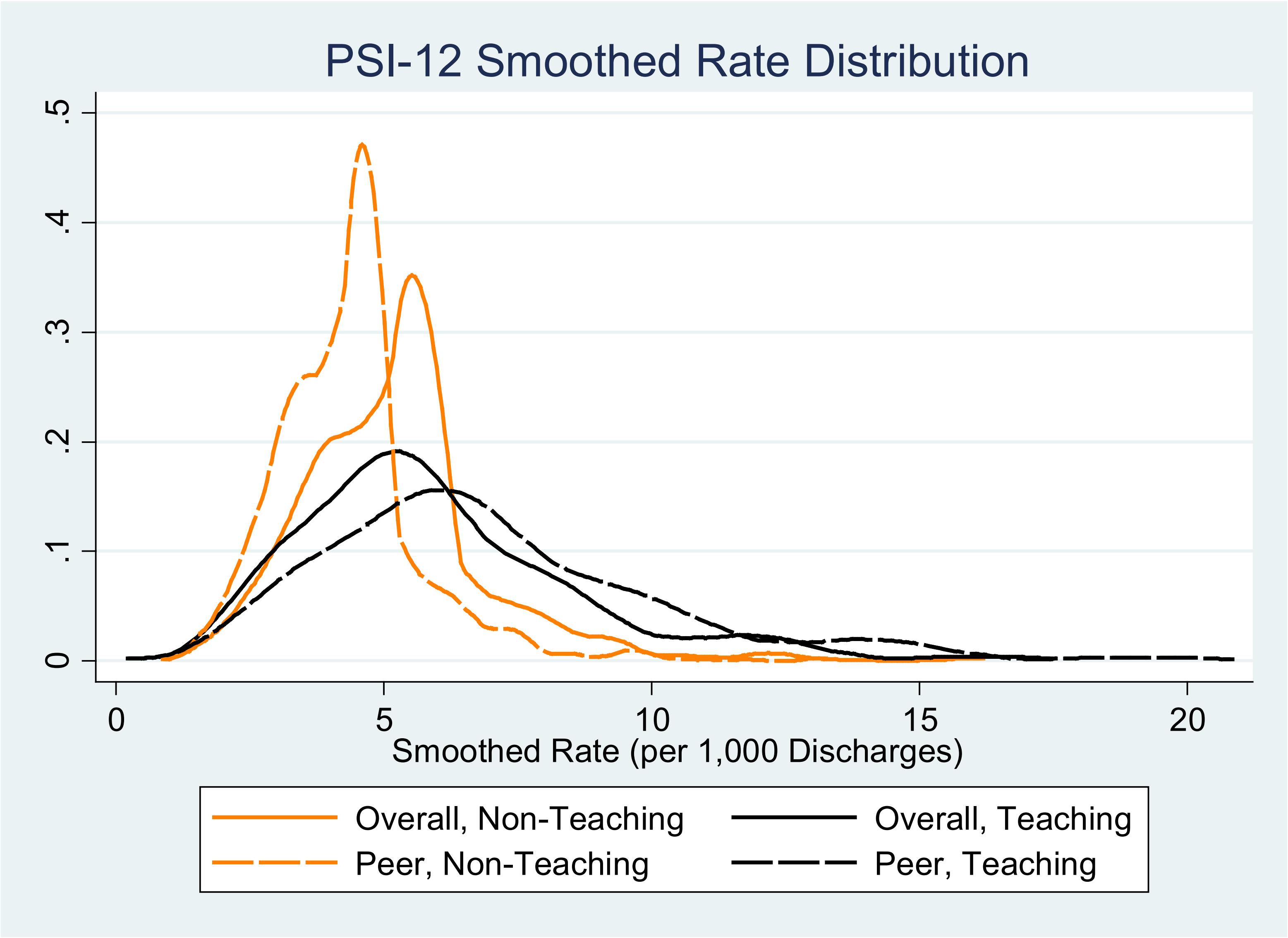
Descriptive Statistics: PSI 12 (DVT/PE)

	Overall	Non-Teaching	Teaching
Hospitals (n)	1,264	944	320
Denominator (mean)	4,605	3,056	9,177
Observed Rate	5.81	4.80	6.81
Expected Rate	5.81	5.52	6.11
Risk-Adjusted Rate	5.81	5.06	6.48

- **Rates have units per 1,000 discharges**
- **Random sample of hospitals from 12 states with Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases (SIDs), 2009 and 2010***

* We would like to thank the HCUP Partners from the following states: AR, AZ, CA, FL, IA, KY, MA, MD, NE, NJ, NY, WA (http://www.hcup-us.ahrq.gov/partners.jsp)

Smoothed Rate Distribution



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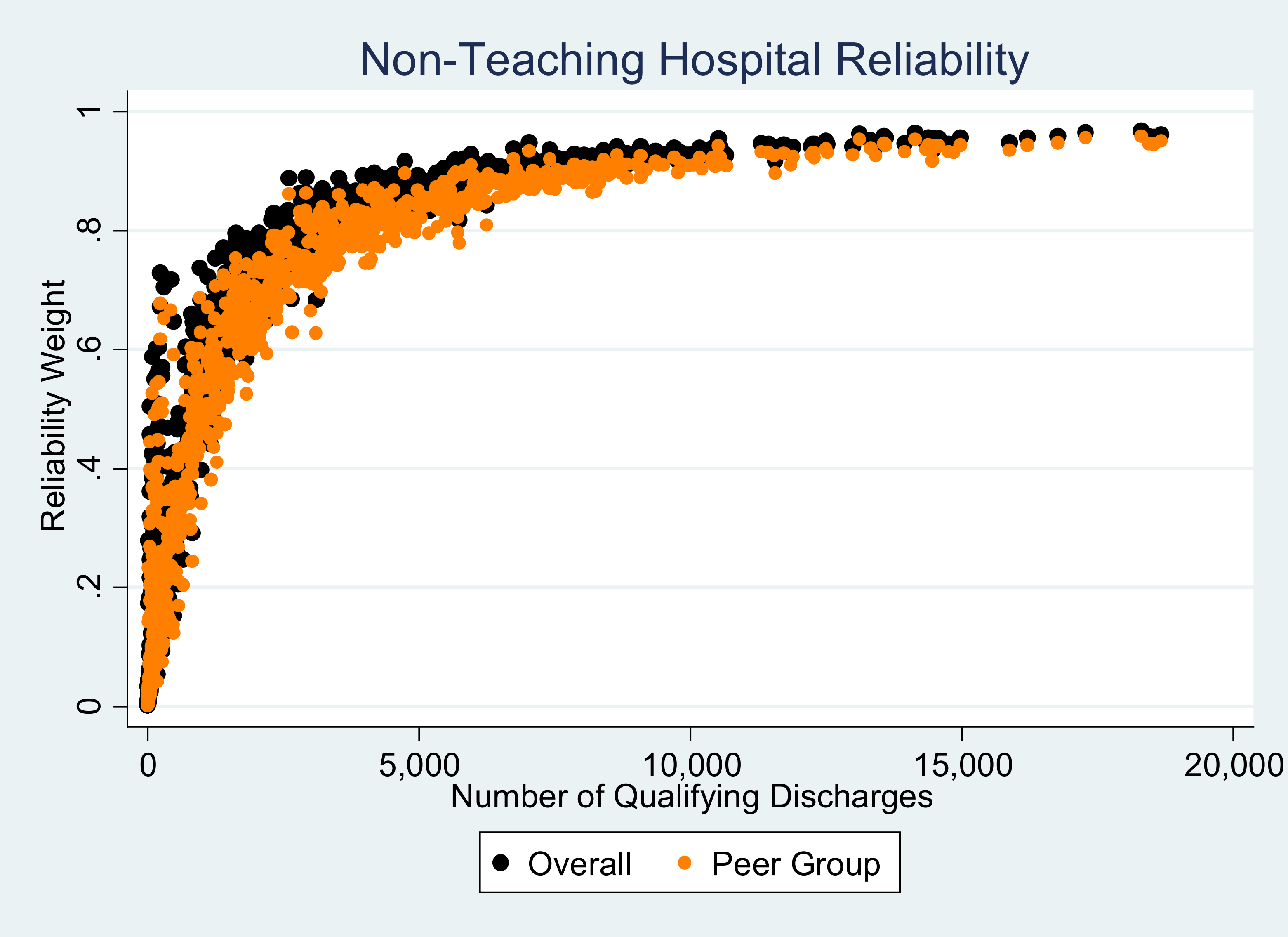
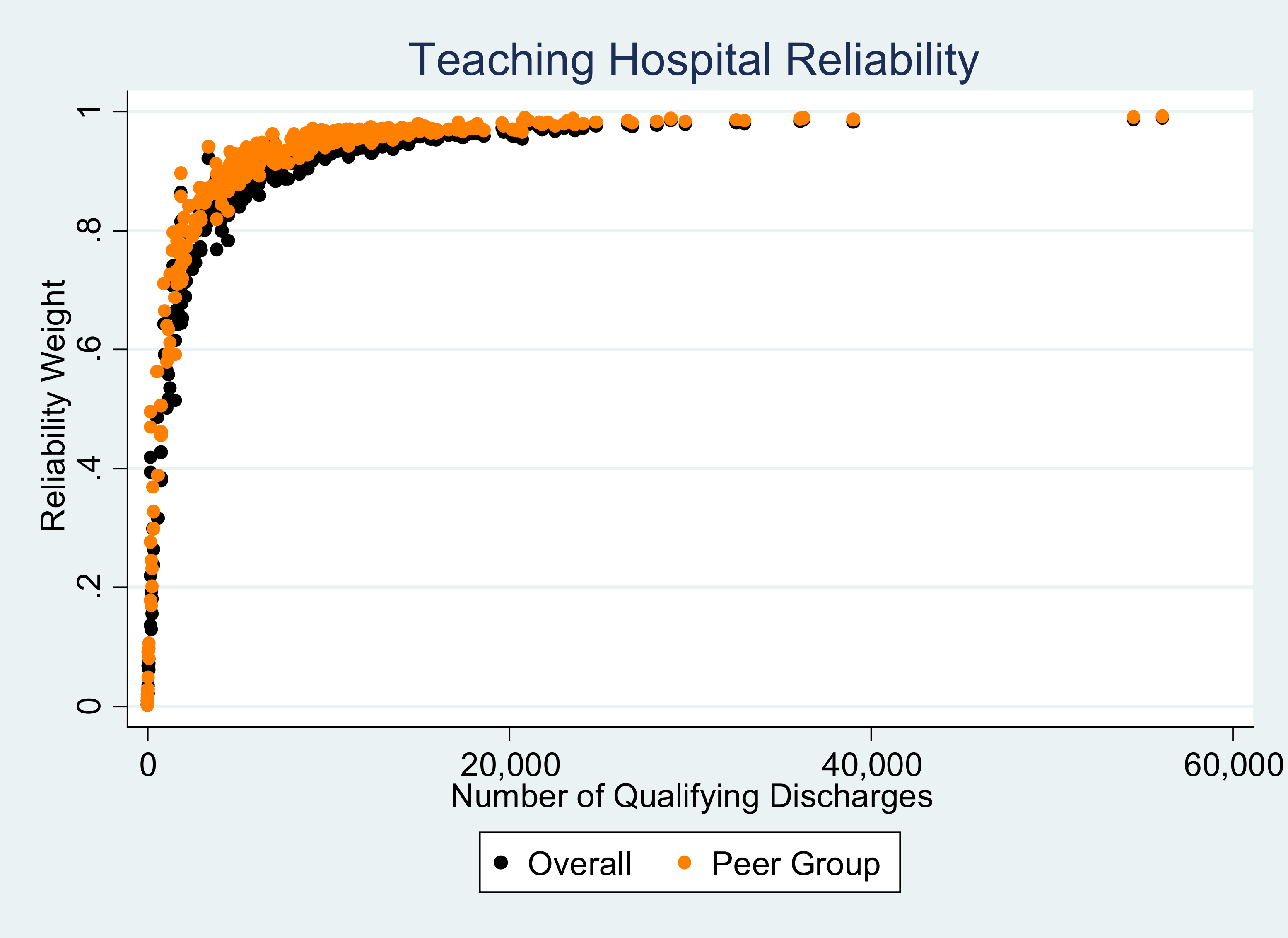
Reliability Estimates – Non-Teaching Hospitals



Reliability Estimates – Teaching Hospitals



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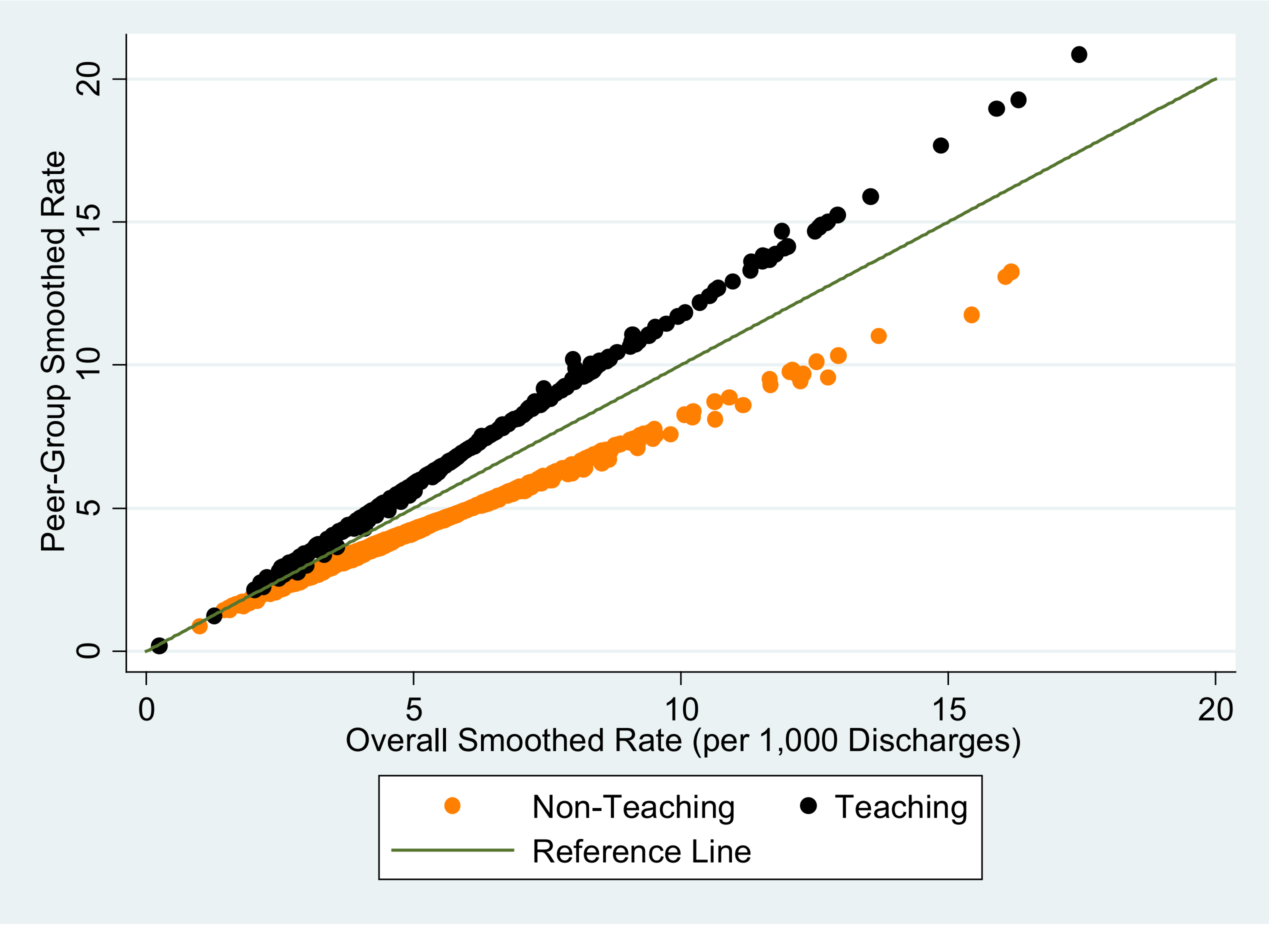
Smoothed Rates



- **Teaching hospitals: 18% move above national average**
- **Non-teaching hospitals: 15% move below national average**

Summary

- **Using peer group targets changes ranking of smoothed rates**
  - Teaching: 18% move above national average
  - Non-teaching: 15% move below national average
  - Rank sum correlation of 0.91
- **Peer grouping changes the variability in PSI 12 distribution through reliability weights**
  - Teaching: Increased variability
  - Non-teaching: Decreased variability

Challenges and Limitations

Practical, Conceptual, and Technical Questions Remain

- What happens for hospitals on the boundary?
  - For example: volume, disproportionate share percentages, or nurse staffing ratios
- What about more precise subgroups?
  - Major versus minor teaching status
  - Subdividing non-teaching hospitals further
- What happens for small peer groups (e.g., two hospitals)?
- How do we handle hospitals missing peer group information?

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References

- **Austin et al. Impact of the choice of benchmark on the conclusions of hospital report cards. *American Heart Journal,* 148(6); 2004.**

- **Romano, P.S. Peer group benchmarks are not appropriate for health care quality report cards. *American Heart Journal,* 148(6); 2004.**

- **Silber et al. The Hospital Compare Mortality Model and the Volume-Outcome Relationship. *Health Services Research,* 45(5); 2010.**

Appendix: Estimating Noise

By the law of total variance:

$$
\begin{aligned}
Var(\epsilon_h) &= E\left\{Var\left(RAR_h - \theta_h|\theta_h\right)\right\} + Var\left\{E\left(RAR_h - \theta_h|\theta_h\right)\right\} \\
&= E\left\{Var\left(RAR_h|\theta_h\right)\right\} + \\
&\qquad E\left\{Var\left(\theta_h|\theta_h\right)\right\} + Var\left\{E\left(RAR_h - \theta_h|\theta_h\right)\right\}
\end{aligned}
$$

The last two terms drop out.

$$
\begin{aligned}
Var(\epsilon_h) &= E\left\{Var\left(RAR_h|\theta_h\right)\right\} \\
&= E\left\{Var\left(\overline{Y}\cdot\frac{O_h}{E_h}\right)\right\} \\
\hat{\sigma}_h^2 &= \left(\frac{\overline{Y}}{n_h\cdot E_h}\right)^2 \sum_{i\in A_h}\hat{Y}_i\left(1-\hat{Y}_i\right)
\end{aligned}
$$

Appendix: Estimating Signal

Signal variance is the total variance $Var(RAR_h)$ minus the noise variance $Var(\epsilon_h)$. Note that:

$$E\left\{(RAR_h - \mu)^2 - \hat{\sigma}_h^2\right\} = Var\left(\theta_h\right)$$

Using this relation we have that:

$$\begin{aligned} Var(\theta_h) &= Var(RAR_h) - E(\hat{\sigma}_h^2) \\ \hat{\tau}^2 &= \frac{1}{H-1}\sum_h \left\{\left(RAR_h - \overline{RAR}\right)^2 - \hat{\sigma}_h^2\right\} \end{aligned}$$

Appendix: Estimating Reliability

We have assumed a simple linear regression which has a known solution found using the least-squares estimate or the maximum likelihood estimate: (MLE)

$$\theta_h - \mu \quad = \quad \lambda_h \cdot (RAR_h - \mu) + \omega_h$$

The MLE is given by:

$$\hat{\lambda}_h = \frac{Cov(\theta_h, RAR_h)}{Var(RAR_h)} = \frac{Var(\theta_h)}{Var(\theta_h) + Var(\epsilon_h)} = \frac{\tau^2}{\tau^2 + \sigma_h^2}$$

Use the relation $RAR_h = \theta_h + \epsilon_h$ to get the numerator result that $Cov(\theta_h, RAR_h) = Var(\theta_h)$.

Future Considerations

- **Multilevel random effects**
  - Cross-classification of groups
- **Incorporating peer groups (or different peer groups) into the risk-adjustment model**
- **Exploring the impact of historical priors, or priors defined outside the analytic population**
- **Application to patient safety indicators**
  - Lower event rates
  - No consistent relationship with characteristics

Conclusions

- **Whether to shrink to peer group means depends on**
  - **Empirical evidence**
  - **Conceptual background**
  - **Precise peer group classification**
  - **Desired interpretation or use**