

# Talk 2: What People Thinking About Quality Improvement Should Know About Propensity Methods

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# What I'm Trying to Accomplish

- Role of observational studies in QI /  $6\sigma$
- What do propensity models do well?
  - The basic idea
  - The value of the idea
  - The importance of selection bias
  - Applications in observational studies
- Some possible avenues for exploration

# Learning About Interventions

- In QI, we often want to assess the impact of an intervention on a process or product. When possible, we design experiments to do this...

# Why Do Experiments?

- Experimental evidence carries more weight
- Experiments leave fewer grounds for doubt
- Experiments often settle questions quickly
- BUT experiments aren't always feasible

# Facts of Life for Observational Studies

- We want comparable groups of subjects who did and did not receive the exposure of interest (except for the actual receipt of the exposure)
- But we can't achieve this through random assignment of treatments
- So we need to make analytical adjustments for baseline diffs

# A Toy Example

- Process with a stable, poor defect rate.
- Policy (“intervention”) designed to improve defects imperfectly applied.
- Experts and workers suggest reasons why the policy might be applied – these are translated into specific measures...
- Various characteristics of the process then used to model policy application.

# Bias in Observational Studies

- An OS is biased if the treated and control groups differ prior to treatment in ways that matter for the outcome(s).
- So we need to adjust for this “imbalance” in covariates by selecting matched sets, forming strata, or through modeling the imbalance directly.
- Hidden vs. Overt Biases

# The Potential Direction and Magnitude of Selection Bias

- What is the effect of HRT on CHD?
  - Does HRT reduce risk of CHD by 35-50%, and extend life expectancy by 2-3 years?
  - Or does it have no effect, and perhaps in the short term, induce risk?
  - Women taking HRT are more likely to engage in other healthy behaviors (exercise, diet, avoidance of smoking) that favorably affect their CHD risk.

# The Propensity Score: Dealing with Selection Bias

- Propensity Score: PS  
= Prob(received treatment | baseline characteristics)
- PS can be estimated with logistic regression, discriminant analysis, classification trees, etc.
- Reduces an entire set of baseline characteristics to a single composite and adequate summary of the covariates.
- Fundamental Model for Outcome =  $f(\text{exposure, propensity, susceptibility, noise})$

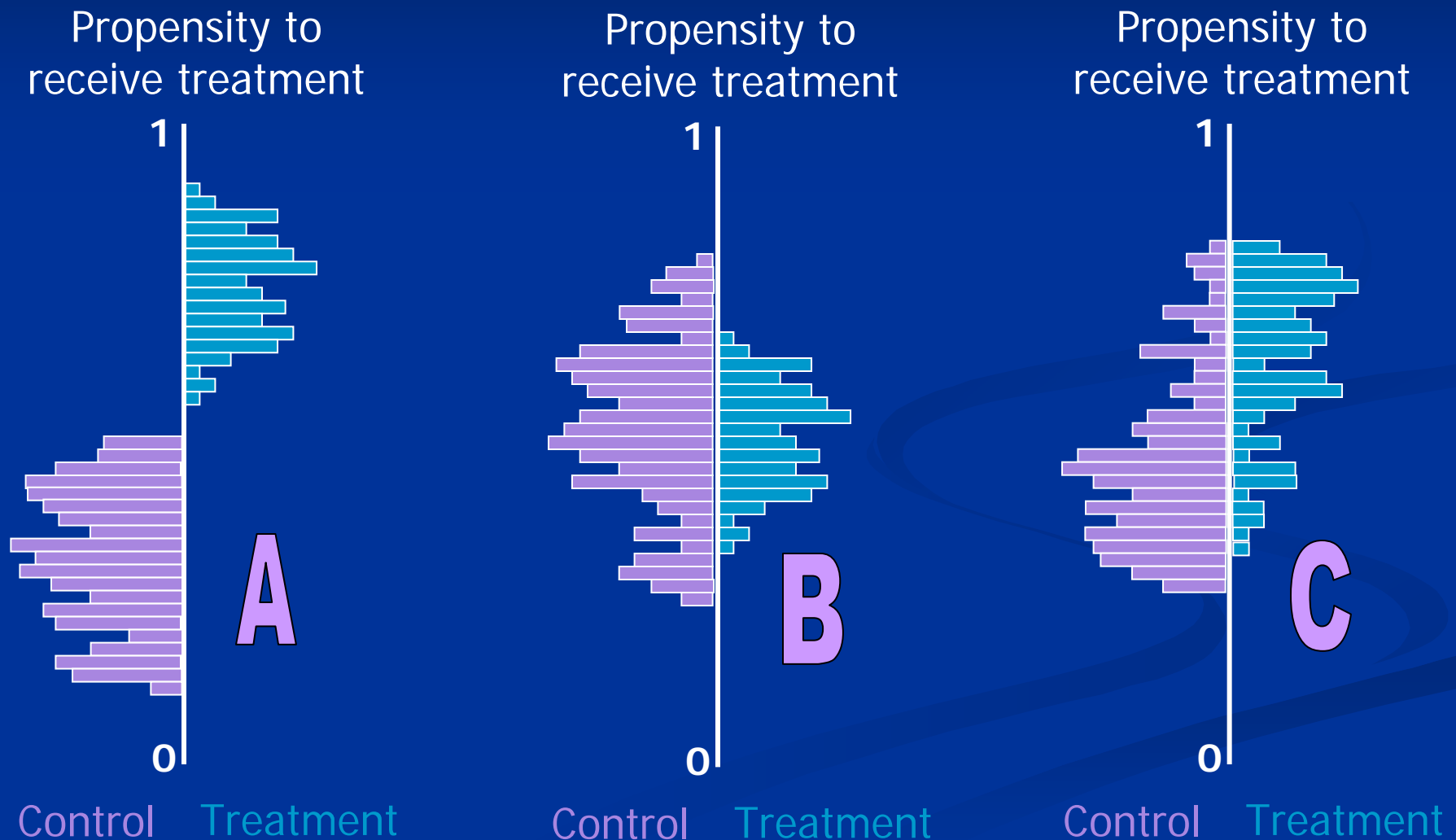
# How is the score used?

- Strata or matched sets that are homogeneous in the PS “balance”  $X$  in expectation -- treated and control subjects in the same stratum tend to have the same distribution of  $X$ .
- Multivariate Matching
- Subclassification / Stratification
- Multivariate Adjustment

# Returning to the Toy Example

1. Estimate the PS for receiving the treatment (policy) for each trip through the process, using logistic regression.
  - Now each trip has a PS value and we know whether or not it was “treated”.
2. Check for overlap in PS between treatment and control groups.

# How Much Overlap?

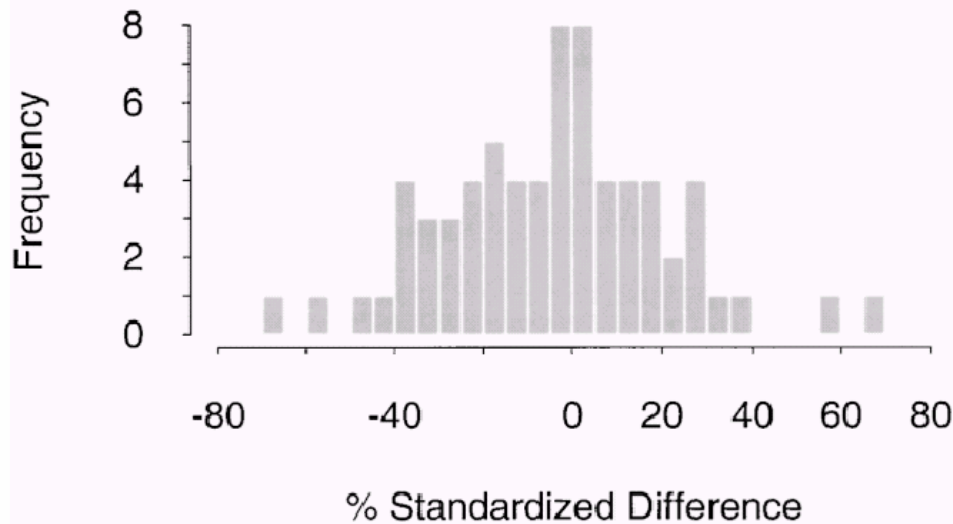


# Next Steps in Toy Example

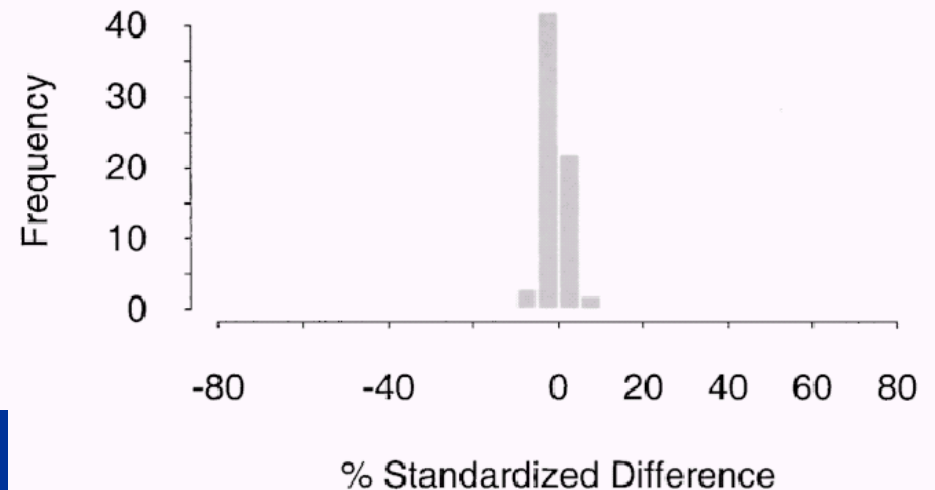
3. Match trips from the treatment group with trips from the control group.
  - Match on PS directly, or match on Mahalanobis distance with PS calipers
  - Optimal and greedy algorithms proposed
  - Tradeoff (inexact vs. incomplete match)
4. Check covariate balance between treatment and control groups

# Checking for Covariate Balance

Before the PS Match



After the PS Match



$$d = \frac{100(\bar{x}_{Treatment} - \bar{x}_{Control})}{\sqrt{\frac{(s_{Treatment}^2 + s_{Control}^2)}{2}}}$$

Normand et al. (2001) p. 395

# The Potential Impact of Hidden Bias

- Overt Bias – resolved with adjustment techniques using measured covariates
- Hidden Bias – assess potential for unmeasured covariates to affect results with sensitivity analysis. These can:
  - Create a false exposure effect
  - Mask a true exposure effect
  - Cause mis-estimation of effect size / direction

# Strategic Issues in Observational Studies (Rosenbaum, 1995, 2002)

- *Design* observational studies
  - Exert as much experimental control as possible, carefully consider the selection process, and anticipate hidden biases
- Focus on *simple* comparisons
  - Increase impact of results on consumers
- Compare subjects who looked comparable prior to treatment
- Use sensitivity analyses to delimit discussions of hidden biases due to unobserved covariates

# Where does this stuff fit in Six Sigma?

- Generally sad quality story – lots of lost opportunities and false starts
  - Conditions providing impetus for change requires information (can we make use of past data – or must we ignore it?)
- **DMAIC** – statistical innovation, plus...?
  - Often focused on new measurements
  - Need to get all “on board” – desirability of simple comparisons / simple innovations

# Areas for Future Study

- Role of observational studies in DFSS
- Extensions of simple comparisons
  - Multiple Outcomes
  - “Dose-response” effect – propensity dosing
  - Statistical Process Control and Charting
  - Sensitivity Analysis in these contexts
- Ease of compliance with policy changes
- Risk Adjustment in Process Control