Estimating causal effects of teacher-child relationships on reading and math achievement in a high-risk sample: A multi-level propensity score matching approach

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Background & Introduction
• Strong and supportive teacher-child (TC) relationships characterized by:
  (Pianta, 1992)
  1. High levels of closeness
  2. Low levels of conflict
• Longitudinal and cross-sectional relations between TC relationships and:
  1. Teacher reports of academic achievement (O’Connor & McCartney, 2007)
  2. Standardized achievement measures (Pianta & Stuhlman, 2004)

Multi-Level Propensity Score Matching
Baseline confounding covariates & school fixed effects

Kindergarten TC relationship

First grade math & reading achievement

Method
Study sample: n = 324 children/parents; n = 22 elementary schools from three inner-city school districts

Confounding Covariates

Limitations of Extant Studies for Causal Inference
Teacher rater effects and teacher reporter biases
Cannot randomly assign TC relationships
Studies do not account for data nested at the school-level
OLS regression models may extrapolate to non-existent data points
OLS regression models may not include all confounding characteristics
Selection into teacher-child relationships may differ by school

Study strengths
- Teacher rater effects and teacher reporter biases
- Studies account for data nested at the school-level
OLS regression models may extrapolate to non-existent data points
OLS regression models may include all confounding characteristics
Selection into teacher-child relationships may not differ by school

Analytical Approach
Timing of Measures

Time 1 (October, Kindergarten)
Confounding Covariates
Time 2 (June, Kindergarten)
Treatment (Quality of TC Relationship)
Time 3 (October, First Grade)
Outcome (Reading & Math Achievement)

Measures of treatment and outcome

Construct
TC relationships (treatment)  
Reading achievement (outcome)  
Math achievement (outcome)  
Confounding covariates

Measure
Student-Teacher Relationship Scale (Planta, 1992); 
Scores greater than the mean = 1; Scores less than the mean = 0 
WJ-III Letter Word ID (Woodcock et al., 2001); Raw score 
WJ-III Applied Problems (Woodcock et al., 2001); Raw score 
Academic competence (ACES); Behaviors (SESBI); Attentional control (Letter); Demographics

Outline of Multi-Level Propensity Score Matching Procedure
1. Propensity score methods use model of treatment assignment to identify comparable individuals on the basis of similar probabilities of receiving treatment
2. Account for school differences by including school fixed effects when estimating propensity scores (a_i)

Logit(P(Z = 1)) = β_0 + a_i + ∑ β_m X_mij

1. Use nearest-neighbor matching with replacement to identify a treatment group (high-quality TC relationship) and a control group (low-quality TC relationship).
2. Assess balance of means and SDs for pretreatment variables.
3. Resulting weights used in multi-level models to predict math and reading achievement from treatment, controlling for pretreatment covariates.

Y_ij = β_0 + τZ_ij + ∑ β_m X_mij + a_i + e_ij, with a_i ~ N(0, σ^2) and e_ij ~ N(0, σ^2_a) independent of one another
6. Compare results to multi-level regressions (to take school-level nesting into account)
7. Compare results to multi-level generalized propensity score models where treatment is modeled as a continuous variable (Imai & van Dyk, 2004)

Results

Methodological Strengths & Limitations

Study Strengths
- Identifies clear treatment and counterfactual states
- Models selection at the school and child level
- Estimates propensity scores with baseline treatment and outcome
- Focuses on high-risk within-group sample of students and schools

Study Limitations
- Ignorability assumption may not be met
- School membership may not have uniform effect on all students
- Binary operationalization of treatment
- Classroom may be more appropriate grouping mechanism

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