Improving Power in a Pragmatic RCT Pilot Trial: A Historical Borrowing Approach

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Overview

To improve statistical power in a pragmatic RCT pilot trial with small sample size, we implemented historical borrowing using data from a previous, similar RCT, and multiple imputation to retain observations with missing values.

Background

- Meals on Wheels (MOW) programs are home meal delivery services that address food insecurity among older adults.

- Weekly or biweekly drop-shipped frozen meals have been introduced for cost savings compared to traditional volunteer/employee daily delivered meals, but there is some evidence of worse health outcomes.

- A pragmatic RCT pilot trial was conducted to assess effect of meal delivery type on nursing home and inpatient usage.

- Pilot trials typically have small sample size and therefore lack power, and we attempt to address this issue by borrowing from historical data.

Methods

- MOW enrollment data was linked to Medicare records using Bayesian Estimation of Bipartite Matchings to obtain covariate and outcome data
  - 16 subjects not definitively linked, so we apply multiple imputation (MI) for the possible matches

- To incorporate historical data, we implement the power prior for static borrowing which takes the form $\pi(\boldsymbol{\theta}|D, D_0, a_0) \propto L(\boldsymbol{\theta}|D)L(\boldsymbol{\theta}|D_0)^{\alpha_0}\pi_0(\boldsymbol{\theta})$

- We also implement data-adaptive weighting (DAW) via the "on-trial" score, a combination of the power prior and propensity score methods for dynamic borrowing $\pi(\boldsymbol{\theta}|D, D_0^*, \hat{\gamma}^*) \propto L(\boldsymbol{\theta}|D)L(\boldsymbol{\theta}|D_0^*)^{\hat{\gamma}^*}\pi_0(\boldsymbol{\theta})$

- For time until nursing home and time until inpatient, we fit a Weibull model, impute survival times, and estimate hazard ratios using a Cox PH model.

- For proportion of study time as an inpatient or in a nursing home, we fit a Beta regression model, impute potential outcomes Y(1) and Y(0), and estimate the ATE E[Y(1)-Y(0)].

Results

Figure 1. ATE estimates of daily delivered meals compared to frozen drop-shipped meals on proportion of time spent as an inpatient or in a nursing home, total follow-up of 180 days.
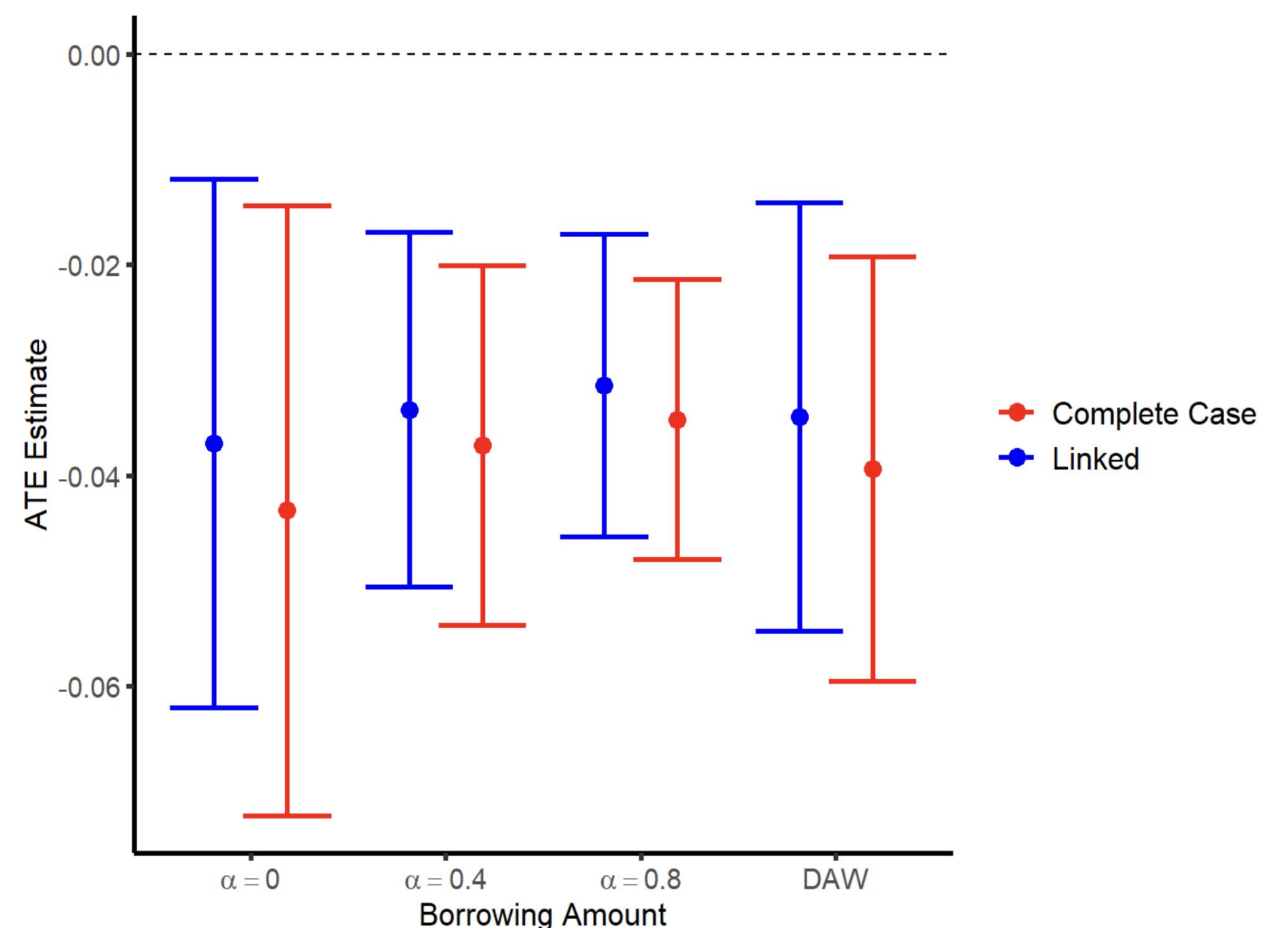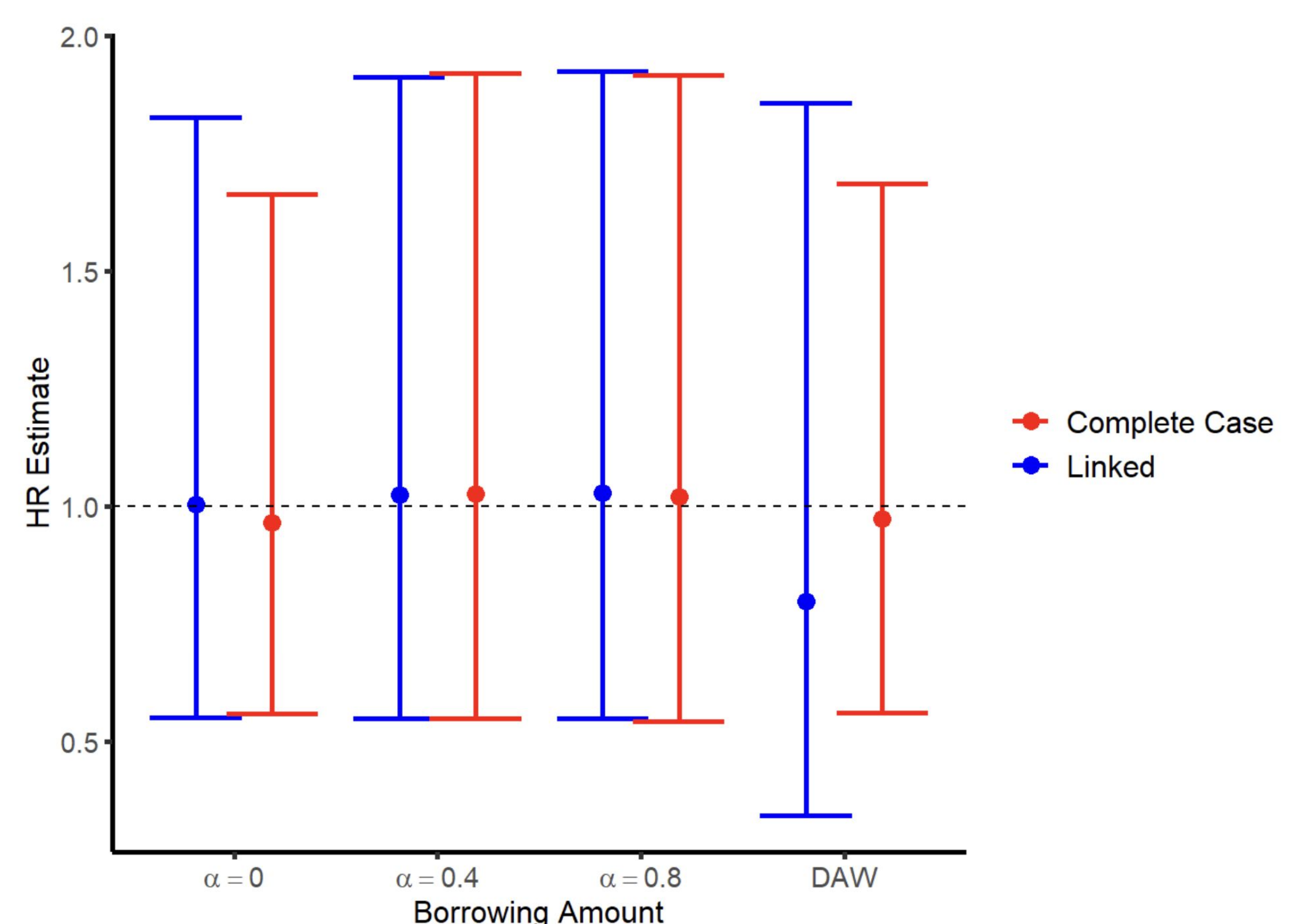

Figure 2. HR estimates of inpatient placement for daily delivered meals vs frozen shipped meals

Conclusion

- No significant difference in hazard for daily delivered meals vs frozen shipped meals; hazard ratios close to 1.

- ATE shows proportion of study time spent as an inpatient or in a nursing home is significantly less when receiving daily delivered meals vs frozen meals.

- For Beta regression, increasing borrowing reduces variance and increases power, MI with possible links has tighter intervals than complete case analysis.

- No improvement in power as borrowing increases or when using MI for possible links for survival outcomes, likely due to larger variance from two-stage MI

Key References

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3. Joanna Harton, Brian Segal, Ronac Mamtani, Nandita Mitra, and Rebecca A Hubbard. Combining real-world and randomized control trial data using data-adaptive weighting via the on-trial score. Statistics in Biopharmaceutical Research, 15(2):408–420, 2023.