Session Topic: **Bridging experimental and observational data**

Discussant: Fabrizia Mealli

1. Shrinkage Estimation for Causal Inference and Experimental Design

Author(s): Rosenman, Evan T. R. *; Miratrix, Luke; Owen, Art; Baiocchi, Michael; Basse, Guillaume W

Abstract: How can increasingly available observational data be used to improve the design and analysis of randomized controlled trials? One approach is to couple an RCT with an observational study using shrinkage, leaning on the observational data more heavily when it exhibits greater congruency with estimates from the RCT. We operate in a stratified setting, and consider two key questions: 1) how can we develop shrinkage estimators that combine causal estimates from observational and experimental sources, and 2) with these estimators at our disposal, how might we design experiments more efficiently?

To answer the former question, we extend results from the Stein shrinkage literature. We propose a generic procedure for deriving shrinkage estimators that leverage observational and randomized data together, making use of a generalized unbiased risk estimate. We develop two new estimators, prove finite sample conditions under which they have lower risk than an estimator using only experimental data, and show that each achieves a notion of asymptotic optimality. We also draw connections between our approach and results from sensitivity analysis, including proposing a method for evaluating estimator feasibility.

We next consider designing a prospective randomized trial. If we intend to shrink the experiment's causal estimates toward those of a completed observational study, how do we optimize the experimental design? First, we show that the risk of the shrinkage estimator can be computed efficiently via numerical integration. We then propose algorithms for determining the best allocation of units to strata, accounting for the imperfect parameter estimates we would have from the observational study. We incorporate results from sensitivity analysis to establish "guardrails" so that our experiment could be reasonably analyzed with and without shrinkage.

Finally, we demonstrate the efficacy of these methods with an applied data analysis on data from the Women's Health Initiative.

2. Generalizing impacts of voluntary interventions using nonparametric regressions
Author(s): Degtiar, Irina*; Finucane, Mariel

Abstract: Impact evaluations are often intended to inform future decisions about whether a policy model should be scaled. However, impact evaluation participants may not be representative of the population to whom the intervention may eventually be scaled, leading to uncertainty regarding the relevance of evaluation findings to future decisions. Generalizability is further challenged when the intervention is voluntary, as future policy scale-up volunteers are not enumerable. We present a novel approach for estimating target population average treatment effects among the treated (PATT) by generalizing results from an observational study to target population volunteers (the target treated group). Our estimation approach accommodates flexible outcome regressions such as Bayesian Causal Forests (BCF) and Bayesian Additive Regression Trees (BART), and incorporates uncertainty regarding target population treatment status into the posterior credible intervals to more fully reflect the uncertainty of scaling up a voluntary intervention. The estimator can also be applied to identify alternative feasible target populations for a scale-up, such as populations expected to benefit most from the intervention, defined by values of key effect modifiers. Estimates from such targeting approaches can inform future policy models and model expansions, particularly when a broader scale-up is estimated to be ineffective. In a simulation based on real data, we estimate the PATT of a national scale-up of a voluntary Medicare health policy model and demonstrate that flexible nonparametric approaches (BCF and BART) improve performance over estimators that rely on parametric regressions. By estimating treatment effects for the target treated population of interest, our generalizability estimator projects impacts into a policy-relevant population to better-guide future policy decisions.

3. Blurring cluster randomized trials and observational studies: Evaluating the SEARCH intervention on incident TB in rural Uganda

Author(s): Nugent, Joshua R*; Balzer, Laura; SEARCH Collaboration, The

Abstract: Many practical challenges complicate the design and analysis of cluster randomized trials (CRTs). First, the number of clusters enrolled and randomized is often constrained by cost or logistics. Second, the measurement of certain endpoints may require sub-sampling, and those sampled may (purposely or not) be unrepresentative of all enrolled participants. Finally, measurement of outcomes among sampled participants is often incomplete, causing concern for bias due to missing data. Motivated by the sub-study of the SEARCH trial to evaluate the intervention effect on incident tuberculosis (TB) in 9 communities in rural Uganda, we demonstrate interlocking methods to handle these challenges. First, we present a targeted minimum loss-based estimator (TMLE) for the one-year incidence of TB infections in each community, accounting for sampling strategy and missingness. Second, we evaluate the assumptions under which parishes, geographic sub-units of the community, can be considered the conditionally independent unit, improving precision and statistical power. Third, we present a second, parish-level TMLE to evaluate the intervention effect, harnessing the conditional independence assumptions. Our application to the SEARCH sub-study highlights the impact of differing assumptions on missing data and dependence as well as the potential gains in precision from our novel approach.