Cluster-Randomized and Quasi-Experimental Studies: Design and Analysis

RTI International is a leader in the design and analysis of cluster-randomized and quasi-experimental studies and applies this extensive experience to plan effective program strategies, improve the quality of existing programs, and evaluate program effectiveness.

We work closely with both public and private health initiatives and clients to ensure the most practical and robust designs possible, both to minimize potential bias and to maximize generalizability. During data analysis, we use methodologies for handling clustered data and collaborate with investigators to draw appropriate conclusions and interpret results in clear and meaningful language.

In research design and program evaluation, the term *cluster* refers to any social or naturally occurring collection or group of persons, animals, or other elements that are the object of study. We see clustering in many areas of scientific inquiry and public policy analysis:

- Public health officials want to know how social and contextual factors have influenced disease transmission among community members.
- Administrators are interested in the impact of a violence-prevention curriculum on student victimization.
- Health policy analysts want to know if a new medical triage system is increasing the efficiency of emergency room intake procedures.

Clustering is used for a variety of reasons. Often the treatments and interventions of interest can be applied only to the larger social unit, for example, mass media messaging, tax policy changes, or whole school reform. At other times, there are ethical, practical, or logistical reasons for introducing treatments or interventions at the group level when we are interested in determining how they affect members of a group. Whenever a treatment, intervention, or policy change is applied to specific groups with the aim of comparing those groups to other similar groups, clustering becomes a factor in the experimental design.

In clustered designs, interventions or treatments are administered at the cluster level, and measurements or observations are collected at the individual level. This leads to the primary pitfall of clustered designs—measurements on individuals within the same cluster are expected to be correlated. This lack of independence, indexed by the intraclass/intracluster correlation (ICC), goes against the traditional assumptions associated with standard sample size determination and thus has important implications for study design. In essence, clustering reduces the amount of unique information and, by extension, the effective sample size. When clustering is ignored at the design stage, researchers greatly increase the risk of promoting and fielding an underpowered study.

Data collected from studies in which observations from individuals within the same cluster may be correlated are vulnerable to two types of data variability—within-cluster variability and between-cluster variability. Thus, ignoring clustering at the statistical analysis stage typically underestimates the true variability in the data and produces biased standard error estimates and misleading

p-values. Commonly used analysis methods such as linear or logistic regression are likely to produce falsely high precision for the regression coefficients and confidence intervals that are too narrow (or *p*-values that are too small), leading to inaccurate conclusions.

Whether designing or analyzing a study, RTI uses a multidisciplinary approach tailored to the needs of the client and the subject under study. At the design stage, we use various methods to obtain preliminary estimates of the ICC on which to base sample size calculations, including literature reviews, pilot studies, and simulations. During the analysis stage, RTI statisticians adjust for clustered data by assuming a more flexible statistical model that allows for dependence within clusters. Our modeling approaches include (1) cluster-specific hierarchical or mixed models to accommodate clustering by introducing an additional level of variability over standard regression modeling and (2) a population-averaged marginal generalized estimating equations (GEE) model, which involves a straightforward extension of ordinary regression to correlated data. We use RTI's SUDAAN® statistical analysis software and other special programs to analyze such clustered data.

Project Experience

Impact Evaluation of a School-Based Violence Prevention Program (2004–2009). RTI designed this 5-year cluster-randomized study to assess the impacts of a school-based violence prevention program that included both curricular and whole-school reform components. The evaluation design includes nested cross-sectional analyses of student populations as well as a nested cohort of high-risk youth who are tracked and surveyed annually. *Client: U.S. Department of Education*

Workplace Prevention and Early Intervention Transitioning Youth into the Workplace (2003–2007). RTI designed this cross-site evaluation as a quasi-experimental clustered study to examine the effectiveness of substance abuse prevention programs on workforce youth. The study included multiple grantee organizations employing multilevel intervention programs among diverse populations. RTI's design effectively captured these complexities and led to statistical analyses that provided the client with information about program processes, outcomes, and cost-effectiveness. *Client: Substance Abuse and Mental Health Services Administration*

Global Network's First Breath Initiative (2005–2008). *First Breath* is a clustered, randomized controlled trial to assess the effects of a neonatal resuscitation training and education program on 7-day neonatal mortality in 88 communities across South Asia, Africa, and South and Central America. RTI helped clinicians develop the study design and calculate sample size by using an innovative simulation method developed by RTI researchers. RTI monitored the trial, periodically presented to the independent Data Safety and Monitoring Board (DSMB) to monitor interim safety and efficacy, and analyzed the final data using GEE to adjust for clustering and country differences. *Client: National Institute of Child Health and Human Development (NICHD)*

Neonatal Research Network: A Randomized Controlled Trial of Benchmarking to Reduce Bronchopulmonary Dysplasia (2000–2004). This trial used cluster randomization to test whether Neonatal Intensive Care Unit heath care teams trained in benchmarking and quality improvement would modify their care practices to improve rates of survival without bronchopulmonary dysplasia in newborns weighing less than 1,250 grams. RTI helped clinicians develop the study design, developed and implemented the cluster randomization scheme, interfaced with the independent DSMC to monitor interim safety and efficacy, analyzed the final data using mixed models to adjust for clustering, and co-authored the primary publication that reported the major findings from this trial. *Client: NICHD*

For more information, please contact

Roy Whitmore, Vice President
Statistics and Epidemiology
Phone: +1.919.541.5809
E-mail: rww@rti.org

James Hersey, Vice President
Public Health and Environment
Phone: +1.202.728.2486
E-mail: hersey@rti.org

RTI International
3040 Cornwallis Road, PO Box 12194
Research Triangle Park, NC 27709-2194 USA

RTI 1008