Institute of Education Sciences
National Center for Education Statistics

NATIONAL INSTITUTE OF STATISTICAL SCIENCES
TECHNICAL EXPERT PANEL REPORT

NEW APPROACH FOR SAMPLING FOR EDUCATION SURVEYS

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NATIONAL INSTITUTE OF STATISTICAL SCIENCES

NEW APPROACH FOR SAMPLING FOR EDUCATION SURVEYS

EXECUTIVE SUMMARY

The National Center for Education Statistics (NCES) is continually challenged by the problems and the opportunities as data gathering and data analysis evolve with the rapidity of technological change. Problems include rising rates of non-response and increasing need to reduce response burden. An alternative for the basic design of a survey or assessment was presented for consideration to NCES with the objective of remediating the problem of decreasing response rates at all levels and simultaneously providing robust estimates of the measured outcomes and unbiased variance estimators. The NCES charged the National Institute of Statistical Sciences (NISS) with convening a panel of technical experts to examine theoretical arguments in favor of the design and to consider whether this design is suited to a large-scale federal survey. Specific issues for the panel to consider were: i) the degree to which the proposed new methodology is truly novel; ii) the degree to which it is advantageous over current practices, especially in regard to accuracy of inferences and to variance estimation; and iii) the degree to which it is suited to a large-scale federal survey both in practical terms and in terms of magnitude of improvement over current designs.

Proposed Design Approach

The idea for the proposed design methodology comes from work in 1962 by J.N.K. Rao, H.O. Hartley and W.G Cochran who sought a computationally simple estimation process that would yield an exact variance formula and unbiased variance estimator. The design proposed here would consider the population as divided into two classes: responders and non-responders. Then each stratum (sample size m) would be partitioned into m/2 zones "so that values of sorting variables deemed as non-response predictors are well distributed across zones." Equivalence groups of units are created by dividing each zone is divided into two groups completely at random. Following the Rao-Hartley-Cochran method a single sample is drawn using proportionate unequal probabilities so that at the final stage, one unit is sampled from each of the m groups (2 groups per zone). If a sampled unit is a non-responder, another unit is sampled; non-responders are replaced until either a respondent unit is drawn or the group is exhausted without response.

A novel application of this approach addresses the repeated surveying for multiple surveys by eliminating sample overlap. By creating the stratum - zone - group structure, any unit within a group that has already been sampled as part of another survey can be treated a fortiori as a non-respondent in this sampling scheme.

The intent of this approach is to mitigate the problems arising from non-response of sampled units. Since there are alternative methods to deal with non-response, theoretical, simulation and real/pilot study comparisons are needed. For the proposed design, both technical and practical aspects need further development. On the technical side, the underlying assumptions have not been rigorously stated. Neither has the justification for the estimation equations nor for the variance estimation been completely worked out.

The essential feature of the design appears to be a substitution procedure with a random component that is coupled to an estimation piece and to variance estimation by treating the groups as the sampled units. However, the group variation is not equivalent to the unit variation. Even a purely unconditional argument that unequal sampling probabilities are preserved under this scheme requires a technical proof. Of course, the number of (potential) non-respondents in the population does not change with the sampling design. So "solving/mitigating non-response" simply shifts those problems to problems of response bias and error.

Summary of Deliberations

Following presentation of the proposed method and discussion of a hypothetical application in the education setting, it was still not clear what problem this method would solve in the context of NCES studies, surveys and assessments. For NCES studies, non-response at the school level is dealt with at the outset for practical reasons. Studies are planned and launched at different times often without the possibility of coordination so that it is difficult to see how the proposed method would fit the context.

1. It is highly dubious that substitution of group non-response for unit non-response would conform with federal standards for reporting statistical data.
2. Benefits of the proposed method have not been convincingly demonstrated either theoretically or via simulation. Implementation of this method would be premature. Based on available information at this time it is not clear that after careful study the method will prove advantageous. Necessary steps to investigate the method and its properties are listed below.
3. Technical development of the proposed method is incomplete. A complete technical formulation would include: i) explicit assumptions, ii) estimators and their properties, iii) variance estimators and their properties, iv) expected total "sample" sizes.
4. If this is really rejective sampling at the final stage, then the theory should be linked to the extensive body of theory for rejective sampling and its properties.
5. Simulation needs to be extensive to demonstrate the claimed properties in practice: improved variance estimation, reduced total "sample" size and robustness to misspecification. Unlike the simulation presented that was SRS not PPS, simulation studies should be based on a more realistic structure, unequal probabilities (as for PPS sampling), and the behavior of the variance estimator should be characterized.
6. Calculation (simulation) and analysis of expected costs is an initial step in planning for implementation, accompanied by development of expected time-schedule for the method to apply in NCES context.
7. The final step prior to implementation would be demonstration of the method via field test and validation of comparative advantages identified in 2, 3 & 4 above.

PREFACE

The National Center for Education Statistics (NCES) continues to evaluate potential innovations in the design of data-gathering via survey and via assessment, and the methodology for organizing and presenting these data for public use and for education research. The value of any innovation depends on its technical correctness, its feasibility, and on its efficiency. In short, the merit of implementing an innovation depends on the current state of the art and practice and on the comparative advantage of the innovation and its relative costs.

Therefore, a panel was convened comprised of experts in sample survey theory and its application and experts in the implementation and the use of NCES education data with the charge of examining a proposal for changing methodology of an education survey, i.e., changing the basic design.

National Institute of Statistical Sciences
Technical Expert Panel

NEW APPROACH FOR SAMPLING FOR EDUCATION SURVEYS

I. INTRODUCTION

The National Center for Education Statistics like other federal statistical agencies is continually challenged by the problems and the opportunities as data gathering and data analysis evolve with the rapidity of technological change. Universally, problems include rising rates of non-response and increasing need to reduce response burden. Opportunities include transfer of manual operations to automated data-gathering and organization and coordination of surveys to integrate information from multiple sources. The constraints in meeting these challenges are to maintain statistical validity throughout the process and to maximize efficiency in the implementation of surveys and assessments.

An alternative for the basic design of a survey or assessment, described below, was presented for consideration to NCES with the objective of remediating the problem of decreasing response rates at all levels and simultaneously providing robust estimates of the measured outcomes and unbiased variance estimators.

The panel was asked both to examine theoretical arguments in favor of the design and to consider whether this design is suited to a large-scale federal survey. In particular suitability depends on information required for implementation, weaknesses that would emerge in this context, requirements for uniformity in application with regard to selective non-response or variation in stratification, etc. How the practicalities will impact attractive theoretical properties of the estimators and the inferences should be assessed. Even though the practical issues can be solved and the statistical theory can be developed; often the interaction of the two does not work as planned. Specific issues for the panel to consider were: i) the degree to which the proposed new methodology is truly; ii) the degree to which it is advantageous over current practices, especially in regard to accuracy of inferences and to variance estimation; and iii) the degree to which it is suited to a large-scale federal survey both in practical terms and in terms of magnitude of improvement over current designs.

Within this context, the panel framed the evaluation of the proposed methodology in terms of five questions.

1. What are the problems at hand?
2. What is the proposed design methodology?
3. What is required to make the design both effective and capable of efficient implementation?
4. What are the benefits that can accrue with this approach to survey/assessment design?
5. What are the alternatives and the comparative advantage of the innovation over those?

This report concludes with a summary of the panel's deliberations.

What are the Problems at Hand?

In brief, three problem areas that challenge NCES in gathering education data fall into the categories of cost to conduct, burden to the respondent and non-response. Aspects of solutions come from all perspectives, including reduction in sample size, technology replacing person-hours, shortened requests for information, sharing of information across surveys/sources, incentives to participate, and other motivators.

The constraint on all manners of attack on these challenges is the need to maintain the quality and precision of the information gathered without loss of critical data for accurate picture of US education. Improving the statistical design of a single study or survey could reduce cost, reduce or eliminate bias and/or increase the precision of the information. Designing for combining several studies or data resources could offer still greater benefits due to shared information. Devising a statistical design that would stabilize over time or minimize the number of returns to the same source for related (or unrelated) surveys could reduce burden or at least reduce perceived burden.

The potential for advantageous innovation in the statistical design depends on the kind of study. For example, a longitudinal study that identifies a fixed cohort of subjects to be followed to the study's termination will suffer gradual losses to follow-up and increasing potential for bias. An alternative of interlocking samples, that is with one subgroup of sampled individuals 'retired from the sample' each year and with an equal-sized new subgroup matched in age introduced in their stead, acquires an additional source of variation from differences between each retiring subgroup and its replacement.

As a second example, studies that utilize multiple modes of contacting subjects have the opportunity to allocate funds and effort strategically among the modes of contact to maximize response and/or minimize bias and variance. A third example would be the introduction - across studies, across series of a repeated study or across waves of a longitudinal study - of a substitution scheme so that a study participant (e.g., a school) would enjoy a "guarantee time" before being again invited to participate, thereby reducing burden in the long term. The substitution scheme would have to be statistically valid for drawing inferences, with known properties such as bounds on bias, reliable estimates of precision (or variance), etc.

What is the Proposed Design Methodology?

The proposed methodology is directed toward statistical problems that arise when response rates fall. In particular, bias is induced when the likelihood of non-response is not uniform across the sampled population and consequently the responding portion of the original sample behaves like a nonprobability sample.

The idea for the proposed design methodology is not new. In 1962, J.N.K. Rao, H.O. Hartley and W.G Cochran had a clever idea and proposed this strategy for single and for two-stage unequal probability sampling. Their goal was to provide a readily computable (in terms of computations as done in 1962) estimator of the population total, an exact variance formula and an unbiased estimator of variance. The key to accomplishing this for a single stage was to partition the population (N units) completely at random (disregarding for the moment the individual unit unequal probabilities) into several (n) mutually exclusive and exhaustive subgroups. Then a single sample is drawn from each group using the proportionate probability within that group. For a two-stage process, subunits would be selected at random from each sample selected from a group. The idea was to artificially create replicate samples or groups (with PPS within a group) for the purpose of estimating variance while still using the unequal probabilities for estimating the population total.

The proposed design under consideration here modifies the original by starting at the stratum level and first purposively partitioning a stratum (with allocated stratum sample size m) into m/2 zones "so that values of sorting variables deemed as non-response predictors are well distributed across zones." Two distinct possibilities for are: i) to consider the population divided into two classes: responders and non-responders or ii) to consider each unit having a probability of non-response, possibly based on or linked to covariates. As proposed, the method adopts the former. Then each zone is divided into two groups completely at random, and following the Rao-Hartley-Cochran method a single sample is drawn using proportionate unequal probabilities; and at the final stage, one unit is sampled from each of the m groups (2 groups per zone) to comprise the sample for that stratum. In the event a unit is a non-responder, another unit is sampled, continuing until either a respondent unit is drawn from that group or the group is exhausted without response.

If zones are created to be equivalent, then it is not clear why these are required at all as m groups could be formed directly within the stratum. If zones are created to be homogeneous (with respect to likelihood of response) then it is not clear how this differs from stratifying more extensively at the beginning.

The first argument put forward for using this approach, is that by allowing substitution of an equivalent unit to a non-respondent (after as many random draws from the non-respondent's group as necessary to obtain a respondent) non-response can be reduced because non-response is measured in terms of group response rather than unit response. "The unconditional selection probabilities for the responding unit in a random group regardless of units rejected before is the same as the selection probability at the first draw which is easily computable."

A second aspect of this approach is the use only of unconditional selection probabilities for responding units from different groups does not allow usual methods for non-response bias adjustment; however, a calibration method can be used for non-response adjustment.

A novel application of this approach addresses the repeated surveying of a single organization for multiple surveys by eliminating sample overlap. By creating the stratum - zone - group structure, any unit within a group that has already been sampled as part of another survey can be treated a fortiori as a non-respondent in this sampling scheme.

What is Required to Make this Design Both Effective and Capable of Efficient Implementation?

Both technical and practical aspects of this design need further development. On the technical side, the underlying assumptions have not been rigorously stated. Neither has the justification for the estimation equations nor for the variance estimation been completely worked out. For example, the partitioning into zones assumes some sort of model-based prediction for non-response that is used in some unspecified way to create "equivalent" distributions of non-response probabilities or expected proportions of non-responders for all zones*. Without further justification and explicit assumptions about mutual dependence of measured outcomes and of non-response on these (same) model covariates, it is not possible to develop correct formulae for population estimates, for variances and for variance estimates. Neither is it possible to examine the contexts of NCES studies to determine whether these assumptions can be satisfied. How covariates would be selected to predict non-response and what would be the implications of their selections, their relative effectiveness and potential bias is unspecified and apparently unstudied. Although the author writes that both measured outcomes and likelihood of non-response are both assumed to be related to the covariates, no theoretical investigation was offered regarding the consequences or bias due to this mutual dependence or correlation.

Apparent assumptions, both explicit and implicit, require clarification and justification. These include but are not limited to following:

1. Source of figures or models relating measured outcome to covariates for zone definition and for calibration - population estimates may not be applicable.
2. Non-response probabilities either 0 or 1 but fixed for individual units and the same proportion of non-responders for each group within a zone; OR a non-response probability between 0 and 1, depending upon the characteristics of each unit, but "equivalently distributed" across groups and zones.
3. Simplified probability (uniform?) for non-response across stages, i.e., as non-responders are replaced.

4. Reliance on original response rate without adaptive mechanism.
5. Same data collection protocol among stages.
6. Efficacy of strong calibration method.

Thus, the essential feature of the design appears to be a substitution procedure with a random component that is coupled to an estimation piece and to variance estimation by treating the groups as the sampled units. However, the group variation is not equivalent to the unit variation. Even a purely unconditional argument that unequal sampling probabilities are preserved under this scheme requires a technical proof.

Despite the use of various descriptors, “replicate sample units” “reserve sample units,” the substitution of new subunits as needed from a group appears to be rejective sampling with non-response as the rejection criterion.

*Note that the author also refers to an alternative construction of zones as “deep strata” implying that the original strata are partitioned into relatively homogeneous zones with respect to likelihood of non-response.

What are the Benefits that can Accrue with this Approach to Survey/Assessment Design?

The intent of this approach is to mitigate the problems arising from non-response of sampled units. Of course, the number of (potential) non-respondents in the population does not change with the sampling design. So “solving/mitigating non-response” simply shifts those problems to problems of response bias and error.

This particular approach to solution - via rejective sampling at the final stage - trades off the information on the non-respondents. Hence non-response bias cannot be estimated in the usual ways, but calibration procedures can be applied instead although the efficacy of doing this remains to be shown theoretically or demonstrated via simulation with real data.

What are the Alternatives and the Comparative Advantage of the Innovation Over Those?

Innovation does require effort, time and cost. Where there are alternatives, especially an already adopted approach, theoretical, simulation and real/pilot study comparisons are needed.

So, given a population that includes a fixed number of (non-identified) non-respondents, depending on the design the impact surfaces variously through the alternatives of bias, variance, cost and feasibility. Technical formulation of the first three would be the basis for comparing the trade-offs among designs.

To be meaningful, simulation studies must be sufficiently extensive to include the kinds of contexts that are likely to be encountered if the new method is implemented. They must also test the robustness of the method with regard to the key assumptions - both assumptions about statistical properties and sources of variation and also assumptions about the population, the likelihood of non-response as a function of stratifying variables, covariates used in defining zones, and the interrelationships among these.

To deal with non-response alternatives include: i) sampling in waves (including new units rather than using expensive modes to pursue non-responders), ii) adaptive design, iii) 1:1 substitution (deterministic matching determined by covariate patterns, nearest neighbor), iv) over-sampling based on assumed (stratum) response rates. Obviously sequential procedures have the advantage of not exceeding a planned sample size; other approaches do not require intervention or reconsideration mid-survey.

Feasibility evaluation can follow if theoretical and simulation studies demonstrate a comparative advantage. But without any meaningful demonstration of superiority of the proposed design, it is premature at the very least to consider it for implementation.

Summary of Deliberations

Following presentation of the proposed method and discussion of a hypothetical application in the education setting, it was still not clear what problem this method would solve in the context of NCES studies, surveys and assessments. For NCES studies, non-response at the school level is dealt with at the outset for practical reasons. Studies are planned and launched at different times often without the possibility of coordination so that it is difficult to see how the proposed method would fit the context.

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3. Technical development of the proposed method is incomplete. A complete technical formulation would include: i) explicit assumptions, ii) estimators and their properties, iii) variance estimators and their properties, iv) expected total “sample” sizes.

   If this is really rejective sampling at the final stage, then the theory should be linked to the extensive body of theory for rejective sampling and its properties.
4. Simulation needs to be extensive to demonstrate the claimed properties in practice: improved variance estimation, reduced total “sample” size and robustness to misspecification. Unlike the simulation presented that was SRS not PPS, simulation studies should be based on a more realistic structure, unequal probabilities (as for PPS sampling), and the behavior of the variance estimator should be characterized.
5. Calculation (simulation) and analysis of expected costs is an initial step in planning for implementation, accompanied by development of expected time-schedule for the method to apply in NCES context.
6. The final step prior to implementation would be demonstration of the method via field test and validation of comparative advantages identified in 2, 3 & 4 above.

APPENDICES

Appendix A: References

Appendix B: Agenda

Appendix C: Expert Panel Biosketches

Appendix A: References

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Kish, L. & Scott, A. (1971). Retaining units after changing strata and probabilities. *Journal of the Social Statistics Section*, 66, 461-470.

Ernst, L. R., Villiant, R. & Casady, R. J. (2000). Permanent and collocated random number sampling and the coverage of births and deaths. *Journal of Official Statistics*, 16(3), 211.

Singh, A.C. & Ye, C. (2016). Randomly split zones for samples of size one as reserve replicates and random replacements for nonrespondents. *2016 AIR-SDS Working Paper Series*.

Appendix B: Agenda

NCES Panel to Review a New Approach for Sampling for Education Surveys Meeting

November 8–9, 2016 | Washington, DC

AGENDA

Tuesday, November 8, 2016 (PCP Room 7080)

9:00-10:00 am	Arrival Through Security, 550 12th Street, SW, Washington, DC 20202 *Andrew White, Senior Research Statistician, NCES*
10:00-10:30 am	Introductions, Charge to Panel *Nell Sedransk, Marilyn Seastrom, Chris Chapman*
10:30 am-Noon	Presentation Time w/Discussion *Avi Singh*
12:00-1:00 pm	Lunch & Panel Internal Deliberation
1:00- 2:00 pm	Panel Discussion (Closed)
2:00- 3:00 pm	Questions & Discussions *Panel, Avi Singh, NCES Staff*
3:00-4:30 pm	Panel Deliberation (Closed)

Wednesday, November 9, 2016 (PCP Room 7080)

9:00-10:00am	Arrival Through Security, 550 12th Street, SW, Washington, DC 20202 *Andrew White, Senior Research Statistician, NCES*
10:00-11:30am	Panel Discussions & Questions *Panel, Avi Singh, NCES Staff*
11:30am-12:30pm	Lunch & Panel Internal Deliberation
12:30-1:30pm	Final Panel Discussions & Questions *Panel, Avi Singh, NCES Staff*
2:00-3:00pm	Questions & Discussions *Panel, Avi Singh, NCES Staff*
1:30–4:30pm	Panel Deliberation (Closed)

Appendix C: Expert Panel Biosketches

Michael Larsen, Ph.D.

Title: Professor, Department of Statistics & Director, Graduate Certificate in Survey Design & Data Analysis, George Washington University

Michael Larsen, Ph.D., Professor in the Department of Statistics and the Biostatistics Center at George Washington University since 2009. In the Department of Statistics, he is Director of GW's Graduate Certificate Program in Survey Design & Data Analysis. He received a Ph.D. in Statistics from Harvard University. Dr. Larsen is an elected fellow of the American Statistical Association (2012) and an elected member of the International Statistical Institute (2010) and was a Distinguished Scholar at the U.S. Census Bureau (2012). He has been elected to four positions in the ASA's Survey Research Methods Section, including program chair (2012) and chair (2016).

He is serving as president of the Washington Statistical Society in 2016-17. His interests include survey sampling, missing data, record linkage and administrative records, disclosure limitation and confidentiality, Bayesian statistics, hierarchical and mixture models, statistical modeling of complex data, and statistics education. At the National Academy of Sciences, he has participated in a panel and a standing committee on decennial census operations, planning for the American Opportunity Study and a panel on re-engineering Census annual economic surveys. Dr. Larsen served as a member of the NIH's Biostatistical Research Methods and Design study section, a former executive editor for Chance (2008-2010), and associate editor and referee for a number of journals. He has consulted for and collaborated with researchers at a number of government agencies, research organizations, companies, and academic departments. Dr. Larsen has advised several master's degree students and 8 PhD students.

Brian P. Rowan, Ph.D.

Title: Burke A. Hinsdale Collegiate Professor in Education, a Research Professor at the Institute for Social Research, and a Professor of Sociology, University of Michigan

Brian Rowan is the Burke A. Hinsdale Collegiate Professor in Education, a research professor at the Institute for Social Research, and a professor of sociology at the University of Michigan. A sociologist by training (PhD, Stanford University), Rowan's research has focused on the organization and management of schooling, paying special attention to the measurement and improvement of teaching quality. Over the past 10 years, he has been principal investigator of several large-scale survey and video studies of teaching practice, including the Study of Instructional Improvement, the Description of Reading Instruction in the United States, Understanding Teaching Quality, the Measures of Effective Teaching-Extension project, and the Pilot of Educator Effectiveness Tools in Michigan. His current research includes a randomized field trial of an early grades reading intervention, a study of the rise, spread, and consequences of the Common Core State Standards initiative, and a study of online high schools in Florida. He is a member of the U.S. National Academy of Education and past recipient of the William J. Davis award for outstanding scholarship in the field of educational administration. He also has served on the editorial boards of top scientific journals in the field of education and consulted widely with U.S. federal government and U.S. private research organizations. Prior to joining the faculty at the University of Michigan in 1991, he was a senior research director at Far West Laboratory for Educational Research and Development, in San Francisco, California, and chairperson of the Department of Educational Administration at Michigan State University.

Keith Rust, Ph.D.

Title: Vice President, Associate Director, Westat, Inc.

Dr. Keith Rust, a Vice President and Associate Director of Westat's Statistical Staff, is a senior statistician with extensive experience in sampling methods, the design and specification of large-scale sample surveys, and analysis of survey data. His areas of special expertise include methods for analyzing large, complex data sets; methods of deriving survey weights; and sampling error estimation procedures. He has applied his research and knowledge to a variety of education research projects over the past several years, both national and international. Dr. Rust has also directed work on Government sample surveys related to education, health, and social issues. He has experience teaching statistics, particularly relating to survey sampling, to a variety of audiences. Prior to joining Westat 30 years ago, he was a Mathematical Statistician with the Australian Bureau of Statistics. Concurrent with his Westat duties, Keith is a Research Professor at the Joint Program in Survey Methodology, University of Maryland, and has been teaching in that program for the past 25 years. Keith is Fellow of the American Statistical Association, an Elected Member of the International Statistical Institute, a former President of the Washington Statistical Society, and a past member of the National Academies' Committee on National Statistics. He has a Ph.D. in Biostatistics from the University of Michigan.

Joseph L. Schafer, Ph.D.

Title: Senior Mathematical Statistician, Office of Associate Director for Research and Methodology, United States Census Bureau

Dr. Schafer has developed techniques for analyzing incomplete data and incorporating missing-data uncertainty into statistical inference. These techniques include both asymptotic approximations and simulation via multiple imputation, in which missing data are replaced by multiple simulated values. He has worked to develop general-purpose algorithms and software for the analysis of incomplete multivariate data. He has also been extensively involved with several projects undertaken by the Bureau of the Census, including the Post-Enumeration Survey to measure the undercount in the 1990 census. His research interests currently include the formal assessment of uncertainty due to missing data and other sources of nonsampling error in sample surveys, techniques for computation and stimulation of Bayesian posterior distributions, and parametric inference in sample surveys.

Elizabeth A. Stasny, Ph.D.

Title: Professor Emeritus, Department of Statistics, Ohio State University

Elizabeth A. Stasny is Professor Emeritus of Statistics. Her research interests include methods for handling missing data in large sample surveys, ways of discovering and correcting bias in data from random digit dialing, and analysis of large-scale crime data. She has examined trial outcomes for cases in which the death penalty might be the punishment when potential jurors who were opposed to the death penalty were excluded from serving on the juries. In 2010, Dr. Stasny was appointed by U.S. Attorney General Eric Holder to serve as one of eighteen distinguished scholars and practitioners in criminology, statistics, sociology, and the criminal and juvenile justice fields on the newly created Office of Justice Programs (OJP) Science Advisory Board.

Panel convened by National Institute of Statistical Sciences

Nell Sedransk, Ph.D.

Title: Director, National Institute of Statistical Sciences; Statistics Professor, North Carolina State University

Dr. Nell Sedransk is the Director of the National Institute of Statistical Sciences and Professor of Statistics at North Carolina State University. She is an Elected Member of the International Statistical Institute, also Elected Fellow of the American Statistical Association. She is coauthor of three technical books; and her research in both statistical theory and application appears in more than 60 scientific papers in refereed journals. The areas of her technical expertise include: design of complex experiments, Bayesian inference, spatial statistics and topological foundations for statistical theory. She has applied her expertise in statistical design and analysis of complex experiments and observational studies to a wide range of applications from physiology and medicine to engineering and sensors to social science applications in multi-observer scoring to ethical designs for clinical trials.