

Contents

Contributors	xv
Preface	xvii

1. Review of Certain Recent Advances in Randomized Response Techniques	1
<i>T.J. Rao and C.R. Rao</i>	
1 Introduction	1
2 Warner's and Related Techniques	2
3 Cryptographic RRT	3
4 Reverse RRT	4
5 Certain Recent Theoretical and Practical Results	5
5.1 Unified Theory	5
5.2 Stratification and RRT	6
5.3 Cramér–Rao Lower Bound	7
5.4 Game Theory and RRT	7
5.5 Smart Phones and RRT	7
5.6 Alternatives to RRT	8
5.7 Meta Analysis	8
6 Epilogue	8
Acknowledgment	9
References	9
2. The Background and Genesis of Randomized Response Techniques	13
<i>A. Chaudhuri</i>	
3. How Randomized Response Techniques Need not Be Confined to Simple Random Sampling but Liberally Applicable to General Sampling Schemes	17
<i>A. Chaudhuri</i>	
1 Introduction	17
2 Two Prominent RR Devices Revised for General Applications	19
2.1 Warner Stanley's (1965) Device	19
2.2 Simmon's RR Device Revised	20
3 Quantitative RRs	22

4	Protection of Privacy	23
4.1	When a Characteristic Is Qualitative and SRSWR Is Allowed	23
4.2	When a General Sampling Design Is Allowed to Cover a Qualitative Characteristic	23
4.3	Protection of Privacy Covering Quantitative Variables	24
5	Optional RR Techniques	24
	References	26
4.	The Classical Randomized Response Techniques: Reading Warner (1965) and Greenberg et al. (1969) 50 Years Later	29
	<i>T.C. Christofides</i>	
1	Introduction	29
2	Warner's Randomized Response Technique	30
3	The Unrelated Question Model	33
4	Reading Warner (1965) and Greenberg et al. (1969) 50 Years Later	37
5	Epilogue	40
	References	40
5.	On the Estimation of Correlation Coefficient Using Scrambled Responses	43
	<i>S. Singh</i>	
1	Introduction	43
2	Two Scrambling Variable Randomized Response Technique	45
3	Scrambling Variables Are Dependent	46
4	Estimation of the Correlation Coefficient ρ_{xy}	48
5	Bias and Mean Squared Error of r_{xy}	54
6	Scrambling Variables Are Independent	58
7	Bias and Mean Square Error of \hat{r}_1	59
8	Single Scrambling Variable Randomized Response Technique	61
9	Bias and Mean Squared Error of \hat{r}_2	63
10	Correlation Between Sensitive and Nonsensitive Variable	67
11	Bias and Mean Square Error of \hat{r}_3	69
12	Simulation Study	69
	Acknowledgments	82
	Appendix	83
	References	89
6.	Admissible and Optimal Estimation in Finite Population Sampling Under Randomized Response Models	91
	<i>S. Sengupta</i>	
1	Introduction	91
2	Notations and Preliminaries	92

3 Estimation Based on Single RR	96
3.1 Nonexistence of a Best Estimator	96
3.2 Admissibility Results	96
3.3 Optimality Results	98
4 Estimation Based on Independent Multiple Responses	99
4.1 Nonexistence of a Best Estimator	100
4.2 Admissibility Results	100
4.3 Optimality Results	101
5 Concluding Remarks	101
References	102
7. A Mixture of True and Randomized Responses in the Estimation of the Number of People Having a Certain Attribute	105
<i>A. Quatember</i>	
1 Introduction	105
2 A General RR Technique for the Estimation of Group Size	108
3 Combining True and Randomized Responses	109
4 A Vivid Illustration of This Strategy Including True and Masked Responses	114
References	117
8. Estimation of Complex Population Parameters Under the Randomized Response Theory	119
<i>L. Barabesi, G. Diana, and P.F. Perri</i>	
1 Introduction	119
2 Foundations of Functional Linearization	121
3 Functional Linearization with the RR Technique	123
4 Some Simple Examples	125
5 Further Examples with Some Inequality Indices	126
6 Final Remarks	129
Acknowledgments	129
References	130
9. An Efficient Randomized Response Model Using Two Decks of Cards Under Simple and Stratified Random Sampling	133
<i>S. Abdelfatah and R. Mazloun</i>	
1 Introduction	133
2 Efficient Randomized Response Model Under Simple Random Sampling	136
2.1 The Proposed Model	136
2.2 Efficiency Comparison	139

3	Simulation Study	141
4	Efficient Randomized Response Model Under Stratified Random Sampling	142
4.1	The Proposed Stratified Model	142
4.2	Efficiency Comparison	147
5	Double Sampling for the Proposed Stratified Model	148
6	Conclusion	153
	References	153
10.	Software for Randomized Response Techniques	155
	<i>M. Rueda, B. Cobo, A. Arcos, and R. Arnab</i>	
1	Introduction	155
2	Software for Helping to Conduct a Survey with RR	156
3	Software for the Estimation with Data Obtained Using RR Techniques	158
4	Summary	162
	Acknowledgments	164
	References	164
11.	Poststratification Based on the Choice of Use of a Quantitative Randomization Device	169
	<i>O. Odumade, R. Arnab, and S. Singh</i>	
1	Introduction	169
2	Poststratification Based on the Choice of a Quantitative Randomization Device	170
3	Relative Efficiency	173
	Appendix	174
	References	189
12.	Variance Estimation in Randomized Response Surveys	191
	<i>A.K. Adhikary</i>	
1	Introduction	191
2	Variance of Horvitz–Thompson (1952) Estimator	194
3	Variance of Hansen–Hurwitz (1943) Estimator	197
4	Variance of Raj’s (1956) Ordered Estimator	200
5	Variance of Murthy’s (1957) Unordered Estimator	202
6	Variance of Ratio Estimator Based on Lahiri (1951), Midzuno (1952), and Sen’s (1953) Sampling Scheme	204
7	Variance of Hartley–Ross (1954) Unbiased Ratio-Type Estimator	206
	References	207

13. Behavior of Some Scrambled Randomized Response Models Under Simple Random Sampling, Ranked Set Sampling and Rao–Hartley–Cochran Designs	209
<i>C.N. Bouza-Herrera</i>	
1 Introduction	209
2 Scrambling Procedures	210
3 Behavior Under RHC Unequal Probability Model	212
4 Behavior Under RSS	214
5 Conclusions	219
Acknowledgments	220
References	220
14. Estimation of a Finite Population Variance Under Linear Models for Randomized Response Designs	221
<i>P. Mukhopadhyay</i>	
1 Introduction	221
2 Optimal Estimation of V	224
3 UMVU Estimation	228
References	230
15. Randomized Response and New Thoughts on Politz–Simmons Technique	233
<i>T.J. Rao, J.Sarkar, and B.K. Sinha</i>	
1 Introduction	233
2 Not-at-Home's	234
2.1 Randomized Response Hartley–Politz–Simmons [RR-HPS] Technique	234
2.2 A New RR-HPS Technique	236
Acknowledgments	246
Appendix	246
References	251
16. Optional Randomized Response: A Critical Review	253
<i>R. Arnab and M. Rueda</i>	
1 Introduction	253
1.1 Warner's Technique: The Pioneering Method	254
1.2 Ericksson's Technique	255
1.3 A More General Model	256
2 General Method of Estimation	256
3 Optional Randomized Response Techniques	258
3.1 Full ORT	258
3.2 Partial ORT	264

4	Efficiency of the ORT	267
5	Conclusion	268
	References	269
17.	A Concise Theory of Randomized Response Techniques for Privacy and Confidentiality Protection	273
	<i>T.K. Nayak, S.A. Adeshiyan, and C. Zhang</i>	
1	Introduction	273
2	Vital Attributes of Randomization Experiments	275
3	Statistical Estimation for Fixed P	278
4	Estimation Under Invariant Post-randomization	280
5	Assessing Privacy and Confidentiality Protection	282
6	Discussion	284
	Acknowledgments	284
	References	285
18.	A Review of Regression Procedures for Randomized Response Data, Including Univariate and Multivariate Logistic Regression, the Proportional Odds Model and Item Response Model, and Self-Protective Responses	287
	<i>M.J.L.F. Cruyff, U. Böckenholt, P.G.M. van der Heijden, and L.E. Frank</i>	
1	Introduction	288
2	Univariate and Multivariate RR Data, No Explanatory Variables	289
2.1	Theory	289
2.2	Estimation	291
3	Logistic Regression of Univariate RR Data	292
3.1	Theory	292
3.2	Estimation	293
3.3	Extensions	294
4	Extensions of Regression Approaches to Multivariate RR Data	297
4.1	The Multivariate Logistic Regression Model Proposed by Glonek and McCullagh	297
4.2	Proportional Odds Model	301
5	Models Including Self-Protective Responses	304
5.1	Item Response Models	304
5.2	Self-Protective Responses	305
5.3	Example	306
5.4	Remaining Issues	311
	References	313

19. Eliciting Information on Sensitive Features: Block Total Response Technique and Related Inference	317
<i>K. Nandy, M. Marcovitz, and B.K. Sinha</i>	
1 Randomized Response Technique	317
2 Block Total Response Technique	318
3 SBTRM : Use of BIBD and Complimentary BIBD	320
4 Relative Comparison of BIBD-Based SBTRMs	320
5 Deriving the EB Estimators	321
6 Illustrative Example	324
7 Concluding Remarks	326
Acknowledgment	326
Appendix	326
A.1 Illustrative Examples	327
References	328
20. Optional Randomized Response Revisited	331
<i>R. Mukerjee</i>	
1 Introduction	331
2 Early Work	332
3 Scrambled Response	334
4 General Sampling Designs	337
5 Concluding Remarks	338
Acknowledgments	339
References	339
21. Measures of Respondent Privacy in Randomized Response Surveys	341
<i>M. Bose</i>	
1 Introduction	341
2 Qualitative Stigmatizing Variable	343
3 Quantitative Stigmatizing Variable	346
3.1 Continuous Stigmatizing Variable	346
3.2 Discrete Stigmatizing Variable	347
4 Concluding Remarks	349
References	350
22. Cramer–Rao Lower Bounds of Variance for Estimating Two Proportions and Their Overlap by Using Two Decks of Cards	353
<i>C.-S. Lee, S.A. Sedory, and S. Singh</i>	
1 Introduction	353
1.1 Simple Model	354
1.2 Crossed Model	356

2	Cramer–Rao Lower Bounds of Variances for the Simple Model	357
3	Cramer–Rao Lower Bounds of Variances for the Crossed Model	359
4	Comparison of the Variances and Lower Bounds	361
5	Unique Estimates	364
6	Range Restricted Maximum Likelihood Estimates	366
	Acknowledgment	370
	Appendix A	371
	Appendix B Codes Used in Simulation Studies	373
	References	385
23.	Estimating a Finite Population Proportion Bearing a Sensitive Attribute from a Single Probability Sample by Item Count Technique	387
	<i>P. Shaw</i>	
	1 Introduction	388
	2 Item Count Technique Using a Single Sample	389
	3 An Alternative Estimator of $V_P(\hat{\theta}_A)$	393
	4 Numerical Presentation	395
	5 Conclusion	401
	Acknowledgments	403
	References	403
24.	Surveying a Varying Probability Adaptive Sample to Estimate Cost of Hospital Treatments of Sensitive Diseases by RR Data Gathering	405
	<i>S. Pal and S. Roy</i>	
	1 Introduction	405
	2 Formulation of Problem	406
	3 RR Surveys	407
	4 Adaptive Cluster Sampling	407
	4.1 Network	408
	5 Revised Adaptive Randomized Response Surveys	408
	6 Simulation Study	410
	7 Concluding Remarks	412
	References	412
25.	Estimation of Means of Two Rare Sensitive Characteristics: Cramer–Rao Lower Bound of Variances	413
	<i>S.-C. Su, C.-S. Lee, S.A. Sedory, and S. Singh</i>	
	1 Introduction	413
	2 Estimation of Two Rare Sensitive Attributes	416

3 Proposed Randomized Response Model for Two Rare Sensitive Attributes	419
4 Relative Efficiency	422
Acknowledgments	424
Appendix	424
References	425
26. Estimating Sensitive Population Proportion by Generating Randomized Response Following Direct and Inverse Hypergeometric Distribution	427
<i>K. Dihidar</i>	
1 Introduction	427
2 Generating RR by Hypergeometric Distribution	429
3 Generating RR by Negative Hypergeometric Distribution	430
4 Comparative Efficiencies of Inverse Hypergeometric vs Direct Hypergeometric RR Generation for Different Sampling Schemes	432
4.1 SRSWR in n Draws	433
4.2 SRSWOR in n Draws	433
4.3 PPSWR in n Draws	434
4.4 Rao, Hartley, and Cochran's Sampling of Size n	434
4.5 Midzuno's (1952) Sampling of n Persons	435
4.6 Comparison of the Efficiencies	436
5 Numerical Illustration Showing Relative Performances by Simulation	437
6 Concluding Remarks	440
Acknowledgment	440
References	440
27. Incredibly Efficient Use of a Negative Hypergeometric Distribution in Randomized Response Techniques	443
<i>M.L. Johnson, S.A. Sedory, and S. Singh</i>	
1 Introduction	443
2 Singh and Sedory Randomization Device	447
3 Proposed Incredibly Efficient Randomization Device	452
4 Efficiency Comparison	457
5 Limiting Case with Four Decks of Cards	459
6 Relative Efficiency of the Limiting Case	463
Acknowledgments	466
Appendix	466
References	469

28. Comparison of Different Imputing Methods for Scrambled Responses	471
<i>C. Mohamed, S.A. Sedory, and S. Singh</i>	
1 Introduction	471
2 Ratio Method of Imputing Scrambled Responses	474
3 Regression Method of Imputing Scrambled Responses	475
4 Imputing Scrambled Responses Using Higher Order Moments of An Auxiliary Variable	476
5 Some Useful Results	477
6 Properties of Different Estimators	478
7 Application to a Real Data Set	482
Acknowledgments	493
References	493
29. On an Indirect Response Model	497
<i>V.R. Padmawar</i>	
1 Preliminaries	497
2 Introducing the Model	499
2.1 Method of Moments	500
2.2 Maximum Likelihood or Pseudolikelihood Method	504
2.3 Bayesian Framework	509
Acknowledgments	512
References	513
Index	515