THE EFFECTS OF DATA COLLECTION METHODS

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ABSTRACT

At a seven-state level, four methods of data collection yield significantly different estimates of the number of hogs. This significance is due to a multivariate test on operators reporting a positive number of hogs. Data collection methods also have a significant interaction with the states and cause a difference in response rates which is almost significant.

Key words: Data collection techniques, analysis of variance, treatment groups, multiple comparison tests.

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* research community outside the U.S. Department of Agriculture.*
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* *

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SUMMARY

This research project tests the effects of four possible methods of collecting hog data for list frame surveys: 1) the operational method, 2) a mail-personal delivery method, 3) a telephone-personal interview method, and 4) a method using only personal interviews. An analysis of these four methods uses hog data from the list frame surveys in seven states. The three major results of the analysis are:

1. On a seven state level, the personal interview method (method 4) yields a lower nonresponse rate than any of the other methods. This difference in nonresponse rates is almost significant.

2. Although the data collection methods have no significant impact on hog estimates for univariate tests at a seven state level, a multivariate test on only those respondents who had a positive number of hogs is significant. This significance is due mainly to the differences in the personal interview method and the mail-personal delivery method. The telephone-personal interview method and the operational method do not differ significantly from the personal interview method even if a multivariate test is used.

3. A highly significant interaction exists among the states and the data collection methods. Consequently, individual states may have some local conditions that cause these methods to yield significantly different estimates for even the univariate tests. Differences fluctuate from state to state so that over all seven states these differences tend to balance out and result in no significance for univariate tests on the hog estimates.

THE EFFECTS OF DATA COLLECTION METHODS

Background

ESCS currently uses three interviewing techniques -- mail, telephone, and personal interviews -- to collect data for list surveys of hogs and cattle. The agency has always assumed that the three techniques have no impact on hog or cattle estimates but has never rigorously tested this assumption. Many surveys indicate that personal interviews may yield a lower nonresponse rate than mail or telephone interviews, but ESCS has not statistically tested this hypothesis either.

To test the validity of the assumption that data collection methods have no influence on hog estimates, seven states cooperated with the Statistical Research Division on a project that involved the September, 1978 Multiple Frame Hog Survey. The states were: Illinois, Indiana, Iowa, Minnesota, Missouri, North Carolina, and Wisconsin. The entire project had several other phases which are discussed in separate reports.

This phase of the project was general and exploratory in nature. Thus, during the design of the project; the Livestock, Dairy, and Poultry Branch recommended a sample size to detect 10 percent differences in estimates. Stated exactly, the sample size was large enough that differences of 10 percent or greater in the estimates of total hogs would be statistically significant when estimates from the seven states were combined. If differences were detected, then ESCS might develop future research projects of a more specific and sensitive nature.

Five variables were selected for analysis: These were:

1. total hogs,
2. number of sows farrowed during the previous three months,
3. number of sows expected to farrow during the next three months,
4. number of sows expected to farrow during the next four to six months, and
5. response code.

Description of Data Collection Methods Analyzed in this Study

The seven states systematically divided the list sample into four treatment groups: 1) a group receiving the current ESCS procedure of a sequence of mail, telephone, personal interviews (called the "normal" group during the rest of this report); 2) a group receiving a mail-personal delivery sequence; 3) a group receiving a telephone-personal interview sequence; and 4) a group receiving only personal interviews. Strictly speaking, the analysis of this report is <u>not</u> a comparison of interviewing techniques but a comparison of four data collection strategies -- each non-operational strategy being dominated by a specific interviewing technique. ESCS could apply any of these strategies to an entire sample. For example, although the third group is dominated by telephone interviews, a personal interview follow-up is necessary for that part of the group which can not be contacted by telephone. Thus, any of the four strategies is a procedure that could <u>possibly</u> be implemented into the operational program.

Data for the normal group were gathered in the same manner as the current operational procedure. In most states, this meant that a questionnaire was mailed to each operator sampled. Those operators who failed to respond within a few days were telephoned. Whenever contact could not be made using the telephone, the questionnaires were sent to field enumerators who attempted to complete the reports by using any possible type of interview. Usually this meant a personal interview although sometimes operators were again telephoned.

The mail-personal delivery group employed a procedure that was the most different from the operational procedure. Operators received a questionnaire in the mail, and if they failed to return it within the specified period of time, a field enumerator took them a copy of the questionnaire and asked the operator to fill it out by himself (i.e. without any assistance from the enumerator). The purpose of this procedure was to obtain data for the situation in which farmers read and interpret questionnaires without enumerator assistance as is the case in mail surveys. Although ESCS could implement the mail-personal delivery strategy as an operational procedure, that possibility was not the reason for making it one of the test procedures. The reason was to provide a control method which minimizes the effect of interviewers. Also, this method should measure any effects which might occur from substantial increases in the mail response rate.

Data for most of the operators in the telephone-personal interview group were gathered by means of telephone interviews with calling conducted from the state office headquarters. Telephoning is the primary method to follow up mail nonresponse in the operational program. Questionnaires for operators that were not contacted after repeated attempts or for which no phone numbers were found were sent to field enumerators who tried to contact the operators in person.

Historically, the personal interview method has been a principal method of data collection for ESCS, and currently it is the method used for most area frame surveys. During this study operators in the personal interview group were interviewed without any previous mailing or announcement of the survey. The only use of the telephone was to set up appointments.

Data Used to Analyze Data Collection Methods

For this project ESCS did not use those strata designated as "zero hogs", "zero livestock", or "unknowns". Also omitted were some of the strata composed of extreme operators. Those strata which were analyzed during this project are in Table 1.

Table 1: States and Strata Analyzed in the Research Project

State	Strata Analyzed
Illinois	83, 84, 85, 86, 93
Indiana	84, 85, 86, 87, 93
Iowa	82, 83, 84, 85, 86
Minnesota	84, 85, 86, 87, 88
Missouri	82, 83, 84, 85, 86
North Carolina	82, 83, 84, 85, 93
Wisconsin	85, 86, 87, 93, 94

Characteristics and Problems of Data Used for Analysis

In all states except Wisconsin, the operators contacted during the project had also been contacted during the three previous quarters of the hog survey. These operators were familiar with the normal method. Therefore, they expected a telephone call or a personal interview when they did not respond to the mail questionnaires. Wisconsin used a new sample so operators were contacted for the first time.

This situation explains some of the problems associated with the mail-personal delivery method, the method that proved to be the least popular with farmers. Several operators preferred to be interviewed. Many asked the enumerators delivering the questionnaires why they had not been telephoned or were not being interviewed as in previous quarters. About one hundred operators simply refused to fill out the form themselves but would supply the information if they were interviewed. In these instances, enumerators conducted an interview rather than obtain no information at all. (This situation occurred most commonly when the farmers were busy in the barn or the field when the enumerator arrived.) Although these problems were due primarily to a change in prior procedures, Wisconsin also reported similar problems which indicated that the personal delivery technique itself was unpopular.

Thirteen of the operators contacted in the mail-personal delivery group could not read. This fact only emphasizes that local conditions need to be considered when planning any type of survey -- especially a mail survey in which these types of problems may never be detected.

Despite these problems the mail-personal delivery method does present a contrast to the other methods in the percentages obtained by different types of interview. Table 2 gives the percentages of each method by type of interview.

TABLE 2

Type of Interview by Data Collection Method

All Seven States

Method \ Type of Interview	Completed by Mail	Completed by Telephone	Completed by an Enumerator Contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	25.3	60.3	14.4
Mail-Personal Delivery	34.3	1.6	64.1
Telephone-Personal Interview	0	90.2	9.8
Personal Interview	0.1	2.7	97.2

Nonresponse is a term used to combine two different situations. In one case, the selected unit refuses to supply the information requested and is classified a "refusal". In the other, the interviewer can not locate anyone who can supply the requested information, and the sample unit is classified as "inaccessible". Table 3 shows the type of response for each method.

TABLE 3

Response Rates by Data Collection Method

All Seven States

Method \ Response	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	87.2	10.0	2.8
Mail-Personal Delivery	86.5	10.6	2.9
Telephone-Personal Interview	88.2	10.0	1.8
Personal Interview	91.1	6.2	2.7

The results indicate the refusal rate for the personal interview method is much lower than for any of the other data collection methods. The impact of this result is discussed in the next section, "Results at a Seven State Level".

Another interesting cell in Table 3 indicates the inaccessible rate of the telephone-personal interview is lower than for any of the other methods. Although there is no way to establish the reason, sample fluctuation is one possibility. Another possibility is that telephoning for the telephone-personal interview group began earlier than it did for the nonresponse follow-up on the operational group. This possibility would give the telephone enumerators more opportunities to attempt calls to the operators and would allow the field enumerators a longer period for nonresponse follow-up. The advantage that telephone interviewing has over personal interviewing is the ability to attempt calls to an operator several times a day and over several days. Travel costs make these repeated attempts impractical for personal interviews.

Results at a Seven State Level

Mean values for four hog variables as well as the nonresponse rate for each of the four data collection methods are in Table 4. The columns labelled "All Data" represent the mean values of all respondents. The columns labelled "Positive Data" represent the mean values of those respondents who reported one or more hogs. The justification for examining positive reports and omitting zero reports is that a response of "I don't have any hogs" provides little opportunity for a data collection method to have an impact on the reported data.

TABLE 4

Mean Number of Hogs and Nonresponse Rates for Four Methods of Data Collection

Seven States

Data Collection Method	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	122.6	6.8	8.0	6.4	0.13	304.3	16.9	19.5	16.5
Mail--Personal Delivery	119.4	6.9	8.0	6.6	0.14	286.1	16.8	19.3	17.5
Telephone--Personal Interview	123.2	6.9	8.5	5.8	0.12	299.1	16.9	20.2	15.1
Personal Interview	126.4	7.0	7.5	6.3	0.09	312.5	16.8	17.8	15.7
All Methods	122.9	6.9	8.0	6.3	0.12	290.9	16.8	19.2	16.2

Three major findings resulted from this study:

1. On a seven state level the personal interview method yields a lower nonresponse rate than the three other methods of data collection. This difference in nonresponse rates is almost significant.

2. Although the data collection methods have no significant impact on hog estimates for univariate tests at a seven state level, a multivariate test on only those respondents who had a positive number of hogs was highly significant. This significance was due to differences in the personal interview method and the mail-personal delivery method. The operational method and the telephone-personal interview method are not significantly different from the personal interview method.

3. A significant interaction exists among the states and the various data collection methods (at both a univariate and multivariate level). Consequently, local conditions in individual states may cause the data collection methods to yield significantly different hog estimates within that particular state. Differences fluctuate from state to state so that over all seven states these differences tend to balance out and result in no significance for univariate tests on the hog estimates.

One of the major results of the study is that on the seven state level the only univariate test which showed a difference among the methods was the test on nonresponse rates. (The significance levels of all univariate tests are in Table 5.) The personal interview method had a lower nonresponse rate than the other three methods of data collection. Differences between the methods were nearly significant, but the significance level of the data was low enough (.11) to make this finding important. (See Appendix A for details of Duncan's procedure which was the multiple comparison procedure used in the analysis.)

Experience indicates it is easier for many farmers simply to ignore questionnaires that they receive in the mail or hang up on telephone enumerators than to refuse a field enumerator standing in front of them.

On the seven state level, the other variables were unaffected by the method of data collection when univariate tests were run. For some variables the sample size was not large enough to determine some rather large differences as significant. For example, differences of twelve and thirteen percent for the farrowing variables were not significant because these items have larger variances than the "total hogs" variable upon which the sample size was based.

Although no univariate tests were significant, a multivariate test on the positive data showed that the effects of the methods across all variables was significant. Indeed, the significance level was much less than 1 percent (see Table 6) for estimates at a seven state level. The reason for this significance can be seen in Table 4. The personal interview method tended to have the opposite effect of the mail-personal delivery method on the means of total hogs, expected first quarter farrowings, and expected second quarter

TABLE 5

Significance Levels of the Data when Testing the Hypothesis that Four Methods of Data Collection Yield Equal Estimates [(mail-telephone personal interview) vs. (mail-personal delivery) vs. (telephone-personal interview) vs. (personal interview)]

State	All Data					Positive Data			
	Total Hogs	Previous Farrowings	Expected Farrowings First Quarter	Expected Farrowings Second Quarter	Nonresponse Rate	Total Hogs	Previous Farrowings	Expected Farrowings First Quarter	Expected Farrowings Second Quarter
	α value	α value	α value	α value	α value	α value	α value	α value	α value
Illinois	0.69	0.92	0.59	0.49	0.54	0.79	0.79	0.81	0.76
Indiana	0.30	0.27	0.02*	0.15	0.31	0.37	0.70	0.62	0.23
Iowa	0.37	0.85	0.24	0.49	0.27	0.02*	0.74	0.24	0.41
Minnesota	0.68	0.37	0.13	0.99	0.21	0.96	0.58	0.16	0.54
Missouri	0.96	0.62	0.72	0.77	0.48	0.59	0.28	0.57	0.38
North Carolina	0.95	0.57	0.80	0.93	0.99	0.82	0.75	0.24	0.15
Wisconsin	0.16	0.29	0.50	0.20	0.05*	0.13	0.49	0.26	0.16
7 States Combined	0.78	0.98	0.31	0.53	0.11	0.21	0.96	0.21	0.16

*Significant differences between the four interviewing methods is indicated by an α value $\leq$ .10.

farrowings (the means of previous farrowings were almost equal). While the personal interview method gave the highest estimate of total hogs and low estimates of expected farrowings, the mail-personal delivery method gave the lowest estimate of total hogs and high estimates of expected farrowings. The advantage of a multivariate test over a set of univariate tests is the ability to take into account this relationship across all variables.

The difference in these two procedures might be attributable to the fact that the mail-personal delivery method tended to minimize the effect of the enumerator while the personal interview method tends to maximize the effect of the enumerator. Is this enumerator effect good or bad? The enumerator effect is good if the enumerator explains terms and questions to the respondent so that the questionnaire is completed accurately. The amount of editing required on mail questionnaires has indicated that the respondents do have difficulty in completing the questionnaire without enumerator assistance. The enumerator effect is bad if the enumerator's presence, attitude, appearance, etc. cause respondents to bias their answers. Because testing of enumerator effects for personal interviews is usually difficult and/or expensive, there are no ESCS studies of this effect. (A report on another phase of this project gives some results about the effects of telephone enumerators.)

A significant interaction exists between the states and the data collection methods at both a univariate and multivariate level. For example, when a multivariate test was run, the significance level of the data was .005 for all data and .001 for positive data. A significant interaction indicates that the relationships of the methods are contradictory from state to state. For example, in Indiana the hog estimates (positive data) have almost the opposite relationships of those in Iowa. Therefore, the conclusion is that the method of data collection is important in conjunction with the conditions that exist in the state where each method is applied. Office procedures, local conditions that affect respondents' attitudes, and individual enumerators are examples of conditions that might contribute to the state effect. Because of this interaction, it would be incorrect to study the differences among the data collection methods in one state and infer that similar differences exist in all states.

Results at a State Level

At the state level, the univariate tests showed the method of data collection did have a significant impact on the nonresponse rate in Wisconsin, one "positive data" variable in Iowa, and one "all data" variable in Indiana. State estimates for each method of data collection are in Appendix B.

The nonresponse rates in Wisconsin were 4 percent for the personal interview and telephone-personal interview methods and 10 percent for the normal and mail-personal delivery methods. The significance of the nonresponse rates in Wisconsin is important because Wisconsin is the only state where operators in the sample were not previously contacted. This fact implies (but does not prove) that the previous survey experience of operators in the other six states tended to nullify the effects of the data collection methods on nonresponse rates. Thus, the effect on nonresponse rates in seven states with new samples may be greater than the effect on the seven states used in this study.

TABLE 6

Results of Wilk's Multivariate Test for Differences
In Four Methods of Data Collection

State	Multivariate Test (Wilk's Statistics)	
	All Data	Positive Data
	α value	α value
Illinois	0.79	0.41
Indiana	0.10*	0.55
Iowa	0.11	0.01*
Minnesota	0.12	0.13
Missouri	0.94	0.47
North Carolina	0.85	0.03*
Wisconsin	0.76	0.61
7 States Combined	0.21	0.0007*

This test is only on four hog variables and does not include the response rate.

*Significant difference between the four methods are indicated by a value $\leq$ .10.

In Iowa the mean number of total hogs (positive data) was significantly affected by data collection methods. The estimate from the mail-personal delivery method was much lower than the other three -- 299 vs. 372, 383, and 384. (See Appendix Table A3.)

In Indiana the expected farrowings during the first quarter (all data) were significantly affected by the data collection methods. The personal interview method had a significantly higher mean than did the other three groups -- 8.4 vs 5.1, 5.2, and 5.5 (See Appendix Table A2.) However, when one examines only the positive data, differences are no longer significant.

Wilk's multivariate test (See Appendix A for details) considers the level of all hog variables simultaneously. Table 6 shows the results of this test -- significant differences exist among the data collection method in North Carolina, in Iowa (positive data), and in Indiana (all data). The nonresponse rate was not included in the Wilk's test statistic so this variable did not influence the multivariate test.

In North Carolina, although no univariate test showed significant differences among the methods, the multivariate test showed significant differences for positive data. This significance is probably due to the consistently high estimates given by the mail-personal delivery method fo all four variables. In Iowa the significance of the multivariate test is due primarily to the low estimate of total hogs from the mail-personal delivery method. In Indiana the significance is due to the high estimate of expected farrowings (first quarter) from the personal interview group -- an effect that disappeared for positive data.

Results When Outliers Are Omitted

A very large report (outlier) in a group may by itself have a large effect on the mean of the group. There are two ways to view the impact of these large reports. One could say that an operation which expands to a large number of hogs will cause any method to which it is assigned to be significantly different from the other methods. On the other hand, the specific method may have caused the operator to report the large number of hogs.

Because of the liklihood of the first viewpoint, outliers in the data were identified and their effect on the results analyzed. This analysis does not invalidate the results of the previous analysis but simply presents an alternative way of examining the data.

Estimates with the outliers removed (positive data) are in Table 7. The analysis with outliers removed did not differ much from the analysis that included the outliers. Differences among the methods for positive data are still not significant at the seven state level for any of the four hog variables. Also, the multivariate test on the positive data was still significant. At the state level only total hogs in Iowa showed significant differences among the methods. The test on this variable was the only one that was significant before the outliers were removed. Consequently, the differences are not attributable to a few extreme values.

TABLE 7

Significance Level of the Hypothesis that the Four Data Collection Methods Yield Equal Estimates

(Outlying Data Points Removed)

State	Positive Data			
	Total Hogs	Previous Farrowings	Expected Farrowings First Quarter	Expected Farrowings Second Quarter
	α value	α value	α value	α value
Illinois	.98	.85	.87	.35
Indiana	.48	.62	.89	.31
Iowa	.03*	.78	.21	.47
Minnesota	.81	.77	.24	.72
Missouri	.53	.42	.59	.50
North Carolina	.71	.71	.19	.18
Wisconsin	.12	.52	.35	.17
7 States Combined	.21	.94	.16	.14

*Significant differences between methods are indicated by an α value $\leq$ .10.

Conclusions

The final question is "What does this flood of statistical results really mean?" The amount and complexity of the analysis in this study tend to hide overall conclusions in a maze of facts, hypotheses, and significance levels. Although different interpretations are possible, the authors feel that three major points emerge in the comparisons of the four data collection procedures:

1: The personal interview method appears as the best method because it achieves a much lower nonresponse rate and it does not yield hog estimates which are significantly different from the operational procedure. The lower nonresponse rate is important because nonresponse can affect all hog estimates and, thus, all the other hypothesis tests performed in this study. Hog estimates which are not statistically different from the operational procedure are important because they assure the continuity of statistical series already estimated under the operational program. Although the testing of the hog estimates was designed to detect only 10 percent differences in hog estimates, the closeness of the estimates from the operational and personal interview methods withstood a group of tests that included both univariate and multivariate analysis, analysis of positive data, and analysis that accounts for outlier effects. The primary argument against implementing the personal interview method is, of course, its high cost in comparison to the operational method.

2: The telephone-personal interview method is a reasonable alternative to the operational method since no differences in the effects of these two methods were found. Before this study Estimates and Survey Divisions considered substituting the telephone-personal interview method for the operational method. Their consideration arose because the cost benefits of the initial mailing required by the operational method were declining. Thus, substitution of the telephone-personal interview method could decrease survey costs. By finding no significant differences in the telephone-personal interview method and the operational method, the analysis of this study supports that substitution.

3: The differences in the mail-personal delivery and the personal interview method probably deserve further investigation. Despite the fact that neither of these two methods are currently used for list surveys of livestock, mail and personal interviews are part of the normal procedure and the operational procedures of other surveys.

Besides comparing the data collection methods, this study also illustrates the need for several states in most research projects. Not only may one state yield estimates with too much variability to yield accurate results, but also one state may have local conditions which cause results contradictory to the results from other states. In this study the highly significant interaction between states and data collection methods gives firm evidence of contradictory results in different states.

All the results and conclusions in this study are made with the knowledge that the sample size was not large enough to detect any significant differences less than 10 percent. Of course, differences less than 10 percent may be important, but using more than seven states for a research project puts an obvious strain on any operational survey which is concurrent with the research project. Although ESCS must recognize this strain, ESCS must also recognize that the accuracy of future research projects may often require seven or more states.

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Appendix A

The following tables (A1-A7) provide the sample means for total hogs, previous farrowings, expected first quarter farrowings, expected second quarter farrowings, and the nonresponse rate in each state. All five variables are given for all data, and the first four variables are given for the operators with a positive number of hogs.

TABLE A1

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

Illinois

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	169.3	9.6	12.7	7.8	0.18	541.9	[illegible]	37.3	28.1
Mail--Personal Delivery	185.9	10.3	13.0	9.5	0.20	554.4	3.6	41.2	35.7
Telephone--Personal Interview	182.9	9.8	12.7	9.0	0.15	558.0	[illegible]	36.4	29.3
Personal Interview	192.3	10.4	10.6	9.6	0.16	[illegible]	[illegible]	36.4	31.2
All Methods	182.6	10.0	12.2	9.0	0.17	567.0	2.0	37.9	31.1

TABLE A2

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

Indiana

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	95.6	5.6	5.2	6.0	0.08	270.8	15.0	14.7	15.7
Mail--Personal Delivery	117.1	6.2	5.5	6.0	0.18	286.2	13.5	13.1	13.5
Telephone--Personal Interview	85.3	4.9	5.1	4.1	0.09	279.8	16.3	15.5	14.6
Personal Interview	111.7	7.0	8.4	7.0	0.08	264.9	14.4	16.2	13.6
All Methods	102.4	5.9	6.0	5.8	0.11	275.5	14.8	14.8	14.4

TABLE A3

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

Iowa

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	208.7	10.3	12.5	10.0	0.28	382.6	19.1	22.9	19.1
Mail--Personal Delivery	173.0	9.3	12.7	10.2	0.22	298.8	16.9	22.8	19.2
Telephone--Personal Interview	200.7	10.5	14.0	8.2	0.25	372.2	19.9	26.0	16.0
Personal Interview	201.9	10.7	10.8	8.4	0.17	384.[illegible]	19.5	20.0	16.5
All Methods	196.1	10.2	12.5	9.2	0.23	359.5	18.9	22.9	17.7

TABLE A4

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

Minnesota

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	89.3	5.5	6.4	5.5	0.11	171.4	10.0	12.2	10.5
Mail--Personal Delivery	98.4	7.1	6.0	5.4	0.14	180.0	11.4	9.9	9.2
Telephone--Personal Interview	99.1	6.3	6.2	5.0	0.12	173.8	10.7	10.2	9.8
Personal Interview	88.3	5.1	4.1	5.7	0.06	177.7	9.6	8.6	11.6
All Methods	93.8	6.0	5.7	5.4	0.12	175.8	10.5	10.2	10.2

TABLE A5

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

Missouri

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	78.6	4.9	6.0	4.0	0.07	172.1	10.5	12.1	9.3
Mail--Personal Delivery	83.3	5.1	5.7	3.9	0.09	180.8	11.2	11.2	9.2
Telephone--Personal Interview	85.8	5.1	6.8	4.5	0.10	163.4	9.1	13.0	7.7
Personal Interview	82.1	4.2	6.2	3.8	0.07	166.6	8.8	11.6	8.0
All Methods	82.4	4.8	6.2	4.1	0.09	170.7	9.9	12.0	8.6

TABLE A6

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

North Carolina

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	40.6	2.6	3.0	3.0	0.03	259.4	15.1	17.2	15.2
Mail--Personal Delivery	43.5	2.8	3.1	3.0	0.03	259.7	16.5	17.9	19.0
Telephone--Personal Interview	43.9	2.9	3.0	2.8	0.03	243.2	16.0	17.1	14.9
Personal Interview	44.4	2.4	2.6	2.5	0.03	261.7	14.1	14.1	14.7
All Methods	42.3	2.8	2.9	2.8	0.03	256.0	15.4	16.5	16.0

TABLE A7

Mean Number of Hogs and Response Rates For Four Methods of Data Collection

Wisconsin

Data Collection Methods	All Data					Positive Data			
	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)	Nonresponse Rate (Mean)	Total Hogs (Mean)	Previous Farrowings (Mean)	Expected Farrowings First Quarter (Mean)	Expected Farrowings Second Quarter (Mean)
Operational (Mail-Telephone-Interview)	85.8	5.6	5.8	5.3	0.10	277.4	17.2	18.3	18.1
Mail--Personal Delivery	79.4	5.6	5.6	5.2	0.10	256.7	15.6	16.5	16.5
Telephone--Personal Interview	78.7	5.2	5.8	4.6	0.04	249.0	15.6	17.8	15.[illegible]
Personal Interview	92.7	6.4	6.7	5.9	0.04	271.9	16.[illegible]	17.8	17.1
All Methods	84.2	5.7	6.0	5.3	0.08	263.7	16.3	17.6	16.7

Appendix B

The following tables show two tables for each state: 1) the type of interview used to obtain data for four data collection methods and, 2) the response rates -- the proportion of completed reports, refusals and inaccessibles -- for four data collection methods.

TABLE B1a

Type of Interview by Data Collection Data

Illinois

Type of Interview / Method	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	23.0	65.0	12.0
Mail-Personal Delivery	36.9	1.9	61.2
Telephone-Personal Interview	0	89.0	11.0
Personal Interview	0	1.3	98.7

TABLE B1b

Response Rates by Data Collection Method

Illinois

Response / Method	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	82.3	16.7	1.0
Mail-Personal Delivery	81.2	16.0	2.8
Telephone-Personal Interview	85.4	12.0	2.6
Personal Interview	84.5	12.5	3.0

TABLE B2a

Type of Interview by Data Collection Method

Indiana

Method \ Type of Interview	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	16.4	73.5	10.1
Mail-Personal Delivery	70.7	2.3	27.0
Telephone-Personal Interview	0	95.7	4.3
Personal Interview	0	0.2	99.8

TABLE B2b

Response Rates by Data Collection Method

Indiana

Method \ Response	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	92.5	4.7	2.8
Mail-Personal Delivery	82.0	6.6	11.4
Telephone-Personal Interview	90.8	5.0	4.2
Personal Interview	92.2	3.4	4.4

TABLE B3a

Type of Interview by Data Collection Method

Iowa

Type of Interview / Method	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	24.5	44.6	30.9
Mail-Personal Delivery	26.8	2.6	70.6
Telephone-Personal Interview	0	90.9	9.1
Personal Interview	0.8	3.9	95.3

TABLE B3b

Response Rates by Data Collection Method

Iowa

Response / Method	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	72.5	23.1	4.4
Mail-Personal Delivery	77.7	18.8	3.5
Telephone-Personal Interview	75.4	23.5	1.1
Personal Interview	83.3	13.3	3.4

TABLE B4a

Type of Interview by Data Collection Method

Minnesota

Type of Interview / Method	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	17.7	76.8	5.5
Mail-Personal Delivery	30.6	1.4	68.0
Telephone-Personal Interview	0	82.3	17.7
Personal Interview	0	7.1	92.9

TABLE B4b

Response Rates by Data Collection Method

Minnesota

Response / Method	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	89.2	7.6	3.2
Mail-Personal Delivery	86.4	13.1	0.5
Telephone-Personal Interivew	87.7	10.9	1.4
Personal Interview	94.5	5.5	0

TABLE B5a

Type of Interview by Data Collection Method

Missouri

Method \ Type of Interview	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	42.1	44.7	13.2
Mail-Personal Delivery	43.2	1.5	55.3
Telephone-Personal Interview	0	86.1	13.9
Personal Interview	0	3.1	96.9

TABLE B5b

Response Rates by Data Collection Method

Missouri

Method \ Response	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	93.3	4.4	2.3
Mail-Personal Delivery	90.6	7.2	2.2
Telephone-Personal Interview	89.8	6.7	3.5
Personal Interview	92.8	1.9	5.3

TABLE B6a

Type of Interview by Data Collection Method

North Carolina

Method \ Type of Interview	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	21.2	59.0	19.8
Mail-Personal Delivery	27.4	1.8	70.8
Telephone-Personal Interview	0	89.9	10.1
Personal Interview	0	0.5	99.5

TABLE B6b

Response Rates by Data Collection Method

North Carolina

Method \ Response	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	96.6	2.5	0.9
Mail-Personal Delivery	97.3	1.4	1.3
Telephone-Personal Interview	97.4	2.6	0.0
Personal Interview	97.0	0.5	2.5

TABLE B7a

Type of Interview by Data Collection Method

Wisconsin

Method \ Type of Interview	Completed by Mail	Completed by Telephone	Completed by an Enumerator contact (Personal Interview or Personal Delivery)
	%	%	%
Normal	29.3	68.9	1.8
Mail-Personal Delivery	22.0	0	78.0
Telephone-Personal Interview	0	98.1	1.9
Personal Interview	0	1.5	98.5

TABLE B7b

Response Rates by Data Collection Method

Wisconsin

Method \ Response	Completed Reports	Refusals	Inaccessibles
	%	%	%
Normal	89.9	5.7	4.4
Mail-Personal Delivery	90.4	8.9	0.7
Telephone-Personal Interview	96.2	3.1	0.7
Personal Interview	95.9	4.1	0

Appendix C

Data Analysis Techniques

1. Weighting the data:

Weights were assigned to each variable to reflect the relative expansion factors. Weights indicate relative importance of each stratum in each state across all seven states.

2. Replication:

The data were ordered by state, data collection method, stratum, crop reporting district, county and reporter. This ordering was systematically divided into ten replicates for analysis purposes. Mean values for each treatment were calculated within each replicate, and combined in the following manner:

$\bar{x}_{sr}$ = sample estimate of the weighted mean in the rth replicate, $r = 1, 2, \ldots, 10$, in the sth state, state = 1, 2, ... 7

$\bar{x}_s$ = sample estimate of the weighted mean in state s

$$\bar{x}_s = \frac{\sum_{r=1}^{10} \bar{x}_{sr}}{10}$$

$\bar{x}_r$ = sample estimate of the weighted mean of the rth replicate over all states

$$\bar{x}_r = \frac{\sum_{s=1}^{7} \bar{x}_{sr}}{7}$$

$\bar{x}$ = sample estimate of the weighted mean over all states and strata

$$\bar{x} = \frac{\sum_{s=1}^{7} \bar{x}_s}{7} = \frac{\sum_{r=1}^{10} \bar{x}_r}{10}$$

The unbiased estimate of the standard error for each state estimate is:

$$SE(\bar{x}_s) = \left[\frac{\sum_{r=1}^{10} (\bar{x}_{sr} - \bar{x}_s)^2}{9(10)}\right]^{\frac{1}{2}}$$

An unbiased estimate of the standard error for an estimate of a seven state total is:

$$SE(\bar{x}) = \left[\frac{\sum_{r=1}^{10} (\bar{x}_r - \bar{x})^2}{9(10)} \right]^{\frac{1}{2}} .$$

Besides simplifying the calculation of standard errors, the use of replicate values in the statistical analysis:

1: assured equal cell sizes in the analysis of variance
2: yielded distributions which are fairly normal.

These benefits of replication make the analytical exploration of data from a complex survey design much more straightforward and accurate.

Univariate and multivariate tests were conducted using the SAS computer package. The processes involved in this analysis are outlined below, although more details are available in the SAS 76 User's Guide.[1]

A general linear model was constructed to fit the values from the replications: $\hat{\underline{Y}} = \underline{X}\ \underline{B} + \underline{E}$, where E is the residual error matrix, $\hat{\underline{Y}}$ is the vector of estimated means for four (quantitative) hog variables, $\underline{X}$ is the data matrix, and $\underline{B}$ is the vector of model parameters. The model parameters consist of three effects: the state, the treatment, and the state-treatment interaction. The treatment effect refers to the method of data collection discussed in the background section of this paper.

The MANOVA option of the GLM procedure in SAS was used to test the hypotheses that 1) there is no difference in the data among treatments and 2) there is no state-treatment interaction. Both univariate and multivariate tests were run on the four hog variables, and an univariate test was run on the response rate.

Duncan's new multiple range comparison test was used on those variables for which the various treatments proved to be significantly different. The test was used to determine which, if any, of the individual treatments yielded values that were significantly different from the other treatment means.

Details of the process may be found in Principles and Procedures of Statistics by Robert Steel and James Torrie[2] and the SAS 76 Guide.

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[1] A User's Guide to SAS 76, by Anthony L. Barr, James H. Goodnight, John P. Sall, and Jane T. Helwig, SAS Institute, Raleigh, North Carolina (1976)

[2] Principles and Procedures of Statistics, by Robert Steel and James Torrie, McGraw Hill Book Publishing Co., Inc., New York, 1960.

Basically, the procedure ranks the means of the various treatments in increasing order. A difference is declared significant if its absolute value exceeds the appropriate test value, where the test value is determined by:

$$T \cdot S \sqrt{\frac{1}{2}\left(\frac{1}{t_i} + \frac{1}{t_j}\right)}, \quad i \neq j$$

where t_i = the number of observations in the ith treatment group,

$$S = \sqrt{\frac{\text{The mean square error}}{\text{Number of observations per treatments}}}, \text{ and}$$

T = the value from the appropriate Duncan's test table.

Wilk's Λ criterion, which was used for the multivariate tests, is essentially a multivariate extension of the F test used in univariate analysis of variance. Full details on Wilk's Λ criterion are in Timm's book.

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[1] Multivariate Analysis with Applications in Educational Psychology, by Neil H. Timm, Brooks/Cole Publishing Co., Monterey, California, 1975.