AN ASSESSMENT OF ALTERNATIVE DESIGNS FOR CONDUCTING PHYSICIAN SURVEILLANCE SURVEYS

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I. INTRODUCTION

Prevention has become an increasingly important component of good health care practice. Moreover, physicians play a key role in encouraging preventive health behavior in their patients. A Physician Surveillance System is being developed by the Centers for Disease Control (CDC) to monitor the role of prevention in primary care physician practices on a state-by-state basis. Eligible physicians were those non-military practitioners in a non-institutionalized setting who listed either of the following as their primary specialty: General Practice, Family Practice, Internal Medicine, or Obstetrics and/or Gynecology. To find a relatively inexpensive but statistically effective survey approach to conduct the surveillance surveys, the University of North Carolina at Chapel Hill, in collaboration with the CDC and the North Carolina Department of Environment, Health, and Natural Resources, conducted a design study in 1991 whose findings are presented in this paper.

Three designs involving mail and/or telephone strategies were compared, all involving an initial contact by mail. The first, an all-mail response design referred to as the MRC design, stands for first class Mail on the first contact, followed by a Reminder postcard, and then a final contact by Certified mail. The second, a mail or telephone response design called the MLT design, stands for first class Mail on the first contact with a second first class mailing Leading into a Telephone contact to transcribe questionnaire responses. The final design, a telephone response design known as TWM, stands for Telephone for transcription of questionnaire responses With first class Mail lead-in.

The comparison among the three survey methods was based on response rates, overall costs, and cost-efficiency models. Findings generally point to the MRC design as being the most cost-effective choice among the three designs we considered.

II. METHODS

Sampling

The physician sampling frame for the survey was obtained through Clark O'Neill, Inc. from the American Medical Association. Population totals by specialty for the 3983 eligible physicians were 367 for General Practice, 1340 for Family Practice, 1543 for Internal Medicine, and 733 for OB/GYN. The sampling design utilized disproportionate stratified selections by physician specialty and systematic sampling within each stratum. Neyman allocation, an optimum allocation method used to estimate the overall survey response rates, was used to determine stratum-specific sampling rates (Kish, 1965). The systematic sample in each stratum was taken from an alphabetized list of physicians and, therefore, was considered to be a simple random sample. After being supplied with the four sampling intervals for the strata, Clark O'Neill, Inc. selected the stratified sample of 1200 physicians. The Survey Research Unit then randomly subdivided the data set within strata into three samples of 400 physicians, to insure the equality of the three designs prior to survey implementation. Sample weights were computed for respondents in each design to account for variation in selection probabilities and additional sample imbalance due to differential nonresponse (Lessler and Kalsbeek, 1992).

General Survey Operations

The first mail contacts of the MLT, MRC and TWM designs began on October 4, 11, and 18, 1991, respectively. The starting dates were staggered to isolate the respective costs and to make the effort reflective of the implementation of a single design.

MRC Design

MRC, the all-mail response design, required that a completed questionnaire be returned by mail at each contact. Those physicians who did not return the questionnaire by the first contact due date were sent a reminder postcard. The same guidelines were used for the third contact in which a questionnaire was sent via certified mail. The higher priority mail, in which a signature was required upon delivery, was used to ensure delivery and to emphasize the importance of the study.

MLT Design

MLT, the mail or telephone response design, required a completed questionnaire be returned by mail only at the first contact. The second first class mail contact, a lead-in to the third, stated that the completed questionnaire should be retained and within several days someone from the Survey Research Unit would call to transcribe the information over the telephone.

TWM Design

TWM, the telephone response design, had the first and second contacts identical to the second and third contacts of the MLT design, in that the completed questionnaire information was obtained through telephone transcription.

Response Rates

The response rates in the North Carolina survey were computed as the number of eligible responding physicians over the estimated total number of eligible physicians in the sample. The following formula used, developed by the Council of American Survey Research Organization's (CASRO) Task Force on Completion Rates (CASRO, 1982), was used:

$$RR = E / [E + (B + U + R) * (E / (E + I + D))]$$

where,

E = completed questionnaires by eligible physicians
I = completed questionnaires by ineligible physicians
B = questionnaires returned because of bad address - eligibility unknown
U = questionnaires not returned - eligibility unknown
R = refusals - eligibility unknown
D = disqualifications - ineligible physicians

Cost and Time Documentation

The purpose of the cost and time documentation was to measure the operational cost of each design for the North Carolina survey by estimating the amount of materials used and the cost and time required for each task. Some examples of costs that were excluded from documentation were those for the purchase of computer equipment and word processing packages that were used, but not exclusively for this study. An attempt was made to estimate all other costs directly associated with the implementation of the three designs.

A standardization procedure had to be used to estimate the cost of each design, because experience gained by performing the same task within each design, such as printing mailing labels, caused the first design implemented (MLT) to take more time than the last (TWM). By standardize it is meant that the times for each task were broken down into time-per-unit of material and the largest per-unit amount was recorded for each design. The largest completion times were used to simulate times needed for inexperienced personnel to complete the specific tasks. In summary, the standardization procedure was initiated to eliminate the learning curve and produce cost factors which could be adequately compared.

Cost Models

Upon completion of the standardized cost worksheet, cost models consisting of fixed and variable costs components were developed for later cost-efficiency comparisons. Fixed costs included tasks and materials such as cover letter design and printer paper. Variable costs included those tasks and materials that were directly dependent on the number of physicians in the sample. The following are the cost models for the three designs:

MRC: $TC = F + S * ((M1 + R1 * C1) + P2 * (M2 + R2 * C2) + P3 * (M3 + R3 * C3))$

MLT: $TC = F + S * ((M1 + R1 * C1) + P2 * (M2) + P3 * (T3 + R3 * C3))$

TWM: $TC = F + S * ((M1) + P2 * (T2 + R2 * C2))$

where, # = 1, 2, 3

TC = Total cost for each design
F = Fixed cost
S = Sample size initially purchased
M# = Cost of mailout for contact #
R# = Percentage of "returns" in contact #
C# = Cost of "returns" in contact #
P# = % from initial sample in contact #
T# = Cost of telephone calls in contact #

"Returns" within each contact included completed questionnaires, refusals from physicians to participate in the study, and mail returned with messages of ineligibility, such as "retired" or "physician has moved outside of North Carolina". The percentage of returns (R2) for MLT and (R1) for TWM was not applicable.

Mean Square Error Models

The mean square error (variance + bias^2) was obtained using the estimated variance from a disproportionate stratified sample and an estimate of the nonresponse bias. The error terms were estimated using the results for those physicians answering "during almost every visit" to the question: "Which response best describes when you or a member of your staff ADVISE smoking patients to stop smoking?". This subject was chosen from the questionnaire because of the well-known health effects of smoking and because of the relatively high frequency of the response category. The adopted variance formula was $DEFF_0 * (1 - F) * S^2 / N$, where (1 - F) is the finite population correction factor, S^2 is the element variance, N is the number of completed questionnaires, and $DEFF_0$ is the overall design effect reflecting effects of variable sampling rates and stratification.

The nonresponse bias term was estimated for each design by using the formula (1 - RR) * (X(r) - X(n)), where RR was the CASRO response rate, X(r) was the estimated proportion from SUDAAN using PROC CROSSTAB (Shah, 1990), of all responding physicians answering "during almost every visit" to the smoking advisement question, and X(n) was the comparable proportion for all nonrespondents. The value of X(r) was estimated with raw weights (inverse of the probability of selection) instead of adjusted weights (inverse of the probability of selection multiplied by the inverse of the CASRO response rate) to produce a more direct estimate for the respondent subset of the population. The values of X(r) used in the bias term for MRC, MLT, and TWM were 0.63, 0.66, and 0.55, respectively.

Since the proportion for nonrespondents (X(n)) was unknown, an estimate was computed by solving for X(n) in the following formula: X(o) = RR*X(r) + (1 - RR)*X(n). Four values of X(o) were used: 0.60, 0.65, 0.70, and 0.75. Because the values of X(r) were approximately equal to or higher than the response rates for the designs, the nonresponding group was considered to have a higher proportion of physicians answering the smoking advisement question with "during almost every visit" than the responding group. Therefore, estimates for X(o) were chosen near and above the three values of X(r). With set values for the proportion of the population answering the smoking advisement question in the designated way, the element variance (S^2) was computed as X(o) * [1 - X(o)].

Cost-Efficiency

Cost-efficiency graphs can visually portray the optimal cost for each design at the lowest or at an acceptable error level, or they can allow one to compare mean square errors among designs for fixed cost (Groves, 1989). Cost and mean square error models from the North Carolina survey were combined to produce cost-efficiency graphs by calculating anticipated mean

square errors for the three designs at various values of the total design cost (TC). Cost-efficiency graphs gave a visually portrayed the optimal cost for each design at the lowest or at an acceptable error level and allowed the comparison of mean square errors among the designs (Groves, 1989). Cost amounts ranging from $2000 to $10000 were substituted into each cost model and a corresponding sample size was produced. The total number of returns (NR) was developed by multiplying the selected sample size times the sum of the probabilities of a return at each contact. The formulas are given as follows:

MRC: $NR = S * [R1 + (1 - R1) * R2 + (1 - R1) * (1 - R2) * R3]$

MLT: $NR = S * [R1 + (1 - R1) * R3]$

TWM: $NR = S * R2$

Since the returns included physicians whose eligibility status could not be verified because of their refusal to participate in the study, the total number of completed questionnaires (N) was estimated by multiplying NR by a ratio of the number of completed questionnaires over the total number of returns (Figure 1). The value N was substituted into the variance term of the mean square error models for each of the four values (Table 1) of the population proportion X(o). Three cost-efficiency graphs are given in Figures 2A - 2C for X(o) = 0.60, 0.65, and 0.70, respectively. The graph of X(o) = 0.75 was produced but did not reveal any significant information beyond Figure 2C and thus was not reproduced here.

III. FINDINGS

The number of completed questionnaires for the MRC (all-mail response design), MLT (mail or telephone response design), and TWM (telephone response design) methods were 229, 208, and 118, respectively. Upon analysis of the survey data it was discovered that 38 physicians, originally considered to be eligible, were categorized as ineligible (I in response rate equation) by their answers to two or more demographic questions in the questionnaire. Therefore, the number of questionnaires completed by eligible respondents (E) for the MRC, MLT, and TWM methods are 213, 194, and 110, respectively.

Response Rate Comparisons

The first basis for comparison among the three survey methods is the CASRO response rates calculated from the North Carolina survey. The overall response rates (Table 2) and standard error estimates (in parentheses) for MRC, MLT, and TWM designs are 65.5% (0.028), 66.0% (0.030), and 44.8% (0.032), respectively. The standard errors of the response rates are calculated as the square toot of the variance of a stratified simple random sample design (Kish, 1965). Two-sample t-tests, using the number of eligible physicians estimated in the CASRO equation as the design-specific sample size, gave an indication that a difference exists between the MRC and TWM response rates ($P < 2.0 \times 10^{-6}$) and between the MLT and TWM response rates ($P < 1.9 \times 10^{-6}$). The difference in response rates for the MRC and MLT designs was not statistically significant.

In relation to stratum-specific response rates (Table 3), General Practice physicians have the highest response rate for the TWM and MRC methods, while Family Practice physicians are the highest for the MLT design. The close connection of General and Family Practice with primary care as opposed to the specialized degrees of Internal Medicine and OB/GYN could explain the difference in the strata response rates for the primary care based questionnaire. Since the difference between the MLT (mail or telephone response design) and MRC (all-mail response design) overall response rates was small, the final decision of the most efficient design is based primarily on the cost analysis.

Cost Comparisons

The second basis for comparison is the overall cost. The standardized costs are approximately $6,242 for TWM, $5,788 for MLT, and $2,681 for MRC. It should be noted that the amounts of material recorded for the cost assessment are quantities actually used and do not include any excess that would normally be ordered or produced.

Major contributors to the total costs of the MLT and TWM designs are the telephone toll charges and interviewer salaries. In general, at least two telephone contacts with office personnel was required before a completed questionnaire could be obtained, thus adding to the interviewer time and the number of phone calls. This need for repeated contacts was mostly due to the miscommunication between the physician and his/her staff about the questionnaire. Also, several physicians (MLT = 38, TWM = 101) requested that a second questionnaire be sent to them, for reasons such as "threw questionnaire away" or "never received the mailing".

The relative low cost of the MRC design is attributed to: 1) use of clerical personnel for tasks such as stamping envelopes, as opposed to trained interviewers, 2) absence of telephone charges, and 3) less time needed for supervisors. A major contributor to the cost is the time (12.58 hours) taken to manually fill out the certified mail receipts. An alternative, suggested by a Chapel Hill postmaster to reduce the amount of time needed, was to use mailing labels instead of hand-printing the addresses on the receipts. However, this option should be closely examined since blank mailing labels can be expensive.

Cost-Efficiency Comparisons

Cost-efficiency is the final basis for comparison of the three designs. It is evident from the first graph in the cost-efficiency analysis (Figure 2A) that the MRC design has the lowest mean square error throughout the entire range of the total cost. This finding is attributed to MRC having the lowest variance (Table 1) and the lowest bias (Table 3). Considering that the design effect is greatest for TWM and smallest for MLT, the low variance associated with MRC over the range of values for X(o) is credited to the large numbers of completed questionnaires within this design.

The relative sizes of the mean square errors for MLT and TWM vary with the total cost values. For the total cost values below $6500, the error value for TWM is higher than the value for MLT. For range of approximately $6500 to $9500, the error

values appear to be identical. For values greater than $9500, the mean square error for MLT is highest between the two. Throughout the range of cost values, the variance for TWM remains greater than MLT. This is attributed to the low numbers of completed questionnaires (N) for TWM. The reason for the apparent switch in the error values comes from the absolute value of the bias term. The value for the bias term, noted in Table 3, is 0.06 for MLT and - 0.05 for TWM. As the total number of completed questionnaires increases with design cost, the variance term becomes less of a factor in determining mean square error. Thus the mean square error of TWM decreases below that of MLT as variance decreases and the role of the bias term increases. For this situation in which the population proportion is equal to 0.60, the bias estimate of MLT becomes larger than the value for TWM in the total cost range of $6750 to $7000.

As indicated in the second graph in which X(o) equals 0.65 (Figure 2B), a distinct separation between the error values for TWM and MLT has occurred. Variance and bias values for TWM (telephone response design) are the largest among the three designs and over the range of cost values. Also, the mean square error values for this design have increased above the values in the first graph. The order inversion across the design costs the MLT and TWM designs, as demonstrated in the first graph, disappears with an X(o) value as small as 0.61. The graphical overlap of the mean square errors now occurs with the MRC (all-mail response) and MLT (mail and telephone response) designs. The mean square error values for MLT remain larger than the MRC values, but the difference becomes negligible within the plot. Considering that the variance of the MRC design is lower than MLT, the overlap is explained by an increased significance of the bias term in the mean square error models, as mentioned in discussion of the first graph. However, the overlap occurs shortly above $5500 as opposed to the range of $6500 to $9500 in the first graph.

Even larger absolute biases for all three design, when X(o) = 0.70, lead to somewhat different trends in the mean square error (Figure 2C). One is an overall increase in the mean square error above the values in previous graphs. Trends in the mean square error are also flatter over the range of cost. The flatness of the trend in the mean square error functions implies that little improvement in the quality of estimates could be realized by increasing the sample size. It was evident in the omitted plot, where X(o) = 0.75, that the mean square error of the MRC design increased above that of MLT and there existed an overall positive shift and an even flatter trend in all of the error values.

IV. CONCLUSION

Upon completion of the cost and response rate analysis for the Physician Surveillance study, the Mail - Reminder postcard - Certified mail design is recommended as the most cost-efficient design to monitor prevention in the primary care procedures of physicians. This is based on the response rate of 65.5% and the lowest cost of $2,681, over the MLT (66.0% and $5,788) and TWM (44.8% and $6,242) designs. The cost-efficiency graphs allowed the conclusion that as the population proportion of respondents answering "during almost every visit" to the smoking advisement question (X(o)) increases beyond 0.65, MLT becomes with most cost-efficient design. However, the MRC design (mail response design) is preferred over MLT (mail or telephone response design) because the overall response rate loss negligible and the cost of MRC is less than half the cost of MLT.

REFERENCES

CASRO Task Force on Completion Rates (1982). On The Definition of Response Rates. Special Report. New York: Council of American Survey Research Organizations

Groves, R. M., Survey Errors and Survey Costs, John Wiley and Sons, New York, 1989.

Kish, L., Survey Sampling, Wiley and Sons, New York, 1965

Lessler, J.T. and Kalsbeek, W.D., Nonsampling Error in Surveys, Wiley and Sons, New York, 1992

Shah, B. V., Software for Survey Data Analysis (SUDAAN) Version 5.30, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709, 1990.

TABLE 1: Ranges of Variance used in Design-specific Mean Square Error Models

Design	Range of N	X(o): Overall respondent proportion for the population 0.60	0.65	0.70	0.75
MRC	(121, 773)	(0.0003, 0.0022)	(0.0003, 0.0020)	(0.0002, 0.0019)	(0.0002, 0.0017)
MLT	(44, 342)	(0.0006, 0.0054)	(0.0006, 0.0051)	(0.0006, 0.0047)	(0.0005, 0.0042)
TWM	(24, 183)	(0.0016, 0.0125)	(0.0015, 0.0118)	(0.0014, 0.0109)	(0.0012, 0.0098)

N = number of completed questionnaires

TABLE 2: CASRO Response Rates for Design by Physician Specialty (Strata)

Specialty:	MRC	MLT	TWM
General Practice	71.3	67.0	57.6
Family Practice	65.9	71.8	42.8
Internal Medicine	59.6	61.1	34.1
OB/GYN	64.1	60.8	43.9
Totals	65.5	66.0	44.8

TABLE 3: Values for bias term and nonrespondent proportion answering the smoking advisement question, X(n)

X(o) = 0.60:

Design	RR	X(r)	X(n)	Bias
MRC	0.655	0.629	0.544	0.029
MLT	0.660	0.664	0.475	0.064
TWM	0.448	0.546	0.644	- 0.054

X(o) = 0.65:

Design	RR	X(r)	X(n)	Bias
MRC	0.655	0.629	0.690	- 0.021
MLT	0.660	0.664	0.622	0.014
TWM	0.448	0.546	0.734	- 0.104

X(o) = 0.70:

Design	RR	X(r)	X(n)	Bias
MRC	0.655	0.629	0.834	- 0.071
MLT	0.660	0.664	0.769	- 0.036
TWM	0.448	0.546	0.825	- 0.154

FIGURE 1: Completed questionnaires estimated from the total cost of each design

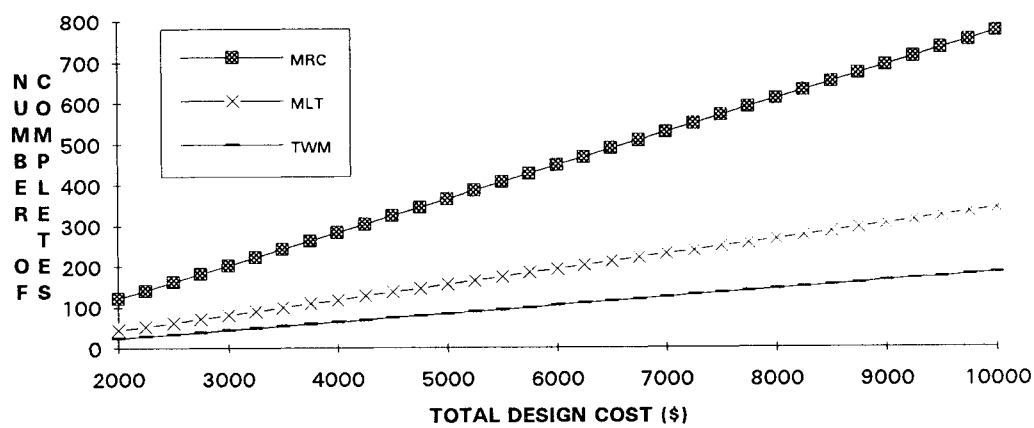

FIGURE 2A: Cost-Efficiency plot for X(o) = 0.60:

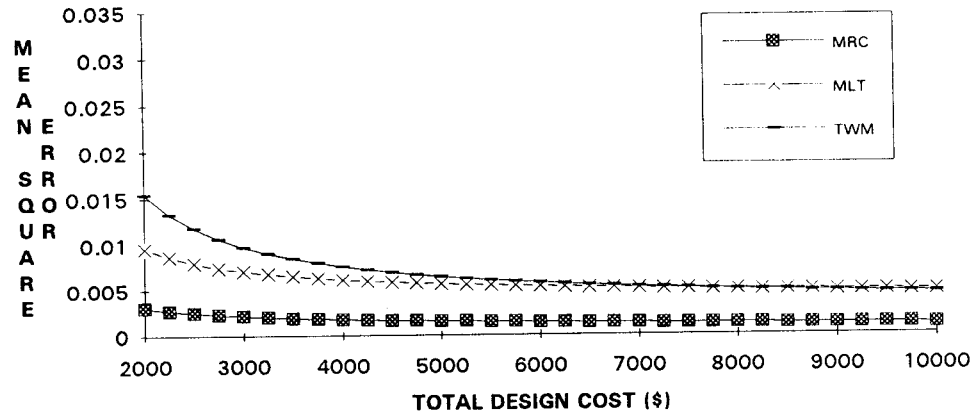

FIGURE 2B: Cost-Efficiency plot of X(o) = 0.65:

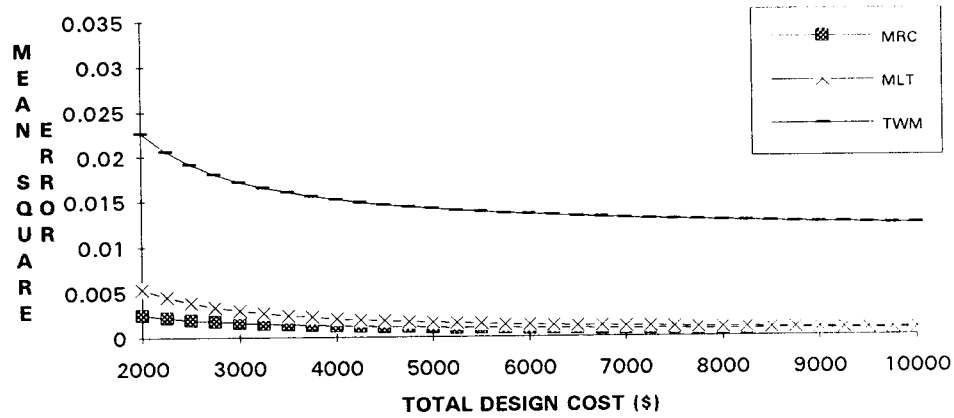

FIGURE 2C: Cost-Efficiency plot for X(o) = 0.70: