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ABSTRACT

The National Household Education Survey (NHES) was conducted for the first time in 1991 as a way to collect data on the early childhood education experiences of young children and participation in adult education. Because the NHES methodology is relatively new, field tests were necessary. A large field test of approximately 15,000 households was conducted during the fall of 1989 to examine several methodological issues. This report examines a technique that was used to increase the coverage of 14- to 21-year olds and to capture more dropouts in the sample. The effectiveness of the multiplicity sample in achieving these goals is described. The multiplicity sample results in more older youths and status dropouts, but does little to add to the sample size of younger youths and the event dropouts. The multiplicity sample is effective in reducing undercoverage bias for some statistics, but not others. Ways to improve estimation are discussed. Since the cost of screening households to find those with 14- to 21-year-old members (less than 1 in 4 households) is large relative to the cost of conducting the Household Respondent Interview, it is recommended that the multiplicity sampling approach be implemented in any future survey on dropouts. One table and six figures supplement the discussion. An appendix contains five detailed tables of field test findings. (SLD)

NATIONAL CENTER FOR EDUCATION STATISTICS

Technical Report

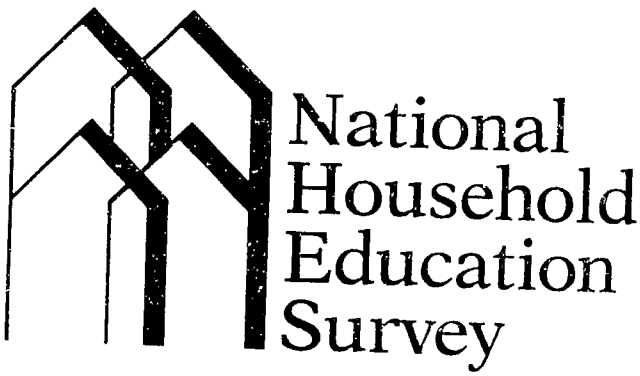
July 1992

National Household Education Survey

Technical Report No. 3

Multiplicity Sampling for Dropouts in the NHES Field Test

Contractor Report



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July 1992

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Foreword

The National Household Education Survey (NHES) represents a major new initiative of the National Center for Education Statistics (NCES). Between February and May of 1991, the NHES was fielded for the first time as a mechanism for collecting data on two different sectors of education policy interest: the early childhood education experience of young children and participation in adult education. Because the NHES methodology is relatively new and relies on some innovative approaches, a field test of the methodology was an essential first step in the development of the survey. Many of the methods of evaluated during the 1989 NHES field test were adopted for the full-scale survey.

A large field test of approximately 15,000 households was conducted during the fall of 1989. A number of methodological issues associated with collecting and analyzing data on education issues from a random digit dialing telephone survey were examined. This report is one of five that describe the 1989 NHES Field Test experience. The five reports are the first in a series of technical publications pertaining to the design and conduct of the NHES that NCES hopes to continue in the years to come. NCES believes that the reports contained in this series will provide users of the NHES data with a better understanding of the NHES methodology and that they will assist the survey design efforts of others.

The first report in this series, *Overview of the National Household Education Survey Field Test*, describes the design of the field test and the outcomes of the field test data collection activities. It reports on the response rates obtained, both unit and item, and the burden associated with survey participation. Each of the next four reports in the series focuses on a specific issue that was examined in the 1989 NHES field test.

The second report, *Telephone Undercoverage Bias of 14- to 21-Year-Olds and 3- to 5-Year-Olds*, analyzes data from the Current Population Survey to identify the extent of telephone coverage for two distinct populations of interest and the bias associated with this type of undercoverage for estimates of school dropouts and early childhood education program participation. Methods for adjusting survey estimates to partially reduce this bias are developed and evaluated.

The third report, *Multiplicity Sampling for Dropouts in the NHES Field Test*, examines a technique that was used to increase the coverage of 14- to 21-year-olds and to capture more dropouts in the sample. The report describes the effectiveness of the multiplicity sample in achieving these goals.

The fourth report, *Proxy Reporting of Dropout Status in the NHES Field Test*, focuses on measurement errors arising from the use of proxy respondents. During the 1989 Field Test, a knowledgeable household member was used as a source of information on the school enrollment of each sampled 14- to 21-year-old in the household. In addition, 14- to 21-year-olds were asked to report on their own school enrollment. The report describes the correspondence between the responses given by proxy respondents with those provided by the youths themselves.

The fifth report, *Effectiveness of Oversampling Blacks and Hispanics in the NHES Field Test*, describes the approach used to increase the number of black and Hispanic households/youth in the sample. During the field test, an approach that uses demographic information at the telephone exchange level to develop sampling strata was used to oversample black and Hispanic households. The report examines the yield of the field test sample design versus that which would have been expected without oversampling. The effects of oversampling on the precision of survey estimates are reported.

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Acknowledgments

Many individuals made significant contributions to the 1989 National Household Education Survey (NHES) Field Test and to the preparation of this report. The authors gratefully acknowledge their efforts. The 1989 Field Test was conducted by Westat Incorporated under contract with the U.S. Department of Education, National Center for Education Statistics (NCES). Lance N. Hodes was the corporate officer at Westat with oversight responsibility for the NHES Field Test. Mary Collins served as the associate project director for the NHES Field Test and was a major contributor to all phases of the study. In her role as survey manager, Carin A. Celebuski led the development of the Field Test dropout component questionnaires. Jacque Wernimont and David R. Martin, both Westat senior systems analysts, played major roles during the design and implementation of the survey and creating the database used in the analyses found in this report. Jerry West was the NCES project officer.

Critical technical review of this report was provided by NCES staff Michael Cohen, Bob Burton, Marilyn McMillen, and Jeffrey A. Owings, Branch Chief, Longitudinal and Household Studies Branch. Don Malec of the National Center for Health Statistics also reviewed the report. The authors wish to thank each of these individuals for their careful reading of this report and for their comments and suggestions.

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Introduction

During the fall of 1989, the Field Test of the National Household Education Survey (NHES) was conducted by the National Center for Education Statistics (NCES) to explore the feasibility of collecting education data by telephone from a sample of persons in their households. The NHES is the first major attempt by NCES to go beyond its traditional surveys, which rely upon school-based data collection systems and are typically conducted by mail or in-person data collection methods.

A household survey has the potential to provide the types of data needed to study current issues in education, particularly those which are difficult to adequately address through a school-based survey. Such issues include dropping out of school, adult and continuing education, preschool education, the status of former teachers, and home-based education. Consequently, the NHES methodology may greatly enhance the scope of issues covered by the data collection activities of NCES.

Since the NHES data collection methods were untested for education surveys, the Field Test was developed to evaluate the use of this approach. Two topics of broad policy interest were included in the Field Test: the early childhood education characteristics of 3- to 5-year-olds, and the educational status of 14- to 21-year-olds with a special focus on youth who dropped out of school before completing high school. By including both of these study areas in the Field Test, the ability to use the NHES to study multiple, complex topics, employing different sampling requirements and respondent rules could be evaluated.

Westat, Inc., under contract with NCES, conducted all of the Field Test interviews using computer-assisted telephone interviewing (CATI) methods. The use of CATI methods made sampling respondents for interviews easy and nearly invisible to the telephone respondent, an important benefit when several persons may be sampled in a household. CATI also directed the interviewers through complex skip patterns and provided the opportunity to incorporate edit checks to help resolve inconsistencies in the data while the respondents were still on the telephone. Another major advantage of the use of CATI was that data analysis could begin soon after data collection ended, because data entry and many of the edit checks were done during the interview.

The sampling scheme used in the Field Test was a variant of the Mitofsky-Waksberg random digit dial (RDD) procedure[1] in which every residential telephone number has the same chance of being drawn into the sample. Because of the need for more precise estimates of blacks and Hispanics, special sampling methods were used to increase the sample size for these persons. The design for the Field Test was essentially the same as planned for a full-scale NHES study, except the overall sample size was smaller.

The sample resulted in collecting data from 15,037 households representing all civilian, noninstitutionalized persons in the 50 states and the District of Columbia. Although only persons living in telephone households could be sampled for the Field Test, adjustments were made in the weights so that the estimates of persons living in both telephone and nontelephone households could be produced.

Respondents in sampled households were asked a series of screening questions. This interview, called the Screener, was used to enumerate all the members of the household, determine the eligibility of each person in the household for the early childhood education (3- to 5-year-olds) and youth (14- to 21-year-olds) studies, and obtain some data on the characteristics of the household. A total of 4,374 households had at least one person enumerated in the Screener who was eligible for an extended interview. The response rate to the Screener was 79 percent.

The early childhood education interview was conducted with the parent or guardian who was identified as knowing the most about each sampled 3- to 5-year-old child's care and education. Accordingly, this interview was called the Parent Interview. Of the 1,551 children identified in the Screener, parents completed interviews for 1,530 children, a completion rate of 99 percent.

If the household contained any 14- to 21-year-olds, then a Household Respondent Interview (HRI) was attempted for each of these members. The HRI was used to determine the current and previous educational status of the youth; this interview could be completed by any adult household member who knew about the educational activities of the youth, including self-reports by the youth. Of the 4,441 youths identified in the Screener, HRIs were completed for 4,313 youths, for a 97 percent comple-

tion rate. As part of a special methodological study of multiplicity sampling, mothers in a subsample of the households were asked to complete the HRI for their 14- to 21-year-old children who did not live in their household. These youth are included in the numbers stated above.

A Youth Interview (YI) was then attempted for a subsample of the 14- to 21-year-olds in the household. All the youth who were not currently enrolled in school and did not have a high school diploma or equivalent (as reported in the HRI), and a sample of all other youth, were targeted for the YI. The interview contained more detailed items on the educational experiences of the youth that could only be answered by the youth. Of the 1,863 youths sampled, 1,604 completed the YI, a completion rate of 86 percent. These numbers include a sample of 133 youths who did not live in the sampled households, but were included through the multiplicity sample when their mothers completed the HRI.

This report describes the usefulness of multiplicity sampling procedures in the NHES Field Test, one of several methodological studies undertaken in the Field Test. The Field Test is described in greater detail in another report entitled *Overview Report on the 1989 National Household Education Survey Field Test*," the first in a series of reports on the Field Test. The Overview Report describes the sample design, the data collection methods and instruments, the response rates, and other salient aspects of the collection and analysis process for the Field Test.

Multiplicity sampling[2] was used in the Field Test in an attempt to increase the number of dropouts included in the sample and to reduce the bias associated with telephone coverage. A sample of 25 percent of the households was randomly selected to examine the use of multiplicity sampling in a telephone survey. All women between the ages of 28 and 65 in the randomly subsampled households were asked about their children who did not currently live with the mother. The mothers were asked to complete an interview for each of these "out-of-household" youths, and the youths themselves were eligible for sampling to complete an extended interview.

The next section describes some of the salient aspects of the sample design of the Field Test, especially those most related to the multiplicity sampling procedure. The subsequent sections describe various aspects of the effectiveness of the multiplicity sampling procedures, especially with respect to the implementation of the procedures in a full-scale survey. The last section summarizes the findings and makes recommendations for the application of multiplicity sampling in a full-scale survey on dropouts.

Data Source and Estimation Methods

As noted above, the NHES Field Test consisted of a series of related interviews. Figure 1 diagrams the flow of these interviews (the Screener, the Household Respondent Interview, and the Youth Interview) for a sampled household.

A random sample of 25 percent of all households was selected to participate in the multiplicity sample experiment. In these households, all females aged 28 to 65 years were asked to enumerate and complete an HRI for each of their 14- to 21-year-old children who did not currently live in their household. Youths who were living away from home in student housing were classified as in-household members. All other eligible (i.e., civilian and noninstitutionalized) 14- to 21-year-olds identified in this process were considered "out-of-household" members.

The Field Test was designed to investigate the efficiency of multiplicity sampling in accomplishing two goals. One of these goals was to increase the sample size for 14- to 21-year-olds, especially for dropouts. The other goal was to improve the coverage of the 14- to 21-year-old population by including youths who live in a household without a telephone but have a mother living in a telephone household. Of course, there are still youths who are not covered in a telephone survey even with the multiplicity sample. Youths who live with their mothers in nontelephone households and youths who live in nontelephone households and do not have mothers who live in telephone households are not covered.

One way of representing the population of 14- to 21-year-olds appears as figure 2, which shows the domains for which estimates are desired. Domains A and B are not affected by the multiplicity sample because the youths can only be sampled through one telephone number (the telephone number of the household in which they live). Since the NHES is a

Figure 1. – Flow of NHES interviews for 14- to 21-year-olds

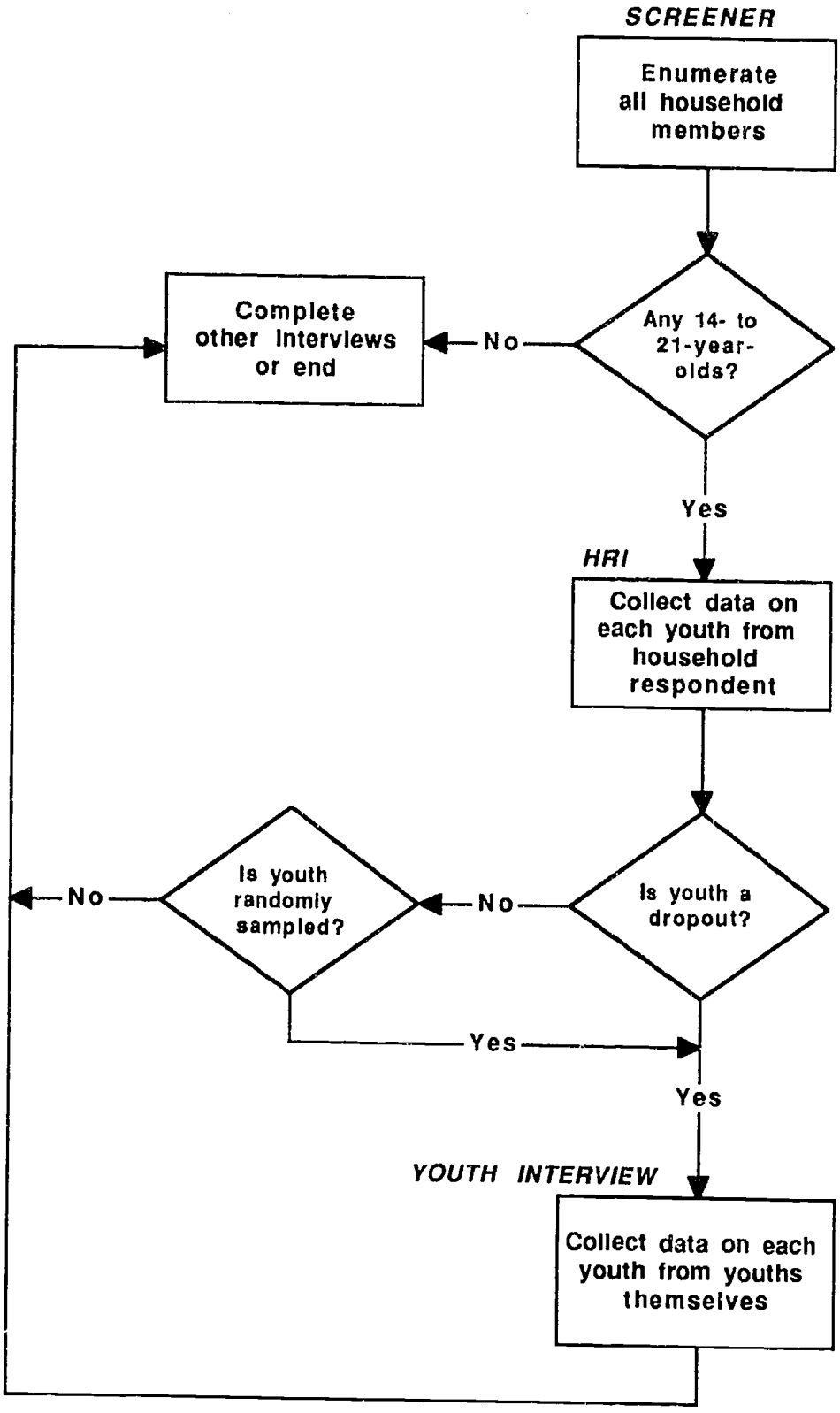
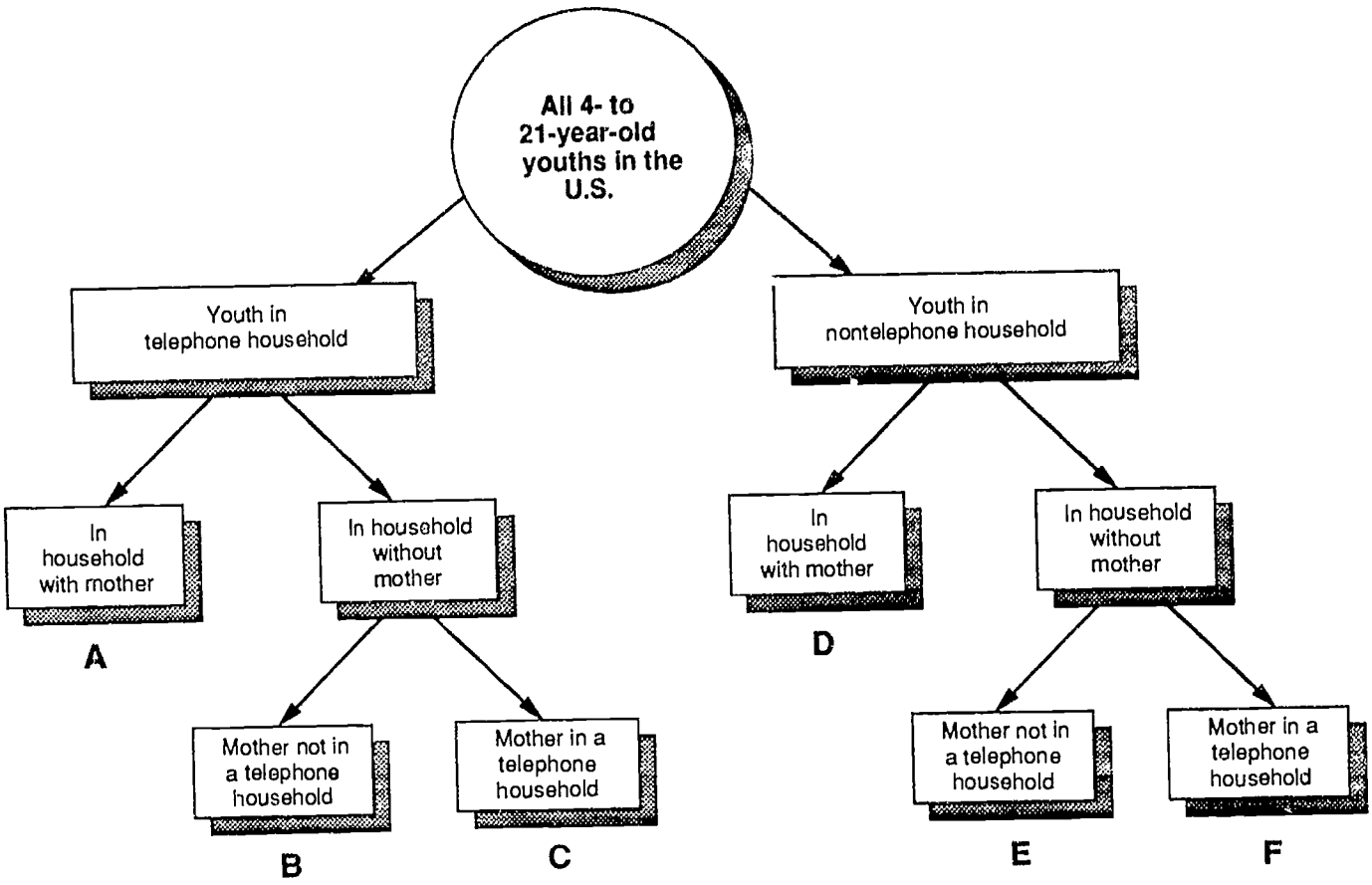


Figure 2.–Domains of 14- to 21-year-olds for the NHES Field Test



telephone sample, domains D and E are excluded by design even with multiplicity sampling.

The multiplicity sample does have an impact on estimates for domains C and F. The use of the multiplicity sample makes it possible to cover and produce estimates for youths from domain F. It also makes it possible to produce two estimates for domain C, since a youth in this domain could be sampled in two ways. First, the youth's household could be sampled and an HRI would be attempted for each of the youths in the household. These youths would then be eligible for the Youth Interview. Second, the mother's household could be sampled and included in the multiplicity sample. The mother should enumerate the youth as being out-of-household and complete the HRI for that youth. These youths would also be eligible for a Youth Interview.

Procedures were developed to incorporate the out-of-household sample in the estimation process. One method, called a dual frame approach,[3] makes use of the fact that a particular domain of persons (youths who live in telephone households with mothers who live in different telephone households) can be estimated in two ways. In the dual frame approach, estimates for this domain are made from each frame or source and then averaged to form a single estimate. The weights used to average the estimates from the two domains can be specified so as to minimize the variance of the overall estimate.

The other method of estimation, called a network approach[4], is based upon the determination of the overall probability of including a youth in the sample. Youth from all domains except domain C, could only be sampled from one household. For domain C youths, the probability of selection involves the possibility of sampling from two households: their own telephone household and the telephone household of their mother. These two approaches to estimation result in identical weights for the Field Test.

The estimation procedure included several stages of weighting and adjustments, such as the inverse of the probability of selection and nonresponse adjustments. Below, only those aspects of estimation which are directly related to the multiplicity sample are described.

The discussion of multiplicity sample estimation procedures can be facilitated by the introduction of adjustment factors. The adjustment factors are modifications to the standard weights for youths. For completeness, the factors associated with each of the domains are given, even though some of the domains are not affected by the multiplicity sample. Let

S = 1 if the youth is in domain A or B;

S = 4 if the youth is in domain F (subsampled at a rate of .25);

S = 0.8 if the youth is not an out-of-household youth in domain C;

and

S = 0.8 (.2x4) if the youth is an out-of-household youth in domain C.

The value of S for youths in domains A and B are unity, since these domains are not affected by the multiplicity sampling. In domain F, the value of S is 4 since one-fourth of the sample was included in the multiplicity sample experiment. The domain C estimate based upon the youths sampled from their own household (in-household youths) has an adjustment factor of .8, and the estimate based upon the out-of-household youths has an adjustment factor of .2. The factors of .8 and .2 were used because about 80 percent of the domain C youths were expected to be sampled from in-household youths.[5] However, the adjustment factor for the estimate for the out-of-household youths must be multiplied by four since the households were subsampled at a rate of one-in-four. Therefore, the total adjustment for out-of-household youths is .8. These adjustment factors approximate the optimal factors which are proportional to the sample sizes.

Completion Rates, Sample Sizes and Characteristics of Out-of-Household Youth

In this section, the completion rates from the Field Test data for the HRI and the Youth Interview are examined and the size of the sample arising from the use of multiplicity sampling is investigated. These estimates are then used to speculate about the resulting sample sizes for surveys with different screening sample sizes.

Household Respondent Interview Completion Rates

One of the goals of the experiment was to examine the increase in the sample size for 14- to 21-year-olds as a result of the use of the multiplicity sample. This can be evaluated by looking at the number of cases and the completion rates by household status (in-household or out-of-household).

In the Field Test, the HRI was completed for nearly all youths regardless of the household status. The completion rate for the in-household youths was 97.1 percent. For the out-of-household youths, the completion rate was 96.5 percent. The proportion of the nonrespondents who were refusals (as opposed to another type of nonresponse such as not located, or language problem, etc.) were also nearly equal, 2.0 percent for in-household students and 1.5 percent for out-of-household students. These completion rates and the number of eligible HRI cases that were identified in the Screener by the household status and response status are shown in the detailed tables in the Appendix A.

The results indicate that there is no appreciable difference in response rates by household status for the HRI. Because of the very high completion rate, no further analysis of the HRI completion rate is required. The other implication of this result is that subsequent analysis of the multiplicity sampling (including Youth Interview completion rates and sample sizes) can be based upon the completed HRI's without significant distortion due to differential nonresponse from the HRI. This result has added significance because the sampling rates for the Youth Interview were determined from HRI data.

Household Respondent Sample Size and Characteristics

The multiplicity sampling experiment resulted in the inclusion of 192 youths with completed HRI's who would not have been included in the sample otherwise. Since the multiplicity sample was only used in one-fourth of the sample households, we can estimate that the sample size would have been about 770 out-of-households youths if multiplicity sample

was used in all 5,000 households. This amounts to about 6 percent of all the 14- to 21-year-olds identified in a survey with 15,000 screened households. For samples of other sizes, the estimated sample sizes can be found using these proportions. For example, if 60,000 households were screened and multiplicity sampling procedures were used in all the households, then a sample of about 3,00 out-of-household youths would be expected with a total sample of 9,600 youths.

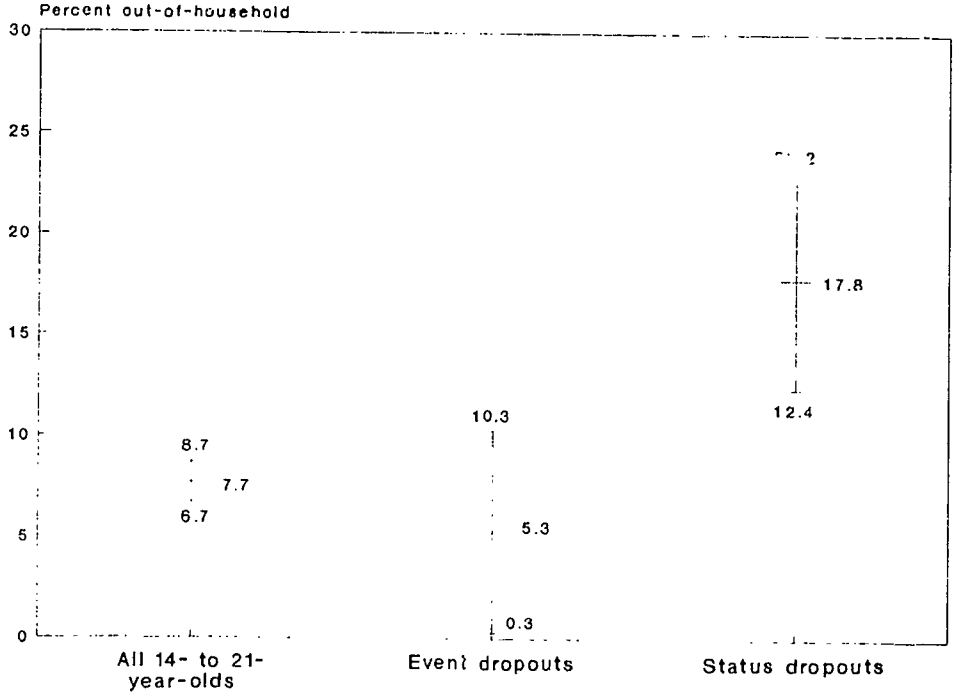
Since the multiplicity sample was implemented with the hope of increasing the sample size for certain youth (dropouts and those without telephones), the characteristics of the out-of-household youths are important indicators of the success of the procedure. First, the estimates of all youth by household status are discussed, and then a few of the characteristics of the youth by household status are explored.

The percent of 14- to 21-year-olds that are classified as out-of-household is estimated to be 7.7 percent.[6] This is an estimate of the number of 14- to 21-year-olds not currently living with their mothers who would be identified through the mother's household. Note that this differs from the estimated 16 percent of the sample that are out-of-household because youths in domain C have two chances of being in the sample.

One way of looking at the impact of the multiplicity sample for dropouts[7] is to examine the percent of all status dropouts and all event dropouts who are out-of-household youth. Figure 3 shows estimated percents of out-of-household youth with approximate 95 percent confidence intervals. The relative usefulness of the multiplicity sampling for status dropouts is evident from this figure, since the percent of out-of-household youth who are status dropouts is larger than the percent of the total. The same is not true for event dropouts.

Another way of seeing the impact of the multiplicity sample for different types of youth is to compare the percent of youth by household status. Figure 4 shows this type of comparison for youth by their age. Youths 14 and 15 years old account for a small proportion of the out-of-household youth population, but for about one-fourth of the in-household youth.

Figure 3. — Estimated 95 percent confidence interval for percent out-of-household youth, by dropout status



Source: 1989 National Household Education Survey Field Test

Figure 4. — Estimated percent of youth by household status and age

Source: 1989 National Household Education Survey Field Test

This result indicates that the multiplicity sampling is likely to increase the sample size for older youth more than for younger ones. The same type of analysis (see table A-2) reveals that the multiplicity sample is also effective for increasing the sample size for those note currently enrolled in elementary or secondary school.

These findings suggest that multiplicity sampling for 14- to 21-year-olds is reasonably effective in increasing the sample size for older youth and those who are not currently enrolled in elementary or secondary school. The increase in sample size is large for status dropouts but not for event dropouts. These findings are consistent with the expected benefits of multiplicity sampling.

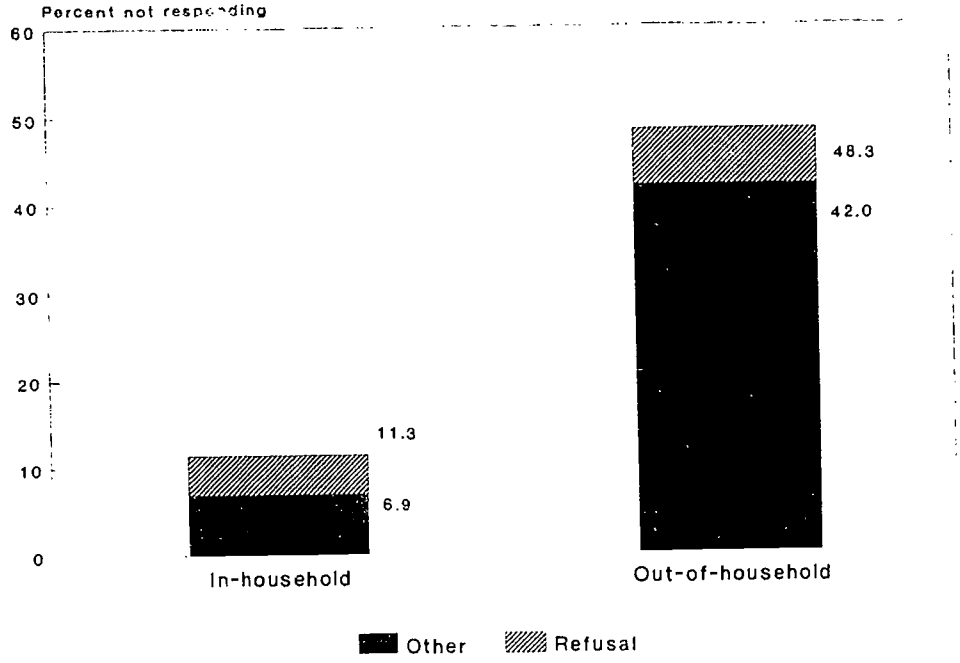
The other desirable feature of the multiplicity sample is the ability to include youth who otherwise would not be covered in a telephone survey. This issue is addressed after the completion rates for the Youth Interview are described.

Youth Interview Completion Rates

A subsample of the 14- to 21-year-olds for whom HRI's were completed was selected for the Youth Interview. The rates used for the subsampling depended upon responses to items in the HRI. All of the youth classified as dropouts were included in the sample for the Youth Interview. About 20 percent of the remaining youths were randomly sampled for the Youth Interview. The sampling algorithm used for in-household and out-of-household youth was identical.

Figure 5 shows the percent of youth not responding to the Youth Interview by household status. The most striking result is that the percent not completing the interview is much lower for the in-household youths than for the out-of-household youths. Much of the difference in completion rates can be accounted for by noting that the vast majority of the nonresponses are not refusals, but fall into the "other nonresponse" category. This category includes youth

Figure 5.— Percent not responding to Youth Interview, by household status and reason for nonresponse



Source: 1989 National Household Education Survey Field Test

who could not be reached by telephone and those for whom the household respondent did not provide locating information. Nearly half of the cases of "other nonresponse" are youths who did not live in telephone households. In fact, it is somewhat remarkable that complete Youth Interviews were obtained for 41 percent of the youths who did not live in telephone households.[8]

Across the other characteristics of youths, there is not very much variability in completion rates for the in-household youths (see table A-3). The completion rate varies from a low of 86 percent to a high of 93 percent and the refusal rate varies from a low of 3 percent to a high of 6 percent. The completion rates for out-of-household youths also reveal little substantial variability across the characteristics of the youth.

The findings indicate that there are significant problems associated with locating and obtaining completed interviews for out-of-household youths. These results should be considered in conjunction with the comparison of the dropout reporting in the HRI and Youth Interview.[9] That comparison indicated that the classification of youths as status dropouts from the HRI corresponded fairly well with the classification based on the Youth Interview responses. Since more of the out-of-household youths are status dropouts rather than event dropouts, these results together suggest that 1) the multiplicity sample is useful for enlarging the sample of status dropouts, and 2) the HRI is sufficient for classifying these persons as dropouts.

The results do cast doubt about the usefulness of trying to conduct an extended telephone interview with out-of-household youths. If a Youth Interview with a high response rate is necessary, then significant additional resources (locating resources and personal interview resources) may be needed to obtain an acceptable completion rate.

Estimates of Increased Coverage

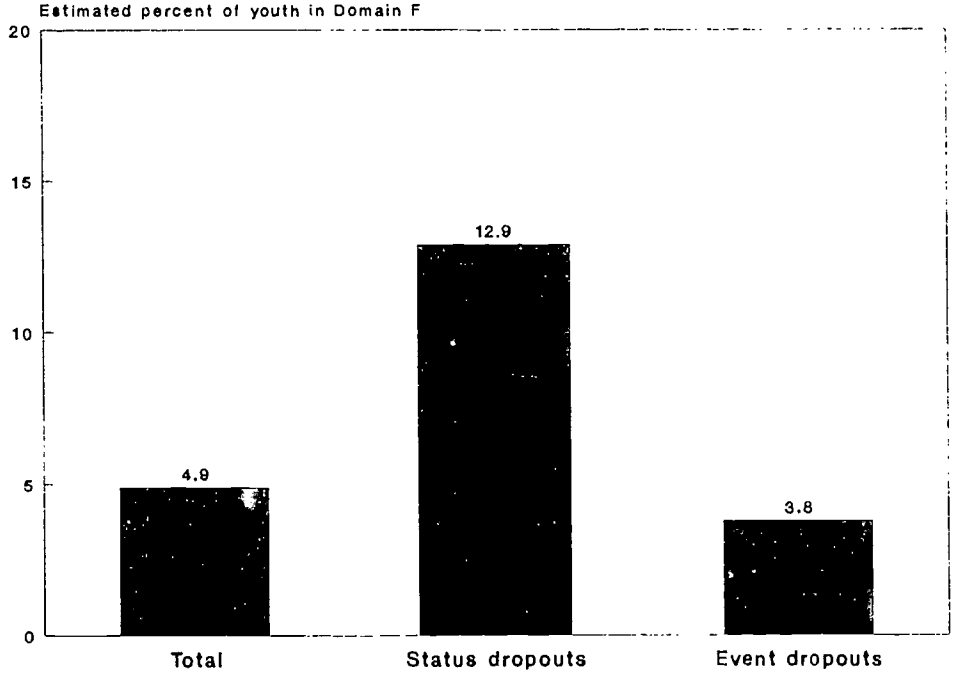
The second objective of the multiplicity sample was to increase the coverage of the population of 14- to 21-year-olds. The coverage is increased because the multiplicity sample provides estimates for youths living in nontelephone households if their mothers live in a telephone household (domain F in figure 2). As noted previously, the multiplicity sample does not eliminate undercoverage bias completely. Youths categorized into domains D and E are still not covered under this procedure.

Figure 6 shows the estimated percent of youths who are covered in NHES only because of the use of the multiplicity sample (domain F) for all youths and dropouts, i.e., the estimated percent of all 14- to 21-year-olds who live in nontelephone households but have a mother living in a telephone household. The estimated percent is an indicator of the reduction in the undercoverage bias due to the multiplicity sample. In other words, it is the percent gain in coverage due to the use of multiplicity sampling.

Technically, the percent bias is the estimated number of persons in domain F divided by the estimated aggregate number of persons in all domains. Because the NHES Field Test was weighted up to the total number of 14- to 21-year-olds in the U.S., the cases in domain F and the other domains were subjected to differential adjustments. These adjustments were introduced to reduce partially the impact of the undercoverage bias. Therefore, the estimated percent without telephones shown in figure 6 (and detailed in table A-4) is only an approximation of the actual bias reduction from multiplicity sampling.

To provide a better estimate of the bias, estimates were computed using the weights prior to the introduction of poststratification and bias reduction adjustments. These bias estimates are given in

Figure 6.— Estimated percent of youth covered due to multiplicity sample



Source: 1989 National Household Education Survey Field Test

table A-5. The estimates of the percent bias using the unadjusted weights do not differ very much from the simpler approximations displayed in the figure 6.

The examination of the reduction in the undercoverage bias begins by looking at estimates of all youths. An estimated 5 percent of the 27,697,000 14- to 21-year-olds in the U.S. are out-of-household youth without telephones. These youth are only covered because of the multiplicity sample. Since 92 percent of all 14- to 21-year-olds live in telephone households,[10] the multiplicity sample eliminates approximately half of the undercoverage bias for estimates of all youths.

Multiplicity sampling was used in the Field Test primarily because dropouts were subject to much higher undercoverage rates. Status dropouts have a telephone coverage rate of only about 70 percent and event dropouts have a telephone coverage rate of about 75 percent. The estimated percent bias for status dropouts is 15 percent and for event dropouts, only 4 percent. Even though the estimated 15 percent bias for status dropouts is larger than the 15 percent for all youth, it still only represents half of the undercoverage bias for this group of youth. The reduction in the undercoverage bias for event dropouts is very small, especially compared to the total undercoverage bias for this group.

The estimated bias for 20- to 2-year-olds is 11 percent, which is larger than for any other characteristic of youth considered, except for status dropout. This result suggests that multiplicity sampling may be useful for persons in this age group for topics other than dropouts.

The estimates of percent bias indicate that the multiplicity sample does reduce the undercoverage bias for all 14- to 21-year-olds and for status dropouts by approximately one-half. The impact for event dropouts is not substantial. The reduction in bias is only one of the statistical measures of the efficiency of the multiplicity sample. A more complete measure which includes the bias reduction is discussed in the next section.

Mean Square Errors of Estimates

The analysis in the preceding sections described the increases in sample size and coverage resulting from the use of multiplicity sampling. The mean square error of the estimate combines these two aspects into one measure of statistical accuracy of the estimates.

The mean square error of an estimate (MSE) is the sum of the variance and the square of the bias of the estimate. The variance of the estimate decreases as the sample size increases, while the size of the undercoverage bias is unaffected by the sample size. The undercoverage bias decreases as the result of using multiplicity sampling.

The mean square errors are needed for estimates both with and without the multiplicity sample. The mean square errors of these two estimates contain some identical bias contributions coming from the bias associated with domains D and E in figure 2. Before discussing this common component, the formulation of the mean square errors for the two estimates is given.

The mean square error for an estimate can be written as

$$MSE(z') = S^2_{z'} + B^2_{z'}$$

where $S^2_{z'}$ is the variance of z' and $B_{z'}$ is the bias of z'. An unbiased estimate of the mean square error from a sample can be found by replacing the variance and bias squared terms with unbiased estimates. The *estimated* mean square error can be written as

$$mse(z') = s^2_{z'} + b^2_{z'} - s^2_b$$

where the first term on the right-hand side is the estimate of the variance of the z', the second term is the square of the estimate of the bias of the z', and the third term is the estimate of the variance of the bias estimate. If the sum of the last two terms is negative (which can happen for small bias estimates and relatively small sample sizes), then the MSE is estimated by letting the last two terms be equal to zero.

Let x' be the estimate from the sample excluding the multiplicity sample and y' be the estimate of the sample including the multiplicity sample. The estimate y' contains a component for domain F, but neither x' nor y' estimate the component of the bias associated with undercoverage in domains D and

E. These components cannot be estimated from the Field Test data. The only estimates of this bias come from the analysis of other data sources, such as the Current Population Survey (CPS) data discussed earlier.

The MSE for both x′ and y′ are both affected by the omission of the component of the variance associated with domains D and E. In comparing these two estimators, the component of the bias associated with these two domains has been ignored, since it is not estimable.

Now, the estimators of MSE for x′ and y′ can be written. For y′, the estimator can be approximated by

$$mse(y') = s_{y'}^2 = \frac{D_1\sigma^2}{n_y}$$

where D is the design effect, s^2 is the unit variance of the estimate and n_y is the sample size for this estimate. Note that there are no bias terms in this estimator.

The estimator for x′ is approximated by

$$mse(x') = s_{x'}^2 + \hat{b}^2 - s_{\hat{b}}^2 = \frac{D_2\sigma^2}{n_x} + (y'-x')^2 - \frac{\sigma_b^2}{n_b}$$

where the terms are defined as before and the last term on the right-hand side of the equation is the estimate of the variance of the bias estimate. The sample size for the estimated bias, n_b, is the number of cases in domain F. Note that in this formulation the population variances are assumed to be equal.

The formulas for the estimated MSE for x′ and y′ have provisions for different design effects, D and D_2. A design effect is used to approximate the ratio of the variance of the estimate from a complex sample to the variance that would have been expected from a simple random sample of the same size. The design effect for y′ (D) should be greater than D_2 because the youths in domain C are effectively oversampled by a factor of two in the multiplicity sample. From the Field Test we estimate that the approximate value of D is 1.6 and the approximate value of D_2 is .5.

The other quantities needed to estimate the MSE of x′ and y′ can also be estimated from the Field Test. If we assume that 60,000 households are screened, then about 19,600 youths are expected (n_y) if multiplicity sampling is used in all households. If it is not used, then the expected sample size is about 17,000 (n_x). The sample size for domain F (n_b) is approximately 220 (7 percent of the estimated 3,00 out-of-household youths expected) in this scenario. These estimated sample sizes were derived in Section 3.2.[11]

The size of the bias depends upon the characteristic being estimated. Estimates of the percent bias for various characteristics are shown in table A-5. These can be converted to totals by multiplying by the appropriate totals given in table A-4. For example, the estimated bias for status dropouts is 346,000 youths (.149 times 2,323,000 status dropouts).

To continue this example, the MSE for x′ and y′ will be estimated for the percent of all youths who are status dropouts. An estimated 8 percent (2,323,000/27,697,000) of all youth are status dropouts. The estimated bias is .012 (346,000/27,697,000) for this statistic. The estimated MSE's are given by

$$mse(y') = \frac{1.6(0.08)(1-0.08)}{20{,}000} = 6.1 \times 10^{-6}$$

$$mse(x') = \frac{1.5(0.08)(1-0.08)}{17{,}000} + (.012)^2 - \frac{(.012)(1-.012)}{220} = 106.7 \times 10^{-6}$$

For this statistic, the estimated bias term dominates the MSE of x′. As a result, the MSE for y′ is much smaller than that of x′. The ratio of the estimated MSE for x′ to y′ is 17 (107/6), indicating the superiority of y′ for this statistic. The ratios for other estimates of percents are shown in table 1 (others are shown in table A-5).

The ratios of the estimated MSE's are large when either the estimated percent bias is larger than average, or when the estimate is a large percent of the total. The first condition arises because of the dominance of the bias term as shown in the example for status dropouts. The second condition arises because the variance of a proportion (P) approaches zero as P approaches either zero or one (the variance is

P(1-P)/n). When the variance approaches zero the bias again becomes the dominant term in the estimate of the MSE.

Table 1. Estimated ratio of mean square error without multiplicity sampling to that with multiplicity sampling

Characteristic of youth	Ratio of MSE(x') to MSE(y')
Age	
14 to 15 years	1.1
16 to 17 years	1.0
18 to 19 years	10.9
20 to 21 years	44.0
Race/ethnicity	
Hispanic	2.9
Black, Non-Hispanic	7.8
Non-Black, Non-Hispanic	69.1
Status dropouts	
Yes	17.3
No	210.9
Event Dropouts	
Yes	1.6
No	1,324.6

Source: 1989 National Household Education Survey Field Test

The ratios depend upon the relative contribution of the variance and the bias estimates. As noted in the status dropout example, the bias term is dominant since it is about 15 times the size of the variance term. For the estimate of persons who are not status dropouts, this relationship is even more exaggerated because the bias term is larger than for status dropouts (the variance term is the same). The bias term is larger because it is the product of the estimated percent bias and the percent of the population in the subgroup. Status dropouts constitute only 8 percent of the population and non-dropouts are 92 percent. As a result, the ratio for non-dropouts, and other characteristics shared by large proportions of the population, tend to be very large.

The ratios of the MSE's show that the multiplicity sample has a significant positive impact on estimates of older youths, but very little impact on estimates of younger youths. The multiplicity sample is effective in improving the accuracy of the estimates of status dropouts, but for event dropouts it has very little impact. These results are consistent with those reported earlier and with the expected benefits of multiplicity sampling in this population.

Summary and Recommendations

The analysis of the Field Test data indicates that the multiplicity sample is effective in increasing the sample size of 14- to 21-year-olds included in the survey. The multiplicity sample results in more older youths and status dropouts, but does little to add to the sample size of the younger youths and the event dropouts.

The completion rates for the HRI and Youth Interview reveal that mothers are willing to provide the information for the youths who no longer reside in their households, but it is difficult to contact these youths for extended interviews. The primary difficulty in obtaining extended interviews is that many of the youths do not have telephones in their homes.

The data from the Field Test also show that the multiplicity sample is effective in reducing the undercoverage bias for some statistics but not for others. The procedure is most effective for status dropouts, older youths, and youths not currently enrolled in elementary or secondary school. In these cases the bias is approximately halved. On the other hand, for younger youths and event dropouts the procedure does not significantly reduce the undercoverage bias. The estimated mean square errors confirm these findings.

Since the cost of screening households to find those with 14- to 21-year-old members (less than one in four households) is large relative to the cost of conducting the HRI, it is recommended that the multiplicity sampling approach be implemented in any future survey on dropouts. The cost and effectiveness of obtaining extended interviews with out-of-household youths suggest that those resources might be better allocated to other problem areas if the goal is to estimate the percent who are dropouts. This recommendation is consistent with the finding that for status dropouts and older youths (the groups captured most frequently in the multiplicity sample), the HRI is a reliable data source. On the other

hand, if other characteristics of status dropouts which cannot be obtained from the household respondent are important, then extended interviews with the youths themselves are necessary.

The estimates of the mean square errors also reveal the importance of the undercoverage bias for estimates of dropouts. In a full-scale implementation of the NHES for dropouts, special procedures should be implemented to reduce the impact of this bias. One of the procedures available is multiplicity sampling, as discussed in this report. Another method is to implement estimation procedures, such as those used in the Field Test, to reduce the bias. A third, more satisfying but also more costly, procedure is to implement a dual frame survey to cover non-telephone households. The dominance of the bias terms in the estimates suggests that it would be advisable to reduce the telephone sample size somewhat if those resources could be used to eliminate undercoverage bias. These recommendations are specific for the sampling and estimation of the number of dropouts and the characteristics of dropouts. For other populations and statistics, the optimal procedures may be very different from those suggested for dropouts.

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5. About 80 percent of the sample of youths from domain C should have been derived from the in-household sample because of the one-in-four sampling of households for the multiplicity sample. This is how the original factors of .8 for the in-household sample and .2 for the out-of-household sample were derived.

6. Another approach is to estimate the number of additional households and youths per household that are included as a result of the multiplicity sample. Estimates from the Field Test show that an additional 5 percent of households with about 1.1 youths per household are included from multiplicity sampling. The multiplicity sample also raises the average number of youths per household very slightly for households with in-household youths. The net result is consistent with the 8 percent increases noted above.

7. A status dropout is defined as a 14- to 21-year-old who was not enrolled in October of the current year and did not have a high school diploma or equivalent. Event dropouts are defined as the subset of status dropouts who were enrolled in school in October of the previous year. In other words, a status dropout is someone who is not currently enrolled and does not have a diploma or equivalent, and an event dropout is a dropout who left school within the last year.

8. Interviews with youths who do not live in telephone households were accomplished by obtaining work telephone numbers or telephone numbers of friends whom they frequently visit. In addition, telephone calls to the mothers' households were attempted during the Thanksgiving weekend to interview the youths at that location.

9. See *Proxy Reporting of Dropout Status in the NHES Field Test* for details on the reporting of dropout status by self/proxy in the NHES Field Test.

10. See *Telephone Undercoverage Bias of 14- to 21-Year-Olds and 3- to 5-Year-Olds* for the estimates of the telephone undercoverage rates based upon CPS data.

11. These comparisons are based on designs which have equal numbers of screened households. A different approach to evaluating the effectiveness of the designs is to fix the total cost of data collection and compare the mean square errors of the estimates. Under a fixed cost scenario, the number of screened households would be significantly decreased and the multiplicity sampling approach would be less favorable than that given in the fixed screened households approach.

APPENDIX

Detailed Tables

Table A-1.—Number of household respondent interviews, by household status and response status

Household status	Total	Response status					
		Completes	Nonresponse			Completion rate	Refusal rate
			Total	Refusals	Other*		
Total	4,441	4,313	128	67	61	97.1%	1.5%
In-household	4,242	4,121	121	63	58	97.1	1.5
Out-of-household	199	192	7	4	3	96.5	2.0

*Includes not-located youths, language problems, and miscellaneous categories of nonresponse.

Source: 1989 National Household Education Survey Field Test

Table A-2.—Estimated number of 14- to 21-year-olds by household status and selected characteristics

Selected characteristics	Total (thousands)	Household status			
		In-household		Out-of-household	
		Number (thousands)	Percent	Number (thousands)	Percent
Total	27,697	25,552	100.0%	2,145	100.0%
Age					
14 to 15 years	6,571	6,471	25.3	100	4.7
16 to 17 years	6,767	6,587	25.3	179	8.4
18 to 19 years	7,385	6,732	26.3	653	30.4
20 to 21 years	6,974	5,761	22.5	1,213	56.5
Race/ethnicity*					
Hispanic	2,784	2,588	10.1	196	9.1
Black, Non-Hispanic	4,060	3,709	14.5	351	16.4
Non-Black, Non-Hispanic	20,736	19,147	74.9	1,589	74.1
Gender					
Male	13,897	12,920	50.6	977	45.5
Female	13,800	12,632	49.4	1,168	54.5
Elementary/secondary enrollment					
Currently enrolled	13,477	13,204	51.7	273	12.7
Currently not enrolled	14,220	12,348	48.3	1,872	87.3
Status dropouts					
Yes	2,323	1,910	7.5	413	19.3
No	25,374	23,642	92.5	1,732	80.7
Event Dropouts					
Yes	587	556	2.2	31	1.5
No	27,110	24,996	97.8	2,114	98.5

*Does not add to total because of missing values for race or ethnicity.

Source: 1989 National Household Education Survey Field Test

Table A-3.—Number of Youth Interviews by household status, response status and selected characteristics

Selected characteristics	Household status									
	In-household					Out-of-household				
	Number	Completes	Nonresponse			Number	Completes	Nonresponse		
			Total	Refusals	Other*			Total	Refusals	Other*
Total	1,721	89.3%	10.7%	4.4%	6.3%	131	51.1%	48.9%	6.9%	42.0%
Age										
14 to 15 years	217	92.6	7.4	2.8	4.6	1	100.0	0.0	0.0	0.0
16 to 17 years	302	89.4	10.6	4.6	6.0	5	40.0	60.0	20.0	40.0
18 to 19 years	576	88.0	12.0	4.5	7.5	41	51.2	48.8	2.4	46.3
20 to 21 years	626	89.3	10.7	4.8	5.9	84	51.2	48.8	8.3	40.5
Race/ethnicity**										
Hispanic	194	86.6	13.4	5.7	7.7	11	27.3	72.7	18.2	54.5
Black, Non-Hispanic	240	90.0	10.0	3.8	6.3	12	33.3	66.7	0.0	66.7
Non-black, Non-Hispanic	1,278	89.6	10.4	4.3	6.1	105	55.2	44.8	6.7	38.1
Gender										
Male	846	88.1	11.9	4.5	7.4	62	58.1	41.9	3.2	38.7
Female	875	90.5	9.5	4.3	5.1	69	44.9	55.1	10.1	44.9
Elementary/secondary enrollment										
Currently enrolled	463	91.4	8.6	3.7	5.0	4	100.0	0.0	0.0	0.0
Currently not enrolled	1,258	88.6	11.4	4.7	6.8	127	49.6	50.4	7.1	4.3
Status dropouts										
Yes	275	87.3	12.7	6.2	6.5	31	38.7	61.3	9.7	51.6
No	1,446	89.7	10.3	4.1	6.2	100	55.0	45.0	6.0	39.0
Event Dropouts										
Yes	79	86.1	13.9	3.8	10.1	2	0.0	100.0	0.0	100.0
No	1,642	89.5	10.5	4.4	6.1	129	51.9	48.1	7.0	41.1

*Primarily youths with language problems, those who did not live in telephone households, and those for whom no locating information was provided.

**Does not add to total because of missing values for race or ethnicity.

Source: 1989 National Household Education Survey Field Test

Table A-4.--Estimated number of 14- to 21-year-olds by household status, telephone presence, and selected characteristics

Selected characteristics	Total (thousands)	In-household total (thousands)	Out-of-household		Percent of 14- to 21-year-olds without phones
			With phones (thousands)	Without phones (thousands)	
Total	27,697	25,552	786	1,359	4.9%
Age					
14 to 15 years	6,571	6,471	16	84	1.3
16 to 17 years	6,767	6,587	81	98	1.5
18 to 19 years	7,385	6,732	238	414	5.6
20 to 21 years	6,974	5,761	450	762	10.9
Race/ethnicity*					
Hispanic	2,784	2,588	56	139	5.0
Black, non-Hispanic	4,060	3,709	68	283	7.0
Nonblack, non-Hispanic	20,736	19,147	652	937	4.5
Gender					
Male	13,897	12,920	338	639	4.6
Female	13,800	12,632	448	720	5.2
Elementary/secondary enrollment					
Currently enrolled	13,477	13,204	102	171	1.3
Currently not enrolled	14,220	12,348	684	1,188	8.4
Status dropouts					
Yes	2,323	1,910	114	299	12.9
No	25,374	23,642	672	1,060	4.2
Event dropouts					
Yes	587	556	9	22	3.8
No	27,110	24,996	777	1,337	4.9

*Data does not add to total because of missing values for race or ethnicity.

Source: 1989 National Household Education Survey Field Test

Table A-5.—Estimated bias, mean square errors, and relative errors for estimators, by selected characteristics

Selected characteristics	Estimated percent bias	Estimated MSE(x')* without multiplicity sample (millionths)	Estimated MSE(y')* with multiplicity sample (millionths)	MSE(x')/ MSE(y')
Age				
14 to 15 years	0.9%	15.9	14.5	1.1
16 to 17 years	1.6	14.1	14.8	1.0
18 to 19 years	5.5	170.0	15.6	10.9
20 to 21 years	11.0	663.3	15.1	44.0
Race/ethnicity				
Hispanic	6.5	20.8	7.2	2.9
Black, Non-Hispanic	7.3	77.6	10.0	7.8
Non-Black, Non-Hispanic	4.6	1,040.7	15.1	69.1
Gender				
Male	4.9	524.0	20.0	26.2
Female	5.1	551.0	20.0	27.6
Elementary/secondary enrollment				
Currently enrolled	1.2	30.6	20.0	1.5
Currently not enrolled	8.4	1,688.7	20.0	84.5
Status dropouts				
Yes	14.9	106.7	6.1	17.3
No	4.2	1,296.6	6.1	210.9
Event dropouts				
Yes	4.4	2.7	1.7	1.6
No	5.0	2,197.0	1.7	1,324.6

*The estimated MSE's exclude the bias associated with youths having mothers not living in telephone households.

Source: 1989 National Household Education Survey Field Test

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