Planning the 1990 Census: Priorities for Research and Testing

Interim Report

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ABSTRACT

The Panel on Decennial Census Methodology met during the year 1984 to investigate the following technical issues related to the 1990 United States census: (1) adjustment of census counts and characteristics; (2) sampling; and (3) administrative records. A number of recommendations were made. It was suggested that a low priority be given to research and testing directed toward taking a sample survey instead of a census for the population count and basic characteristics; that the costs of each stage of followup and the feasibility of sampling for followup be studied; and that machine-readable records be tried for a sample of the data. Further testing of telephone followups and further research in the area of verification of content were also supported. Suggestions for alternate ways of obtaining housing data were made. Further study of the feasibility of a two-stage data collection, using the short form and long form, was encouraged. Further studies evaluating coverage were strongly recommended, while it was felt that the pretest of the post-enumeration study methodology was too ambitious. Continuation of the Forward Trace Study was supported. Other issues of reliability, ancillary data, statistical estimation, and operational constraints were discussed. (GDC)

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Interim Report

Panel on Decennial Census Methodology
Committee on National Statistics
Commission on Behavioral and Social Sciences and Education
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Panel on Decennial Census Methodology
Committee on National Statistics
National Research Council
2101 Constitution Avenue
Washington, D.C. 20418

PANEL ON DECENNIAL CENSUS METHODOLOGY

JOHN W. PRATT (Chair), Graduate School of Business, Harvard University

PASTORA SAN JUAN CAFFERTY, School of Social Service Administration, University of Chicago

ANSLEY J. COALE, Office of Population Research, Princeton University

DONALD DESKINS, Department of Sociology, University of Michigan

IVAN P. FELLEGI, Deputy Chief Statistician, Statistics Canada, Ottawa

WAYNE A. FULLER, Department of Statistics, Iowa State University

*JOSEPH B. KADANE, Department of Statistics, Carnegie-Mellon University

BENJAMIN KING, Research Statistics Group, Educational Testing Service, Princeton, N.J.

ALBERT MADANSKY, Graduate School of Business, University of Chicago

ALBERTO PALLONI, Center for Demography and Ecology, University of Wisconsin

JOHN ROLPH, Rand Corporation, Santa Monica, Calif.

COURTENAY M. SLATER, CEC Associates, Washington, D.C.

JOSEPH WAKSBERG, Westat, Inc., Rockville, Md.

STEPHEN E. FIENBERG (ex officio), Chair, Committee on National Statistics

CONSTANCE F. CITRO, Study Director

MICHAEL L. COHEN, Research Associate

JEANNETTE FLETCHER, Senior Secretary

*Dr. Kadane was unable to participate in the preparation of this interim report.

COMMITTEE ON NATIONAL STATISTICS

STEPHEN E. FIENBERG (Chair), Department of Statistics and Social Science, Carnegie-Mellon University

LEO BREIMAN, Department of Statistics, University of California, Berkeley

JOEL E. COHEN, Department of Populations, Rockfeller University

WAYNE A. FULLER, Department of Statistics, Iowa State University

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JANE A. MENKEN, Office of Population Research, Princeton University

PAUL MEIER, Department of Statistics, University of Chicago

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JOHN W. PRATT, Graduate School of Business, Harvard University

CHRISTOPHER A. SIMS, Department of Economics, University of Minnesota

BURTON H. SINGER, Department of Mathematical Statistics, Columbia University

COURTENAY M. SLATER, CEC Associates, Washington, D.C.

JUDITH M. TANUR, Department of Sociology, State University of New York, Stony Brook

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PREFACE

In its report to the Bureau of the Census, the American Statistical Association Technical Panel on the Census Undercount recommended "that the Bureau of the Census sponsor an outside technical advisory group on undercount estimation and related problems" (American Statistical Association, 1983:11). Partly in response to that recommendation, the Census Bureau requested the Committee on National Statistics of the National Research Council to establish a panel: (1) to suggest research and experiments, (2) to recommend improved methods, and (3) to guide the Census Bureau on technical problems in appraising contending methods.

The Panel on Decennial Census Methodology was charged with investigating three major issues from a technical viewpoint, setting aside legal considerations:

(1) Adjustment of census counts and characteristics. This topic includes exploration of formal criteria to evaluate measures of undercount and alternative adjustment procedures.
(2) Uses of sampling in the decennial census. This topic includes investigation of whether the sampling of lists and areas to improve coverage and sampling of nonrespondents for follow-up can improve accuracy for the total population and important subgroups at a given cost.
(3) Uses of administrative records. This topic includes investigation of various types of records to determine their possible utility in improving the accuracy of census counts and the efficiency of census operations.

The panel held its first meeting in January 1984 and met three times prior to preparation of this report. At the first meeting, we took a broad view of the charge and identified additional topic areas beyond those listed for possible investigation. For example, we decided that it was critical to examine uses of census data and the degree of accuracy in the census required to satisfy each use in order to reach sensible conclusions regarding a choice of methodology for the decennial census.

The Census Bureau asked the panel to produce an interim report by June 30, 1984, which was to focus on recommendations for improvements in census

methodology that warranted early investigation and testing. The Census Bureau indicated that the panel's interim report, if completed by June 30, could influence particulars of the design of the first 1990 census pretests scheduled for 1985 and the choice of testing objectives and procedures for 1986 and beyond.

In this interim report we have focused our efforts on three topic areas that are central to the original charge: (1) uses of sampling for the census count, (2) methodologies for evaluating completeness of coverage of the census, and (3) issues related to the adjustment or modification of census counts and characteristics. In addition, we reviewed the Bureau's plans for the 1985 pretest of a two-stage methodology for conducting the census.

This interim report offers recommendations and issues for consideration in each of the listed topic areas based on our review of the Census Bureau's research and testing plans. The panel intends to carry out further work on these topics and to tackle other areas not covered or covered only briefly. We may, in the final report, have occasion to modify some of the recommendations in this interim report. Nevertheless, we believe that the timeliness of these initial recommendations is critical. We are impressed by the need for the Census Bureau to make choices in its research and testing program and also by the limited number of testing opportunities that are available compared with the range of ideas that appear attractive to try out. Hence, we have striven to provide early guidance to the Census Bureau regarding what we believe, at this stage of our review, to represent the most promising avenues to pursue.

John W. Pratt, Chair
Panel on Decennial Census
Methodology

ACKNOWLEDGMENTS

The Panel on Decennial Census Methodology wishes to thank the many people who contributed to the preparation of this report.

The staff of the Bureau of the Census has been extremely helpful, and we would like to thank particularly certain individuals for their assistance. Peter Bounpane, assistant director for demographic censuses, and Barbara Bailar, associate director for statistical standards and methodology, have been very generous of their time in providing assistance to the panel. The following individuals delivered presentations at meetings of the panel: Barbara Bailar, Peter Bounpane, Howard Hogan, Susan Miskura, and Kirk Wolter. Other Census Bureau staff who provided valuable information include: Frederick Bohme, Charles Cowan, Albert Csellar, Robert Fay, III, Penelope Harvison, Cary Isaki, Matt Jaro, Charles Jones, Nampeo McKenney, Eli Marks, Stanley Matchett, Leonard Norry, Paula Schneider, Henry Woltman, and Arthur Young.

A number of members of the statistical community gave very helpful presentations at meetings of the panel: Eugene Ericksen of Temple University and Mathematica Policy Research, Monroe Sirken of the National Center for Health Statistics, John Tukey of Princeton University and AT&T Bell Laboratories, and Kenneth Hill and Robert Warren of the Committee on National Statistics. We would also like to thank Harold Nisselson of Westat Inc., who is serving as a consultant to the panel.

Many staff members of the Committee on National Statistics provided useful guidance and assistance, especially Edwin Goldfield, Thomas Jabine, Albyn Jones, Daniel Levine, Margaret Martin, and Miron Straf.

The panel is grateful to Christine McShane, editor for the Commission on Behavioral and Social Sciences and Education, for her fine technical editorial work, which contributed greatly to the organization and readability of this report. Eugenia Grohman, associate director for reports for the commission, made very helpful comments on the report. We would also like to thank members of the Commission on Behavioral and Social Sciences and Education and the Committee on National Statistics who reviewed the report and offered cogent comments.

The panel would finally like to express special thanks to the panel's own staff. Constance Citro, study director, and Michael Cohen, research associate, coordinated the panel's activities and organized and prepared background materials. They were largely responsible for drafting the report and deserve special credit for its timeliness. Jeannette Fletcher served ably as secretary for the panel.

Finally, I wish to thank the panel members themselves for their generous contributions of time and expert knowledge. Several of them prepared background materials for discussion and took responsibility for leading working groups; other members provided detailed comments on drafts of the report. Of course, no individual member of the panel

should or would want to be held responsible for every word or idea expressed, but the report does reflect the collective thinking of the panel to date on the issues addressed. Thus far it has been a pleasure to work together, and I look forward to continuing the effort of the panel to explore important areas of methodology for the decennial census.

John W. Pratt, Chair
Panel on Decennial Census
Methodology

1. INTRODUCTION

The next decennial census of population and housing in the United States is scheduled to take place on April 1, 1990. Planning for this census, which will be the nation's twenty-first in an unbroken series since 1790, officially began last fall with an appropriation for fiscal 1984. Well before that date, substantial work of direct relevance for 1990 was conducted. The 1980 decennial program in fact included several experiments and postenumeration studies designed to help plan improvements in methodology for subsequent censuses.

To the general public and many casual users of census data, it may appear that the Bureau of the Census has ample time to plan wisely for the 1990 census. In fact, there are relatively few opportunities to thoroughly test changes or modifications to census procedures, particularly if the changes represent major departures from the past. Moreover, only tests conducted under census conditions, that is, experiments incorporated into the next census as distinct from pretests, can adequately assess the impact of alternative procedures on public cooperation with the census.

The Census Bureau's testing program for 1990 got under way this spring with tests of address compilation methods in several localities around the country (Bureau of the Census, 1984b). Two large-scale pretests are planned for spring 1985. Pretests will also be conducted in 1986 and 1987. Finally, the research and testing program will culminate in 1988 in "dress rehearsals" of the procedures planned for 1990.

This testing schedule means that the Census Bureau's only opportunities to try out new procedures and concepts for 1990 are the pretests scheduled for 1985, 1986, and 1987. The dress rehearsals, as the name implies, are not used to test new ideas but to run through the procedures the Census Bureau expects to follow in the decennial census itself. The only changes the Census Bureau anticipates from the dress rehearsals are corrections of problems encountered in the field, not innovations in census procedures at that late date.

In addition to the compressed time schedule for testing and research, two other critical factors affect the ability of the Census Bureau to modify census methodology: staff and budget resources. The Census Bureau has long been known for the high quality and dedication of its technical

staff. The current budget for research on decennial census methodology, particularly for research on the undercount, is generous by the standards of earlier censuses. Nevertheless, no agency of government, particularly in the constrained world of the 1980s, can expect to have sufficient staff or resources to try out more than a few promising ideas and concepts. It is critical to designing the best census for 1990 that the Census Bureau choose priorities for the expenditure of resources and staff time wisely and that it make the most of the testing opportunities afforded over the next few years.

Why is it so important to choose wisely among alternatives for testing and research for the 1990 census? The decennial census has been a source of controversy throughout its history. Numerous instances can be cited from the past of criticism impugning the accuracy of census figures and questioning the procedures and costs of conducting the census (Bureau of the Census, 1982a:App.IIIb; Conk, 1984). Yet it appears that social and political forces have converged in recent years to make the census in this country--and in other countries as well--a matter of greater controversy than before.

On one hand, there is increased concern with the need to protect the privacy of individual citizens and a sense that the public is oversurveyed and less willing to respond to government inquiries. Indeed, in the last few years, the level of public suspicion and hostility to plans for the census caused the governments of several Western European countries to delay their census programs or cancel them entirely (see Redfern, 1983).

On the other hand, legislators have more and more frequently turned to statistics to handle tough policy decisions. In fiscal 1981, federal grant-in-aid programs allocated well in excess of $50 billion to states and local areas via formulas that depended in important ways on census figures (or statistics based on census figures, such as current population estimates) to determine who got how many dollars (Emery et al., 1980; Gonzalez, 1980; Office of Management and Budget, 1983:Chap.5). Census data are used by constitutional mandate to determine the number of seats in the U.S. House of Representatives that are allotted to each state. They are used as well in drawing up congressional and state and local legislative districts to meet rigid criteria for equitable representation of the population. In addition to these critical governmental needs, census data support many other major uses. Data from the latest census serve to document the social and economic condition of the country as a whole and of small areas and groups in the population. Comparative information from successive censuses serves to illuminate trends over time. Researchers, planners, and decision makers in business, government, and academic institutions make use of census data for a wide range of important planning and analysis purposes. All of these uses have underscored more than ever before the importance of obtaining a complete and accurate count of the population as well as accurate data about characteristics.

Yet to obtain highly accurate data costs money. The 1980 census cost close to $1.1 billion dollars--about $4.75 for each inhabitant of the United States (Bureau of the Census, 1983b:88). The per capita amount is small compared with the per case cost of most government and private-sector sample surveys. Moreover, the costs of the census include

planning, collection, and processing activities that span most of a decade and provide data that are of value for the decade and beyond. Nonetheless, costs for data collection that are at the billion-dollar level excite comment and invite close scrutiny to determine how they might be reduced.

Moreover, research conducted by the Census Bureau itself has shown that, while the 1980 census appears to have achieved the most complete coverage in the country's history, there still were inaccuracies. Most significantly, as in previous censuses, important race, sex, and age subgroups of the population experienced differential rates of net undercoverage. There is strong evidence that the black population was undercounted by about 5 percent nationwide. Black males ages 25-54 appear to have had the highest net undercount rates. Coverage estimates for whites and other races are difficult to derive because of the lack of reliable estimates of net legal and illegal immigration. Making a range of reasonable assumptions about the size of the illegal alien population, it appears very likely that whites and other races experienced net undercount in the 1980 census, but that the rate of undercount was smaller and perhaps significantly smaller than the 1.5 percent rate experienced in 1970 (see Passel et al., 1982:6-8).

Differential undercount means possible inequities in redistricting and fund allocation based on census data. The belief that errors in the census affected fund allocation gave rise to an unprecedented number of lawsuits following the 1980 census. By October 1981, over 50 suits had been filed challenging the census results (Bureau of the Census, 1983b:85). Currently, testimony has just been completed in a major case in which the State and the City of New York are suing to have the Census Bureau adjust the 1980 census counts; 23 other cases are awaiting settlement of the New York suit.

Not surprisingly, many ideas have been proposed to improve the decennial census. Some ideas are directed principally at improving coverage and reducing differential coverage errors. One idea in this class is to use administrative records, such as driver's license lists and other sources, to match against the census to identify people who should be added to the census count. The Census Bureau used this approach in a few large cities in 1980 (Bureau of the Census, no date-a). Other ideas are directed principally at reducing costs. One such approach is to make use of sampling, not only to obtain information on characteristics, as is currently standard decennial census practice, but also as part of the procedure to obtain the count. For example, one could attempt contact with a sample of households that do not mail back their questionnaires, rather than all nonrespondents, in the follow-up stage of census operations.

Two important themes stand out in current discussions of methodology for the decennial census. One relates to the degree of emphasis that should be given to counting versus estimation. A census, no matter how diligently administered, can never be complete or without error. Hence, a census, as is true of any survey, provides an estimate of the population. From this recognition has come a view of the decennial process, expressed most often by members of the statistical community, that emphasizes the role of estimation. Its proponents argue that some of

the resources for conducting the decennial census should be shifted from efforts directed toward traditional coverage improvement procedures to efforts directed toward developing the best possible estimates of the total population and subgroups. Input to the decennial year population estimates, in one version of this view (Ericksen and Kadane, 1983), would include a reasonably well-conducted census, but also information obtained from various programs conducted on a sample basis, such as matching of administrative lists to census records, that would provide a basis for adjusting the census counts. There is by no means agreement within the statistical community, let alone other disciplines, on the merits of the various suggestions put forward to incorporate estimation into the census process. Nevertheless, the known errors and the incompleteness of the census count mean that the issue of adjusting census figures needs to be addressed.

The other theme relates to the critical importance of evaluation programs in the methodology of the decennial census. Politicians, policy analysts, statisticians, economists, demographers, other social scientists, and users of census data in all sectors have expressed widely divergent views regarding the most appropriate methodology for conducting the census. But whether they view the census in traditional terms as strictly a counting operation or believe that the census should be the starting point for an estimation process, there is substantial agreement on the importance of evaluating the completeness and accuracy of census statistics.

The Census Bureau has conducted formal evaluation programs for every census since 1950 (Bureau of the Census, no date-a). All of the techniques used to date, in this country and abroad, including demographic analysis, reverse record checks, administrative record matches, and postenumeration surveys (whether recanvassing selected areas or matching independent surveys to census records), have important flaws. In the United States today, the absence of adequate data for estimating net immigration, whether of legal or illegal residents (Marks, 1980), poses particularly severe problems for evaluating the census count even at the national level. Nevertheless, with concern over possible inequities in political representation and the distribution of large amounts of federal dollars, there has never been a greater need for thorough evaluation of the decennial census. This evaluation is necessary whether the object is to inform users of known errors in the census or actually to modify census results.

While there is widespread agreement that evaluation is important and that the issue of adjustment must be faced, many decisions on methodology for 1990 remain to be made. It is clear that there is no lack of ideas and suggestions that appear useful to investigate. It is also clear that the process of determining a reasonable methodology for 1990 will involve difficult choices. Thus, it is not possible to achieve both maximum accuracy and minimal cost; rather, as Keyfitz has noted (1979), explicit cost-benefit trade-offs must be made.

The Census Bureau is actively working on methodology for the 1990 census and is seeking advice and ideas from a wide range of groups and individuals representing many points of view. The Census Bureau has assembled a staff to plan the 1990 census and is recruiting a research

staff specifically to work on issues of undercount and the possible adjustment of census counts. The panel commends and hopes to aid these efforts to design and carry out a thorough research and testing program that will support sound decisions regarding methodology for the 1990 and later censuses. Resources invested in careful research and testing represent the best possible investment for a cost-effective census in 1990.

The Census Bureau's planning staff recently prepared detailed research agendas on the following topics that correspond very closely to the priority areas the Panel on Decennial Census Methodology was asked to address:

-- "Research Plan on Uses of Sampling in the Census Count" (Miskura et al., 1984).
-- "Research Plan on Adjustment for the 1990 Decennial Census" (Hogan, 1984). This document covers research directed toward improved programs for evaluating census coverage as well as research in the area of adjustment of census counts per se.
-- "Record Linkage Research Plan" (Jaro, 1984).
-- "Draft Research Plan on Uses of Administrative Records" (Harahush, 1983).

In the preparation of this interim report, the panel and staff, working through subgroups, examined the first two research plans listed above on the uses of sampling and coverage evaluation and adjustment. Panel members have not yet completed at this time, but intend to complete, a review of the research plans on administrative records and record linkage. The panel also reviewed the Census Bureau's plans, both in written form and through discussions with staff, for the pretests planned for 1985.

The remainder of this report provides the panel's thinking to date and recommendations in the following areas:

-- Chapter 2: Uses of sampling for the census count. Based on the work of the panel's subgroup on sampling, which reviewed the Miskura et al. research plan and related materials, the panel developed several recommendations regarding priorities for research and testing on uses of sampling in the decennial census.
-- Chapter 3: Early pretests. Panel members examined plans for the 1985 pretest in Jersey City of a two-stage methodology that separates collection of the sample (long-form) data from the basic count. The panel developed recommendations for ways to design this pretest to better measure the benefits and costs of the two-stage procedure. The panel also developed recommendations related to other kinds of coverage improvement procedures that the panel believes deserve early testing.
-- Chapter 4: Coverage evaluation methodologies. The panel's subgroup on coverage evaluation reviewed relevant portions of the Hogan research plan and related materials. Based on its work, the panel developed recommendations regarding priorities for research

and testing of improved methodologies for assessing the completeness of census coverage.

-- Chapter 5: Adjustment techniques. The panel's subgroup on adjustment of census counts reviewed relevant portions of the Hogan research plan. The subgroup did not at this time suggest recommendations to the panel, but outlined a series of issues for the panel to address in our final report that must be considered in any decision to modify the 1990 census or subsequent censuses for coverage or content errors.

The research plans drafted by the Census Bureau staff are extremely comprehensive and ambitious. The staff has clearly tried to include all reasonable ideas for consideration in their research and testing program. The thrust of the panel's comments is to single out from these plans the priority areas for research and testing. The panel has also emphasized the cost-effectiveness of thorough analysis of the results of the 1980 census and the various experiments and evaluation programs conducted for 1980 and prior censuses. Throughout the panel has been guided by the belief that the Census Bureau must make the most of limited budget, staff, and testing opportunities. It is vitally important that the research program for the 1990 census be designed to provide a cumulative knowledge base and that the Census Bureau not attempt to try out so many ideas that pretest results cannot be effectively digested. The panel does not pretend to have the answers regarding the "best" methodology for the decennial census or even the "best" testing program. The panel has endeavored, at this stage of our work, to identify the ideas and concepts that appear most promising for early testing and research.

2. THE USES OF SAMPLING FOR OBTAINING THE DECENNIAL CENSUS COUNT

Panel members reviewed the paper prepared by staff of the Bureau of the Census, "Research Plan on Uses of Sampling in the Census Count" (Miskura et al., 1984), and other relevant materials. The Miskura et al. paper describes four applications of sampling for the decennial census and proposes research projects for each type of use: (1) obtaining the census count on a sample basis, (2) using sampling for follow-up of unit nonresponse in the census, (3) using sampling for verification and possible correction of specific subject items during the census, and (4) using sampling for coverage improvement operations. We present and discuss the recommendations of the panel for each of these areas in turn below.

TAKING A SAMPLE CENSUS

Currently, decennial census methodology involves collecting the majority of population and housing characteristics from only a sample of households, who receive the "long-form" census questionnaire. (Sample sizes for the long-form items in recent censuses have ranged from 3.3 to 50 percent and are typically 20 or 25 percent.) However, the counts of persons and housing units as well as basic characteristics, such as age, race, sex, and marital status of the population and tenure and number of rooms for housing, are attempted on a complete count or 100 percent basis.

The concept of taking a "sample census," i.e., taking a large sample survey instead of a full census to obtain the count of the population and related basic characteristics, has been suggested as a means to effect a significant reduction in costs while still satisfying the primary information needs served by a full census (see, for reference, Bureau of the Census, 1982a; Kish, 1979).

Miskura et al. propose several research projects intended to result in a possible design for a sample census. The first project, which is planned for the period from June through September 1984, is to develop appropriate sampling error estimates for alternative designs for a sample census. The second project, scheduled for the period October 1984 through March 1985, is to develop total error models (including sampling and nonsampling error) for the sample designs investigated in the first project. The second project

would investigate the theoretical reduction in nonsampling error required to obtain overall accuracy at least equal to that of a complete count. The Census Bureau staff would then develop cost models and estimate cost model parameters for a sample census. Based on the results of the research, the staff would specify a sample census methodology to be tested initially in 1986.

Problems Involved in a Sample Census

The panel believes that the concept of replacing the census with a large sample survey should be given a low priority in the Census Bureau's 1990 research and testing program for a number of reasons that relate principally to census purposes, costs, and coverage.

With regard to purposes, the decennial census is the only comprehensive source of data for very small geographic areas such as towns, census tracts, and city blocks. There are important needs for data about small areas, including: redistricting of congressional, state, and local legislative districts, which requires block counts by age and race to meet court-mandated criteria for population equality and compactness of districts (Bureau of the Census, no date-b); revenue sharing, which requires population and income data for 39,000 political jurisdictions that include many very small towns, villages, and special districts; and many other important policy planning and analysis purposes at the state and local level. Moreover, the model-based estimation techniques that are used to produce small-area data intercensally for revenue sharing and other purposes must be evaluated and recalibrated periodically against the census.

To obtain small-area population counts and basic characteristics from a sample survey to satisfy the uses outlined above would require a large sampling rate, perhaps as high as 50 percent for small jurisdictions; otherwise, sampling errors would be unacceptably large. Moreover, it would not be feasible to design a clustered area sample that sampled the population of only some geographic areas such as selected counties or cities, because small-area data are needed for every geographic entity of the country. Yet to select a large unclustered sample would probably require an attempt to list all housing units. Given these factors, namely a large sampling rate, 100 percent address listing, and an unclustered design, the panel is doubtful that costs could be significantly reduced, if at all, in comparison with a full census.

Substantial cost savings from sample surveys occur when administrative overhead costs can be reduced by eliminating entire segments of field operations. Such reductions can be achieved using a clustered design, but a design that requires sampling in every county and city would necessitate the same number of field offices as is required for a full census. Moreover, while the size of the interviewer staff could be reduced somewhat, a large sample survey would entail additional costs for drawing and controlling the sample.

Finally, there is the issue of completeness of coverage obtained by a large sample survey compared with the full census. There is a large body of evidence in both the United States and other countries that the census obtains more complete population coverage than even the best-executed sample

survey (Redfern, 1983; Yuskavage et al., 1977). In fact, even the samples taken in conjunction with the census generally produce lower population figures than the complete census (Waksberg et al., 1973). One possible reason for this finding is that the publicity surrounding a census elicits greater cooperation from the public than can be obtained in surveys. While, of course, the Census Bureau would mount a publicity campaign for a sample census, it would be difficult to include a question like "Were you counted?" when only a fraction of the population is supposed to respond. Similarly, the field operations of a census are geared toward finding every housing unit and person and adding missed units to the address list developed in advance of the census. For a sample census, it is unlikely that the same effort would or could be put into adding units to the sampling frame, with the result of less complete coverage.

The less complete coverage obtained by a sample census compared with current methodology would have important adverse implications for many important uses of census data. Concerns about inequities resulting from undercoverage and particularly differential undercoverage of important subgroups of the population are already very strong. Substituting a large sample survey for the census would deepen these concerns still further. The decennial census is also used as the basis for the design of current surveys in both the public and private sectors and to benchmark current population estimates. Less complete coverage would adversely affect these uses of census information.

> Recommendation 2.1. We recommend that for 1990 the Census Bureau put low priority on research and testing directed toward taking a sample survey instead of a census for the count and basic characteristics.

Estimating the Costs of a Sample Census

While we have expressed strong doubts about the utility of a sample census, we believe that it could be useful to obtain rough cost estimates if this estimation could be accomplished with a modest amount of effort. The methodology of a sample census stands at one extreme on a continuum for which the other extreme is a census that asks all questions on a complete count basis. It would be useful to be able to make approximate comparisons of costs at various points on the continuum, including the extremes. It may be that estimates prepared in the 1970s for conducting a mid-decade census on a sample basis would provide a ready base for estimating the costs of a sample census in 1990. The panel intends to explore with the Census Bureau ways of obtaining relevant information for costing out a sample census using an unclustered design and assuming three or four alternative sampling rates.

THE USE OF SAMPLING FOR FOLLOW-UP

On the assumption that the next census will make at least one attempt to count everyone in the population, i.e., that the census will not be replaced entirely by a sample survey, the idea has been put forward that perhaps sampling could be used in the follow-up stage of census operations as a

means of reducing costs (Bureau of the Census, 1982a, 1983a; Ericksen and Kadane, 1983; General Accounting Office, 1982). A census carried out with the use of sampling for follow-up could, for example, at a specified date after Census Day, draw a sample of addresses from which a completed census form had not been returned and follow up only those addresses. The total number of housing units and persons represented by the cases that were followed up would then be estimated and added to the number that sent in their questionnaires. The Miskura et al. paper outlines research projects intended to provide a sound methodological basis for designing follow-up operations to be carried out for a sample of nonresponding units. These projects are similar to those proposed in connection with conducting the entire census on a sample basis, namely to develop sampling error estimates and total error models for alternative sampling designs, except that the focus is on sampling in the follow-up stage of census operations. Again, these research endeavors would lead to a pretest of sampling for follow-up in 1986.

Problems Involved in Sampling for Follow-Up

The panel believes that the use of sampling for follow-up has some of the same drawbacks as the concept of replacing the census entirely with a large sample survey, although the problems are on a smaller scale. Specifically, we believe it is unlikely that significant cost savings could be achieved by follow-up for unit nonresponse on a sample basis compared with a 100 percent effort. Because a greatly clustered design could not be used, given that follow-up operations must be carried out in every geographic area, there would be no opportunity to effect sizable savings by eliminating entire segments of field operations. Moreover, there would be the added costs of drawing and controlling the sample. The possibilities of confusion caused by a large sampling operation concurrent with the census should not be underestimated. Mail returns may well come in, for example, after the cutoff date for drawing the follow-up sample with consequent practical problems for determining whether and how to integrate late returns with the sample. Carrying out follow-up operations on a sample basis would also pose problems for coverage improvement and coverage evaluation programs that involved matching individual records.

Sampling for follow-up would introduce sampling errors that might be unacceptably large for small areas. Moreover, careful attention would need to be given to the sample design and determination of sampling fractions, given the likelihood of large variations in initial mail response rates across geographic areas. For example, in 1980, Madison, Wisconsin, had a mail return rate of over 90 percent, while the rate for the central Brooklyn district office was no more than 55 percent (Ferrari and Bailey, 1983:59).

Sampling in the Final Stages of Follow-Up

There may be reason to believe that sampling for follow-up could prove cost-effective in the very final stages of follow-up operations. It has been estimated that the costs to count an additional person rise sharply as

one moves toward those people who are harder to locate. That is, the per case costs to enumerate people requiring multiple follow-ups or special coverage efforts are many times the per case costs for those persons who mail back their questionnaires (Keyfitz, 1979; National Research Council, 1978). Hence, the benefits of sampling in the final stages of follow-up might well outweigh the drawbacks.

The Merits of Research on Sampling

On balance, we believe sampling for follow-up in the census context presents serious problems. Nonetheless, we believe that it would be useful for the Census Bureau to carry out research designed to provide a body of evidence for a decision whether to field test use of sampling in census follow-up operations or to drop the idea. We suggest as a first step that the Census Bureau analyze data from the 1980 census and also from early pretests to simulate sampling under different mail response rate scenarios. (Our proposal is in basic agreement with the research plan outlined in Miskura et al.) The analysis should attempt to identify stages of follow-up (first round, second round, etc.) and, for each stage, determine cost structures and response patterns to assess the possible cost-effectiveness of sampling. The analysis should also examine cost functions and calculate sampling error and expected contribution to total error for different sized geographic areas and areas differing in mail response rates.

> Recommendation 2.2. We recommend that the Census Bureau analyze 1980 census and early pretest results to simulate sampling procedures and develop cost and error structures under varying assumptions regarding mail response rates. The analysis should attempt to identify stages of follow-up (e.g., first round, second round) and, for each stage, assess the possible cost-effectiveness of sampling. We also recommend that the Census Bureau assess the logistic feasibility of sampling for follow-up, perhaps through expert group discussions prior to engaging in field tests.

The recommended analysis would be particularly useful if data were available on the follow-up status of individual households for a sample of enumeration districts; that is, differentiating households that returned their questionnaires without prodding from those that required one, two, three, or four follow-ups (the maximum prescribed in 1980). Unfortunately, these data were not captured in machine-readable form in 1980.

> Recommendation 2.3. We recommend that the Census Bureau keep machine-readable records on the follow-up status of households for a sample of areas in the upcoming pretests and in the 1990 census, so that information for detailed analysis of the cost and error structures of conducting census follow-up operations on a sample basis will be available.

Telephone Follow-Up

With regard to census follow-up operations, finally, we noted with interest the report on the telephone follow-up experiment conducted during the 1980 census (Ferrari and Bailey, 1983). For this experiment, in seven district offices a sample of units in the address registers that were not in multiunit structures and had not sent back questionnaires by mid-April was selected for telephone follow-up using telephone directories organized by address. (In one district office, a sample of units in multiunit structures was also drawn.) The other nonresponding units in these offices were followed up by enumerators according to standard census practice. Preliminary results indicated several advantages for the telephone technique, namely lower costs per completed interview compared with personal follow-up, lower item nonresponse rates for many items, and fewer duplicate questionnaires. Refusal rates were similar for both techniques. A disadvantage of telephone follow-up was that the directories lacked listings or had out-of-date listings for many addresses.

The report of the experiment, in addition to documenting results, describes in some detail operational problems that were encountered in administering the experiment. For example, a higher than expected rate of return of mail questionnaires after the sample selection date reduced the actual sample size of the telephone follow-up samples. The regular field office staff and the experiment staff also had problems working smoothly together in some offices.

> Recommendation 2.4. We recommend that the Census Bureau conduct further testing of telephone follow-up for unit nonresponse. We also recommend that the Census Bureau review the operational difficulties encountered in the 1980 telephone experiment for their relevance to sampling for follow-up.

SAMPLING FOR VERIFICATION

Miskura et al. distinguish between the use of sampling for verification and the use of sampling for coverage improvement. They define the former as a sampling operation involving reinterview of units to determine the accuracy of the information obtained--in other words, content evaluation. The latter refers to special coverage improvement programs designed to add units to the census count, such as cross-checking with administrative lists, carried out on a sample basis. We note that coverage improvement programs should be concerned not only with adding units and persons, but also with ensuring that persons are not counted more than once in the census.

With regard to content evaluation, the Census Bureau traditionally has evaluated the quality of reporting in the decennial census through sample surveys reinterviewing census respondents after Census Day. Other means, such as matching to administrative records, have also been used for content evaluation. To date, virtually all content evaluations have been carried out on a postcensus basis (Bureau of the Census, 1978b; Miskura and Thompson, 1983). The results have been used to improve questionnaire design

in subsequent censuses and in other ways, but have not been used to alter responses to the census itself.

The only exception known to the panel occurred in 1970 when a verification operation, the National Vacancy Survey, was carried out on a sample basis and used to adjust the census results. The National Vacancy Survey rechecked the occupancy status of 15,000 housing units originally classified as vacant in the census. On the basis of the results, 11 percent of vacant year-round housing units were reclassified as occupied. Persons were imputed for these units, totalling about 0.5 percent of the population in 1970, as were all the housing and person characteristics (Bureau of the Census, 1976:8-30).

The Miskura et al. paper discusses the application of sampling for verification during census operations and proposes several research projects in this area. One project would consider sample design issues for each potential use of sampling, such as the development of a sampling frame, the choice of sample unit, selection procedures, and possible stratification. Estimates of variances associated with particular designs and total error models would also be developed. One particular problem this research would address concerns possible complications stemming from the use of two or more sampling procedures for overlapping frames. Another proposed research project would cover work on selection and data collection methodologies. A third proposed project would focus on estimation techniques to incorporate the results from various verification procedures into the published census data. Miskura et al. limit the application of sampling for verification to procedures that involve reinterviewing census respondents.

The Importance of Verifying Content

The concern over completeness of population coverage in the census can obscure equally valid concerns over the accuracy of the content. Analysis of the fund allocation formula for general revenue sharing, for example, has shown that the per capita income component of the formula is more important than the population component in determining the distribution of funds among jurisdictions (Robinson and Siegel, 1979; Siegel, 1975). Yet reports of income in the census, as in household surveys, are known to be subject to large errors (Bureau of the Census, 1970, 1973, 1975b). These facts suggest that coverage problems should not monopolize resources that could be usefully directed to improving the accuracy of content.

Evaluation research has documented problems in the reporting of many other items in the census besides income. The panel believes that serious attention should be directed to research that might lead to verification of selected content items that have important policy uses as part of the census operation itself, instead of waiting until after the census is completed. As a corollary, we believe research should be directed to the issue of possibly adjusting census reports on the basis of the outcome of verification operations. Obviously, not all items can or should be subject to this kind of verification. For items designated for verification, it seems clear that sampling is necessary to make the process manageable in the field and to keep costs within reasonable bounds.

Because verification and adjustment of census reports have rarely been used as elements of decennial census methodology, it would be prudent for the Census Bureau to set forth and follow a step-by-step research and testing program. Extensive research should be concentrated on a few key items.

Recommendation 2.5. We recommend that the Census Bureau give high priority to research and testing in the area of verification of content on a sample basis during the census. We recommend further that the verification procedures examined not be limited to reinterviews but should include the use of administrative records as well.

Verification of Housing Items

In considering the issue of sampling for verification, the panel looked most closely at questions on structural characteristics of housing units, particularly the item on age of the structure or year when the structure was built. (Time constraints precluded examining other important items as well.) Age of structure is an important component of one of the two fund allocation formulas for the Community Development Block Grant Program. The intent of this formula is to direct funds to older, declining cities in which the housing stock includes a disproportionate share built prior to 1940 (Gonzalez, 1980). Reporting of this item in the census has observable problems (Bureau of the Census, 1972, 1975a; Katzoff and Smith, 1983). The nonresponse rate is fairly high, as is the index of inconsistency (a measure of the difference between census reports and reports obtained in reinterviews for a sample of census respondents). It has been observed that, in some cities, the proportion of housing reported as being built before 1940 has been on the increase rather than decreasing, as one would expect in most circumstances.

It is not surprising that this item should be poorly reported. People who rent their living quarters, particularly if they recently moved into the unit, would be unlikely to have accurate information regarding the age of the structure. Even homeowners may be uncertain about when their homes were built. On one hand, it would seem that buildings housing several families, such as apartments or condominiums, will be those for which response errors are largest. On the other hand, this information is likely to be available in many jurisdictions with far better reporting from administrative sources such as assessment and tax records. A specific suggestion for how the item on age of structure could be verified on a sample basis using administrative records as part of census operations is outlined at the end of this section.

Sampling for verification during the census is not the only means for improving the quality of census reports that should be considered. Continuing with our example of structural items for housing units, it is possible that more accurate information could be obtained by directing questions on these items to respondents believed to be more knowledgeable than the occupant of the unit. We understand that the Census Bureau is considering testing questionnaires that would ask owners or managers of apartment buildings the items on the structure, such as year built, number

of units, condominium/cooperative status, heating equipment, fuels used, source of water, etc. This method is used in the censuses of several European countries at present (Redfern, 1983). We believe that it is worthwhile to explore this approach.

Another approach to consider for some housing items is to obtain them instead from administrative records and drop them from the census. If the primary use for age of structure, for example, is as input to the Community Development Block Grant formula, and cross-tabulation of this item with other census items is of low priority for users, then a cost-effective approach would be to devote resources to gaining access to and improving administrative records for the date of construction and eliminate this item from the census questionnaire.

Clearly, there will be many problems in using administrative records to obtain housing structure items. Records are kept in many different ways and vary in quality and accessibility among jurisdictions. For example, records such as tax assessor's rolls are highly computerized in some jurisdictions, while maintained in paper form in other areas. The number and types of characteristics recorded for each property also vary (see Bureau of the Census, 1984a). Nonetheless, investment in research and testing of the use of administrative records for housing structure items offers the potential to improve the accuracy of the data and reduce respondent burden in the census. Research in this area, to be most beneficial, should investigate the use of administrative records in jurisdictions that differ in the nature and quality of the relevant record systems.

> Recommendation 2.6. We recommend that the Census Bureau investigate the cost and feasibility of alternative ways to obtain more accurate data on housing items. Possibilities include: (1) obtaining housing structure information on a sample basis from administrative records and using this information to verify and possibly adjust responses in the census; (2) obtaining structure information solely from administrative records and dropping these items from the census; and (3) asking structure questions of a knowledgeable respondent such as the owner or resident manager.

A Specific Suggestion for Verifying Age of Housing Units

The panel offers the following scheme as a suggestion for obtaining more reliable data on age of structure and perhaps related housing items. The basic concept is to develop a sample of structures from the address lists compiled for the census and to obtain data from local administrative records about the characteristics of the structures in the sample. It may prove most feasible to carry out this scheme in urban areas where census address listings and identifiers carried on local administrative records can most readily be matched.

Prior to the census, a reasonably complete list of housing unit addresses is constructed. Units that have the same basic address (such as Apt. A and Apt. B at the same street number) can initially be considered to be part of the same structure. Hence, it is possible to draw a sample of basic addresses that is a good proxy for a sample of structures.

The precise design and size of the sample would depend on the nature of the costs among other considerations. We outline one possible procedure. Assume that the sample of basic addresses or structures is drawn with the probability of selection proportional to the estimated number of units in the structure. For concreteness, assume that single-unit buildings are sampled at a rate of 1 in 10, duplexes are sampled at a rate of 2 in 10, and so forth, up to structures with 10 or more housing units that are sampled with certainty. Administrative records data for age of structure and perhaps other items would then be obtained for the structures in the sample.

The sample of basic addresses or structures can be linked to the sample of housing units in the census as follows. Assume that one-fifth of the households are to receive the census long form, which asks for age of structure and related housing items. Given that the sample of basic addresses is specified at the time of the mailing of the census forms, all of the long-form households could be selected from those addresses. Specifically, one scheme would be to send long forms to: all single housing unit structures that are in the sample of basic addresses, two households in all other selected structures with less than 10 units, and one-fifth of the households in all structures with 10 or more units. Recalling the sampling rates for different sized structures, this will achieve a one-fifth long-form sample for structures with more than one unit. To achieve a one-fifth long-form sample of single-unit buildings, it will also be necessary to send long forms to single-unit structures not in the sample of basic addresses. This sampling scheme has the drawback of increasing sampling variance for the long form due to the clustered design. However, it has the great advantage that all of the long-form sample for people living in structures with two or more housing units are included in the sample of basic addresses. Hence, data collected from administrative records for these structures are available to verify or possibly take the place of responses to the census.

Two options are available with respect to the question on age of structure in the census. It could be asked on the census form or it could be omitted. Assume that the question is retained on the census form. The simplest processing method would be to use the value obtained from administrative records for all individuals residing in the structures that are in the sample of basic addresses and to retain the answers of individuals not in the sampled structures. It would also be possible to use regression-type procedures to modify responses of individuals in structures that are not in the sample based on the information obtained for the sampled structures.

Now assume the question is not included on the census form. The values obtained from administrative records could simply be appended to the census data records for persons in structures that are in the sample of basic addresses. For persons not in sampled structures, it would be possible to assign values obtained from sampled structures located in the same area. This should be a very effective procedure in areas in which large groups of units, such as apartment complexes or suburban housing developments, were constructed at the same point in time.

THE USE OF SAMPLING FOR COVERAGE IMPROVEMENT

The research plan geared toward developing sample-based coverage improvement programs in Miskura et al. includes three projects that are similar to those proposed for sampling for verification: a project to work on sample design issues, a project to investigate selection and data collection methodologies, and a project to conduct research on estimation from the results of coverage improvement sampling operations. A fourth project is proposed to conduct research directed at translating the findings from the estimation research into required additions to the census, for example, imputation procedures to add "persons" corresponding to the estimated undercount.

Sampling for coverage improvement has similarities both to sampling for follow-up and sampling for verification. Certainly, carrying out specific coverage improvement operations on a sample basis has the potential to reduce costs and speed the completion of the census, as may the use of sampling in the final stages of follow-up. As with sampling for verification, sampling for coverage improvement is directed toward improving the accuracy of the decennial census without the expense of a 100 percent effort. On the negative side, there are problems of estimation raised by carrying out coverage improvement programs on a sample basis. The panel has not as yet considered the uses of sampling for coverage improvement in any detail and hence does not offer recommendations at this time.

3. EARLY PRETEST PLANS FOR 1990: REVIEW AND COMMENT

For the first pretests, in spring 1985, leading up to 1990, the Census Bureau proposes to test various automated procedures to improve census operations in Tampa, Florida, and to conduct a test of a two-stage census operation in Jersey City, New Jersey (Bureau of the Census, 1984b). Although panel members have not scrutinized plans for the Tampa pretest, the panel supports efforts by the Census Bureau to develop improved automated procedures that have the potential to speed up data collection, improve accuracy, and reduce costs. The panel also supports efforts to automate matching operations that may be used in coverage evaluation and coverage improvement programs.

The panel focused most of its attention on the two-stage pretest, since this test is related to the charge of the panel to investigate the uses of sampling in the census. The panel also developed recommendations related to coverage improvement and questionnaire design, which we believe deserve early pretesting.

THE TWO-STAGE PRETEST

The concept has been put forward in the Congress and elsewhere that census operations, particularly in hard-to-enumerate areas, would be improved if the collection of the "long-form" information were completely divorced from collection of the "short-form" information. In the last two censuses in most parts of the country, questionnaires were mailed out to all households. About 80 percent of the households received a short form that contained basic population and housing items, while the remaining households received a long form that contained the same basic items as the short form plus a larger number of items asked only of the households in the long-form sample. The basic proposal of a two-stage census is to mail out the short form to all households in the first stage and then, some weeks later, make a second mailing of the long form to a sample of households. (The 1960 census employed a two-stage operation in the mailout/mailback areas. In the first stage, the short form was sent to all households, who were asked to hold the form for pickup by enumerators a few days later. In the second stage, enumerators at the time of picking up the short form left a long form

at every fourth address to be filled in and mailed back, see Bureau of the Census, 1966.)

Pros and Cons of the Two-Stage Approach

It has been proposed that the type of two-stage process to be tested in Jersey City might have two advantages over the one-stage operation used in 1970 and 1980: it would reduce the time required to complete the basic count of the population in the first stage and it would obtain more complete coverage of the population.

The reasoning is that households will be more willing to respond if they receive the short form and that the census field staff will be able to more expeditiously and thoroughly complete the count if they are not distracted by having to follow up for responses to long-form questions (see, for reference, Bounpane, 1984).

With regard to the first point, there is evidence that mail response rates are somewhat but not appreciably higher for short-form recipients than for long-form recipients. Overall, the mail return rate in 1980 for short forms was about 2 percentage points higher than the rate for long forms. In centralized district offices, which were responsible for central cities containing hard-to-count areas, the difference was over 7 percentage points (Fansler et al., 1981). The 1970 census experienced similar mail return rate patterns.

Two possible disadvantages of the two-stage procedure are higher costs and poorer quality of the long-form information collected in the second stage.

The experience in 1980 suggests that the increase in mail return rates that might be achieved in the first stage of a two-stage census compared with a one-stage operation will not be great enough to produce significant reductions in follow-up costs for the first stage. Moreover, nonresponse rates to the long form may be substantially higher in a two-stage census, because households in the long-form sample resent being asked a second time for information or believe that they have already furnished all of the information requested in the census. Consequently, there will be higher follow-up costs to obtain the long-form information and perhaps adverse effects on the quality of the information as well. It is likely that many first-stage nonrespondents will also be second-stage nonrespondents, and total follow-up costs for these households will be roughly doubled. Hence, the panel believes that the total costs of the two-stage approach are likely to exceed the costs of a one-stage operation.

Overall, the panel doubts the utility of the two-stage approach to census enumeration. Benefits in terms of improved coverage and timeliness of the basic count appear unlikely to outweigh added costs and problems in obtaining the long-form information.

Research on the Two-Stage Approach

If additional information is required about the advantages and disadvantages of the two-stage approach, we recommend conducting research rather than field testing. Conducting a pretest of the two-stage approach in 1985 will be expensive and, as discussed below, may prove inconclusive. A cost-effective means to obtaining relevant information would be to intensively reanalyze the short-form and long-form records from the 1980 census. Analysis of indicators by race and type of place, such as mail return rates, vacancy rates, reported household size, and number and extent of imputations for item nonresponse to the short-form questions, should provide useful information about the relative impacts of the two forms on the basic count. Similarly, it would be useful to review the experience in the 1960 census with a two-stage procedure.

> Recommendation 3.1. We recommend that the Census Bureau analyze the short-form and long-form records from the 1980 census to obtain information that would be useful in assessing the likely effects on the basic count of collecting the long-form items in a separate phase. We also recommend that the Census Bureau review the experience in the 1960 census with a two-stage procedure.

The Alternative Questionnaires Experiment conducted in conjunction with the 1980 census included some aspects of the type of analysis recommended above (Fansler et al., 1981; Mockovak, 1982a, 1982b, 1983). We believe additional analysis focused explicitly on long-form versus short-form issues would be worthwhile.

Design of the Two-Stage Pretest

Should the Census Bureau decide to go forward with a field test of the two-stage approach in 1985, we believe that the test should be carefully designed to maximize the ability to detect important differences between the two-stage and the one-stage procedures. The current design of the two-stage pretest endeavors to replicate the likely census procedures as much as possible, even when they do not appear relevant to the objectives of the test. For example, as currently proposed, half of the 100,000 housing units in Jersey City will be enumerated as in 1980, with mailout of the short-form questionnaire to 80 percent of the units and the long form to the other 20 percent in the usual one-stage operation. The other half of housing units will be enumerated via the two-stage procedure. Again, 80 percent will receive the short form only and will not receive a second mailing, while 20 percent will receive the short form in the first mailing and a long form about a month later. The long form will reask the short-form questions for most of the 20 percent sample and will reask only the household roster for the rest (see Matchett, 1984).

We believe this design is not well calculated to provide the best evidence about the comparative advantages and disadvantages of the two-stage and the one-stage procedures. The panel believes the sample sizes for the two halves of the experiment are too small to conclusively demonstrate

coverage differences. We suggest an alternative design: half the housing units are enumerated in a single-stage procedure; the long form is mailed to every one of these units. The other half is enumerated in a two-stage procedure; the long form is sent to every unit in the second stage. This design would maximize the ability to detect differences in response rates and coverage as they affect the long-form households, although of course it would not permit making all important comparisons between the two procedures. On one hand, if receipt of the long form in hard-to-enumerate areas significantly affects response rates and reduces coverage, this design has a better chance to detect such differences. On the other hand, the sample sizes are sufficiently large that, if the differences in response rates and coverage are not significant for the two approaches using this design, the test can be considered conclusive.

We are also concerned that the currently proposed design will produce unnecessarily large adverse effects on the second stage response and on the quality of the resulting long-form information. Specifically, we believe that requiring long-form recipients to repeat their answers to the short form questions is likely to discourage cooperation. There is also the problem with this approach that the long-form sample will not provide the same snapshot of the population as the complete count, because some people in the sampled households will be new residents who moved in after the first stage.

If respondents are sent the long-form questions only, with one or two identification questions such as the household roster to permit matching their long-form information with their short-form replies, cooperation should be improved. However, this latter approach has the costs of matching and the introduction of matching errors. With this procedure, moreover, there will be some sample loss because of people who move between the two stages.

A potentially useful variant to incorporate in the two-stage pretest would be to designate part of the two-stage sample to receive second-stage questionnaires that include their short-form answers. This procedure has the potential to elicit greater cooperation because households in the long-form sample will appreciate that they are not being asked to supply the same answers twice. We should note, in this regard, that the two-stage procedure used in the 1960 census required households in the long-form sample to fill out the short-form questions again. A difference in the 1960 procedure from the planned two-stage pretest is that, in 1960, enumerators personally dropped off the long forms at the same time that they picked up the short forms and hence could explain the procedure to the long-form households.

However, there are two kinds of problems in implementing a test of returning short-form answers to households in the long-form sample, at least one of which may have overriding importance. The first problem is operational, namely that it may be difficult, particularly for the first pretest in 1985, for the Census Bureau to develop an efficient means to transcribe short-form answers on the long-form questionnaires. For testing purposes, it should be possible, at a minimum, for the Census Bureau simply to reproduce the sample households' short-form questionnaires and attach them to the long form.

The second problem is more serious and relates to potential disclosure of confidential census information. One way to minimize the possibility of disclosure would be to mail out the long forms containing the transcribed short-form information via first class mail to householders by name with a request that the envelope be forwarded if the addressee has moved. Even this procedure is likely to result in disclosure in a small proportion of cases, because someone other than the addressee opened the envelope, short-form information for the wrong household was sent out, and so on. We recognize, moreover, that just because disclosure problems did not occur in a pretest is no guarantee that disclosure would not occur during a census, which is a much larger and more difficult operation to control.

Nevertheless, to test the panel's hypothesis that cooperation in the second stage will be higher if respondents do not have to repeat their short-form answers, it would be desirable to find a means of returning short-form replies to the households in the long-form sample. Early investigation is required into methods for readily returning the short-form answers to respondents while maintaining the absolute confidentiality of census returns.

In summary, we doubt the utility of the two-stage census procedure. Nevertheless, if scarce testing funds are to be used for a two-stage approach, we believe every effort should be made to design the test so that: (1) differences between the two-stage and the single-stage approach have the best chance of being detected and (2) the two-stage procedure is afforded the best chance to succeed. If this is not done, and if the 1985 pretest shows inconclusive differences or net disadvantages for the two-stage approach, we believe that proponents of the two-stage procedure will be able to argue that more testing is needed. Given that the Census Bureau has relatively few pretest opportunities for each census, it is critical that the 1985 pretest be designed to provide results that will withstand close scrutiny. A two-stage mail census approach represents a significant departure from procedures of the last two censuses. The 1985 pretest should provide results that will support an early decision on whether to drop the idea or to proceed with further testing.

> Recommendation 3.2. Should the Census Bureau be committed to testing the two-stage concept in 1985, we recommend that careful attention be given to the experiment design to ensure that the method is given the best opportunity for demonstrating potential benefits. We recommend designing the pretest to maximize the ability to detect differences in response rates and coverage between the two-stage and the one-stage procedures.

OTHER PRETEST RECOMMENDATIONS

The panel has considered several other issues related to coverage improvement and questionnaire design that we believe deserve early testing. The panel's thinking has been directed toward such groups as Hispanics and young black males that have traditionally been hard to count and, in the case of Hispanics, are hard to identify reliably in the census.

A Specific Suggestion for Coverage Improvement

In the 1977 pretest in Oakland, California, the Census Bureau tested the concept of "network" or "multiplicity" response rules for coverage evaluation (Sirken et al., 1978). Such rules include asking parents to provide names and addresses of children and vice versa. Full results were never published for the Oakland study, but initial results suggested that the address information furnished was not of sufficient quality to warrant further investigation of this method as part of a coverage evaluation program that included matching of samples of persons to census records.

However, the panel believes that the concept of generating lists of individuals in an area from the census operation itself to use as a procedure to improve coverage is worth exploring, at least for hard-to-enumerate areas. The procedure would be to ask respondents in the census for lists of relatives not living in the household. Information needed for nonresident relatives to facilitate locating them and determining if they had been included in the census would include address and also basic demographic characteristics, such as age and sex.

The Oakland results suggested that address information supplied by parents was somewhat more accurate than information supplied by most other categories of relatives. Moreover, parents would probably be the most reliable source of information on a critical match item: birth date. Hence, asking parents to provide basic demographic information and addresses for children not living in the household could improve coverage, particularly of hard-to-count groups such as young black males in central cities.

Recommendation 3.3. We recommend, as one procedure for the first pretest to improve coverage of hard-to-count groups, that the Census Bureau add a question asking parents for names and addresses of children who are not part of the household.

Specifically, we propose that a question similar to the following be added to the census form:

Does anyone living in this household have a son or daughter living somewhere else? Yes_____ No_____ If yes, please list sons and daughters below.

Name _____
(Last First Middle)

Sex _____ Age _____ Birth Date _____
(Month - Day - Year)

Address _____
(Number and Street City State ZIP)

The object is to improve coverage in hard-to-count areas, and hence it would not be cost-effective or even feasible to follow up all children

reported as not living in the household. Instead, the goal would be to examine census returns from areas identified as hard-to-enumerate and to follow up those children reported by their parents as living in the same area. The question suggested above is phrased to ask parents for the addresses of all children not living in the household, so that there is no opportunity for misinterpretation of which children should be listed.

The answers to this question would provide a list of individuals that can be matched against the census. Presumably the list could be constructed and follow-ups (perhaps on a sample basis) of nonmatches done during the census operation. Operational questions for a test include the accuracy of birth date and address obtained from parents, the method of identifying addresses that are from hard-to-enumerate areas and should be followed up, the method of locating addresses, the use of different procedures in city and rural areas, and the method of sharing information in cities with multiple offices. The effects on response rates of asking this question also need to be examined.

Questions on Race and Hispanic Origin

For evaluation of the coverage of important race and ethnic groups of the population, such as blacks and Hispanics, as well as for analyses of the characteristics of these groups from census information, accurate identification of race and ethnicity on the census form is required. Over the decades, different categories of race and ethnic groups have been listed on census questionnaires in response to changing needs for the information. Editing rules for handling responses not falling into one of the designated categories have also changed.

The 1980 census questionnaire included one question that identified 14 separate race and national origin categories, such as white, black, American Indian, Filipino, Guamanian, plus an "other" category, plus a separate question on Hispanic origin. About 40 percent of the Hispanic population in 1980 marked the "other" category for race instead of a category such as white or black (Passel et al., 1982). In 1980, in contrast to the practice in censuses from 1940 through 1970, the Census Bureau did not change Hispanic responses to white, but left them in the "other" category, thereby corresponding to the realities of individual perceptions of identity, but creating a discontinuity with statistics from prior censuses.

The panel knows of no easy answer for reconciling the conflicting demands posed by:

- -- The need for continuity of time series
- -- The need for consistency of census reports with other series, such as vital statistics. (Census and census-based population estimates provide denominators for vital rates. Vital statistics are also used to evaluate coverage via demographic methods. Rules for reporting and editing race and Hispanic origin are not currently consistent between vital statistics and census--see Bureau of the Census, 1983c; National Center for Health Statistics, 1982a, 1982b.)
- -- Changing perceptions of ethnic identification and the need to follow

societal preferences in question wording, given that census information is obtained from individual respondents.

We do not presume to offer specific suggestions for the wording of race and Hispanic origin questions to improve the consistency or utility of the data, but have some comments on methods for question design.

Research on Questionnaire Design

The Census Bureau does not have many opportunities to test important questionnaire changes, such as changes in the race and Hispanic origin questions, prior to a census. Moreover, it is expensive to mount full-scale questionnaire wording tests, as was done prior to 1970 and 1980 and is planned for 1990 in a national content test currently scheduled for 1986.

The focus group technique has been successfully employed to design survey questions. This approach, originally developed in market research, involves in-depth discussions with small, usually homogeneous, groups. Focus groups offer the advantage of being able to probe for underlying meanings and hidden associations evoked by different question wording that may affect responses in unforeseen ways. This feature may be particularly useful for the testing of questions on race and ethnicity.

As a case in point, prior to the 1980 census the Census Bureau conducted numerous tests of different wording of the question on Hispanic origin. The various pretests and dress rehearsals tried out variations of this question, as did the 1976 National Content Test. A number of serious response problems were encountered. For example, in almost every case in which a question had a category with the term "American," such as "Central or South American" or "Central or South Amer.(Spanish)," there was evidence that some non-Hispanic Americans checked these responses (Fernandez and McKenney, 1980). The focus group technique would probably have provided evidence of this behavior and other response problems.

The Census Bureau experimented with focus group techniques and other laboratory methods of questionnaire design prior to the 1980 census. Through focus group sessions and classroom experiments, the Census Bureau assessed the response effects of various aspects of questionnaire design, including the placement of instructions, the position of particular items in the questionnaire, requiring respondents to make machine-readable entries for date of birth, and the use of graphics. The Census Bureau also obtained reactions to specific questions (see Rothwell, 1983). With regard to race and Hispanic origin questions, the focus group sessions and classroom experiments examined effects on item nonresponse of placing the Hispanic origin question immediately following the race question versus separating the two items on the questionnaire. However, these experiments were limited in number and did not include sessions that focused explicitly on race and ethnicity questions.

We believe that the use of focus groups for questionnaire development of sensitive items such as race and ethnicity would be very useful. Similarly, focus group techniques could reveal negative attitudes toward cooperation with the census among traditionally hard-to-enumerate groups in the population and suggest ways of modifying these attitudes.

Recommendation 3.4. We recommend that the Census Bureau use the technique of small focus group discussions as one means of questionnaire development in addition to other methods that it has traditionally employed. We also recommend that the Census Bureau use focus groups that include members of hard-to-count populations to help devise and assess means of reaching these groups in the census.

4. COVERAGE EVALUATION METHODOLOGIES FOR THE DECENNIAL CENSUS

The panel investigated two basic types of decennial census evaluation programs. The first type, labeled coverage evaluation, is concerned with measuring or assessing the completeness of coverage of the population count, on a national level and for various subgroups, often defined by subnational regions, as well as by sex, race, and age characteristics. This implies measuring overcount as well as undercount for these groups. The second type of evaluation program, labeled content evaluation, is concerned with measuring or assessing the completeness and accuracy of the responses to the various questions about characteristics of the population, on either the short form or the long form. Chapter 2, on the uses of sampling, considered some aspects of content evaluation. This chapter examines various methods of coverage evaluation. Yet a third type of evaluation program is concerned with assessing the efficiency with which census processes are carried out, i.e., quality control. The panel has not as yet addressed this important type of census evaluation.

Before 1980, the evaluation programs implemented by the Bureau of the Census had two basic goals: (1) to provide users with an indication of the quality of the published data and (2) to provide guidance for the improvement of decennial census methodology. The quality of a data set can be assessed only in relation to its intended uses. Major uses of decennial census data include providing counts for reapportionment and redistricting and as factors in formulas underlying various federal programs of fund allocation. Therefore, any differential undercount of various subgroups or regions gives rise to questions of fairness for those subgroups or regions and the possible need for adjustments to reduce inequities due to a differential undercount.

In the last few years, there has been extensive consideration of the possibility of using the results of coverage evaluation for the adjustment of the population counts. Prior to the 1980 census (see Wolter, 1983), coverage evaluation programs concentrated on assessing the completeness of the count for population subgroups at the national level, whereas adjustment must be implemented at a much lower level of geographic aggregation. Hence, for adjustment purposes, coverage evaluation programs must encompass the question of whether the information obtained is adequate for the purpose of modifying population counts in subnational

geographic areas. The discussion in this chapter of coverage evaluation methodologies touches on issues related to adjustment. Chapter 5, which outlines issues related to adjustment, imputation, and estimation, approaches the same problem from another angle. The approach in Chapter 5 is to consider what one does once the information from coverage evaluation is shown to be of use: for example, it discusses what methods are available for the modification of census counts and how modified results are presented to users. The panel does not make recommendations on adjustment at this time, but Chapter 5 outlines issues that must be considered in any decision to modify census results.

To aid the Census Bureau in improving its coverage evaluation programs, panel members reviewed the paper, "Research Plan On Adjustment for the 1990 Decennial Census" (Hogan, 1984). The Hogan paper describes many of the issues confronting the Census Bureau in its investigation of adjustment. It closes with appendices describing four studies that are expected to help direct the Census Bureau in its development of existing coverage evaluation strategies, with a view toward their use as programs of adjustment. Since preparing the March draft of the "Research Plan on Adjustment," the Census Bureau has modified particulars of the specific studies proposed for testing. The panel decided for the interim report to direct its comments to the latest written version of the plans. All these studies are either ongoing or scheduled to begin soon. A major focus of this interim report is to make recommendations about the carrying out of these study plans.

There are currently four major methods available for evaluating the coverage of the decennial census:

(1) Pre- or postenumeration surveys (PES), including such surveys as the postenumeration program (PEP) used in 1980 (Cowan and Bettin, 1982);
(2) Reverse record checks (Gosselin, 1980);
(3) Demographic analyses (Siegel et al., 1977); and
(4) The use of administrative records, which includes megalist techniques (Ericksen and Kadane, 1983).

A pre- or postenumeration survey is an evaluation program that uses a sample survey to independently re-enumerate the population. A dual-system estimate (see Bishop et al., 1975) may then be used to estimate the total population, based on estimates of the number of individuals counted in both the survey and the census, as well as those counted by only one, often under the assumption of the independence of survey and census. Dual-system estimation is sometimes referred to by the term capture-recapture.

A reverse record check is "an evaluation program in which a sample of the population is drawn from a frame created prior to the census, traced forward to the time of the census, and matched to the census. The proportion of the sample which is unmatched provides an estimate of the proportion of the population which was missed in the census" (Childers and Hogan, 1983). Usually, the sample is a combination of the following four lists: (1) a sample from the previous census, (2) a sample of births in the intercensal period, (3) a sample of immigrants from the intercensal

period, and (4) a sample of people missed in the previous census as determined from the previous coverage evaluation program. This technique has not been used extensively in the United States but is currently the main method used in Canada.

The method of demographic analysis makes an independent estimate of the population using information on births, deaths, net migration, and other related information. This estimate is then compared with the census count to estimate undercoverage.

Finally, administrative record strategies use one or more national or local rosters to develop lists to be matched to the census records to estimate net undercoverage. The estimation technique used is often dual-system estimation. The various lists may be merged beforehand and matched to the census records, sampled from and sequentially matched to the census (see Ericksen and Kadane, 1983), or completely matched to the census individually. This approach has been used on a limited, experimental basis in the United States; its potential value as a major evaluation technique is the subject of considerable current attention and debate.

The methods used in 1980 for coverage evaluation were primarily demographic analyses and a postenumeration survey. The Census Bureau's pretest plans for 1990 are designed to improve the existing methodologies and also to investigate the strengths and weaknesses of the possible alternatives.

The remainder of this chapter is organized as follows. First, a section is devoted to assessments of the status of coverage evaluation, which provide the foundation for the recommendations that follow. Following this, the panel has a recommendation on completing current research on postenumeration programs. Next is a section describing the four studies outlined in Hogan (1984) and presenting the panel's recommendations on each study. Finally, the panel makes recommendations related to possible use of coverage evaluation for the modification of census results.

THE CURRENT STATUS OF COVERAGE EVALUATION

> Assessment 4.1. Each of the various methods currently used in the United States and other countries to measure the completeness of census coverage is subject to serious limitations, including biases, in measuring the coverage of various population groups.

All of the four major types of coverage evaluation programs listed above are dependent, to a great extent, on one or more operations that have not been developed to a satisfactory degree. These operations include tracing, matching, and the counting or estimation of legal and illegal immigration and emigration. Tracing is the process whereby current information, including name and address, is acquired for individuals starting with information previously obtained, often from a previous census or survey. Matching is the determination of which individuals on two or more lists are actually the same individual. Most types of coverage evaluation programs are also affected by the unwillingness of

persons missed in the census to report in other surveys, sometimes referred to as correlation bias.

Whether the potential biases and inaccuracies of the various coverage evaluation programs for subnational areas are small enough to allow the results of the programs to be used for adjustment has been intensely debated in the last few years. However, these programs have extremely important uses apart from input to adjustment procedures, namely as measures of data quality (which includes their use as rough measures of undercoverage, both nationally and by major demographic groups) and as indicators of areas for improvement in census methodology. Consequently, coverage evaluation studies are important, even with their imperfections.

Assessment 4.2. There is at present no reason to expect a breakthrough in the methodology of coverage evaluation before 1990. However, some significant improvements are possible, expected, and important.

As mentioned above, the most serious problems affecting the performance of coverage evaluation programs are: (1) matching, (2) tracing, (3) estimation of legal and illegal immigration and emigration, and (4) correlation bias. We have not seen any proposed new techniques that give any assurance that these problems will be substantially resolved by 1990. For example, although there is work currently planned to improve matching and tracing (Childers and Hogan, 1984; Hogan, 1984), the Census Bureau has not described any new methodology that would lead to the expectation that the proposed experiments will provide methods greatly superior to those currently in use. Also, the work to date of the Panel on Immigration Statistics of the Committee on National Statistics indicates that, while immigration and emigration data can and should be improved, no currently available methods will accurately measure all legal and illegal movements across this country's borders. This data gap is central to the use of demography and other methods for coverage evaluation, and the panel strongly supports efforts to address this difficulty.

Assessment 4.3. There is, at this time, very little information on the quality of subnational estimates of coverage derived from any of the currently used evaluation programs.

Subnational estimates of coverage are needed for use in adjusting population counts. Differential undercounts on a subnational basis may cause inequity in representation or fund allocation. The various nondemographic coverage evaluation programs currently provide stand-alone estimates of coverage for, at best, about 20-100 areas, due to the small sample sizes that can be processed in each of these areas. No reliable methods currently exist of making subnational estimates of undercount by demographic analysis due to insufficient data on interstate migration and the subnational distribution of legal and illegal net immigration (Siegel et al., 1977).

If it is decided to adjust the counts provided by the decennial census in 1990, estimates of coverage will be needed for quite small geographic levels, e.g., the 39,000 revenue-sharing districts. To do this, some

method of disaggregating the information on coverage to geographically lower levels is required. Among the methods that have been put forward for accomplishing this are synthetic estimation (see Hill, 1980), more elaborate regression models, and log-linear models.

In addition to the problems mentioned earlier, time constraints also limit the possibilities for using the subnational estimates derived from coverage evaluation programs for adjustment of subnational counts for some important purposes. None of the current evaluation programs, except that of demographic analysis, has been demonstrated to be capable of meeting the deadlines imposed by reapportionment and redistricting, which currently are, respectively, December 31, 1990, and April 1, 1991. Opinions differ as to whether alternative, nondemographic evaluation techniques making full use of future technology could meet these deadlines, possibly extended by a few months. (The pressure by the states for redistricting currently is for an earlier deadline.) Nevertheless, there are other important uses for subnational data that do not have such severe time constraints, especially their use in various fund allocation formulas. The possibilities of adjustment by various methods to satisfy these uses appear more feasible.

THE COMPLETION OF CURRENT TESTING

The Census Bureau has in progress a number of studies based on the 1980 census that promise to provide a great deal of useful information pertaining to coverage evaluation and possible adjustment of future censuses.

The Census/CPS/IRS Match Study provides a three-way match that is used to form population estimates. Estimates using this three-way match would have smaller variance and possibly smaller bias than estimates using the two-way match done in PEP. Also, estimates of correlation bias in the PEP would be provided (Miskura and Thompson, 1983). Other studies, e.g., the Demographic Analysis of National PEP Estimates, Local Area Estimation Research, and the Explanatory Analysis of PEP Data (Hogan, 1984), have direct implications for the feasibility of adjustment procedures.

The panel urges that the above tests be completed and fully documented, because the results have potential implications with respect to the effective design of other field tests currently being planned. The panel has an overall concern that the history of tests completed by the Census Bureau has not always been available to help in the design and consideration of new tests.

Recommendation 4.1. We recommend that the Census Bureau assign a high priority to the completion and reporting of 1980-based tests related to coverage evaluation, especially the Census/CPS/IRS Match Study.

STUDIES OF COVERAGE EVALUATION STRATEGIES

The 1985 Pretest of Postenumeration Survey Methodology

The 1980 postenumeration program (PEP) was performed in an attempt to obtain information about, among other things, subnational over- and undercounts.[1] The Census Bureau experienced a number of problems in conducting the 1980 PEP, and its planned pretest on postenumeration survey methodology (Hogan, 1984:Appendix A) has been designed to try to explore ways of overcoming some or all of these difficulties.

As planned, the test will proceed as follows. A sample of 200 blocks in an area designated for a pretest census will be selected, completely relisted, and matched to the pretest census records. The matching will be a two-way computer match between the sample and the census listings. The two-way match (as opposed to a one-way match, which does not determine the matching status of each record on both lists) will enable the Census Bureau to estimate the overcount as well as the undercount. Nonmatches will be followed up using many different sources, e.g., telephone directories, the post office, local welfare rolls, etc., for tracing.

The problem areas to be addressed by this pretest are:

(1) Computer matching;
(2) Balancing the undercount with the overcount;
(3) Evaluating the overcount;
(4) Nonresponse research;
(5) Alternate questionnaire design;
(6) Rules on whether the current or the listed resident should be enumerated;
(7) The use of the PEP to benchmark other evaluation methods of interest;
(8) Homogeneous domains and their effect on block sampling; and
(9) Limited follow-up.

A few of the above issues require some explanation. Balancing the undercount with the overcount refers to developing procedures that treat like components of the undercount and the overcount similarly. For example, the treatment of movers should be symmetric whether one is estimating the undercount or the overcount. Rules on whether the current or the listed resident should be enumerated in the PES refers to the problem of movers and whether new residents or the residents listed as

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[1]The 1980 PEP was a special type of postenumeration survey (PES). In the PEP, records for persons interviewed in April and August 1980 for the Current Population Survey (Bureau of the Census, 1978a) were matched to the census records. In this section we use the terms PES and PEP interchangeably. In 1990, the successor survey to PEP may not even be taken after enumeration, and therefore may not be "postenumeration."

present on Census Day are counted. The use of homogeneous domains (see Tukey, 1981) refers to stratification of the postenumeration survey sample by variables thought to be related to the undercount; such stratification is not necessarily confined to political boundaries, even county or state boundaries.

Of the nine problem areas listed above, certainly some are unrelated to one another and therefore can be tested independently of the rest of the pretest. However, because many of the remaining factors do interact, the panel feels that the test may become confounded and lose its ability to inform as to the advantages or disadvantages of the remaining factors. There is also no indication that the Census Bureau has identified methods and criteria for the evaluation of the many components of this test. Furthermore, the likely sample size will be too small to identify the differences in alternative methods of estimating the net undercount, which, in total, is probably substantially less than 5 percent.

The panel believes that priorities for the PES pretest should be based on an error profile of the PEP in 1980, and the most promising improvements should be investigated. Suitably modified, this pretest might yield useful information on methods for improving the PEP. Finally, the sample design has interest for some of the panel, as it may provide a convenient data set on which some adjustment procedures could be tested.

> Recommendation 4.2. We recommend that the Bureau of the Census narrow the scope of the pretest of the PES methodology. We believe that as planned it is too ambitious and is an inefficient use of scarce Census Bureau staff. We believe that a test limited to the most promising improvements would better serve the interests of the Census Bureau in determining the effectiveness of changes in PES methodology.

Research Study on Hard-to-Count Groups

Demographic analyses of past censuses have indicated a pattern of undercoverage such that certain groups, e.g., black men ages 18-40, appear to be missed more often than the general population. These same groups tend to be missed in independent surveys as well. Therefore, in order to ascertain the completeness of coverage for these groups through direct enumeration, it is necessary for the coverage evaluation program to make use of alternate methods of enumeration. In order to collect the needed information subnationally, demographic techniques are not feasible, as mentioned above. Two techniques that have been proposed for measuring underenumeration for these groups are megalist methods and reverse record checks. Megalist techniques, by using lists more fully representing members of these groups to match to the census, can enumerate people who are missed when survey techniques are used. Reverse record checks are based on the assumption that being missed in the census is strongly age-dependent, and 10 years ago or 10 years hence an individual may have been or may become easier to count. The pretest proposed by the Census Bureau on hard-to-count groups (Hogan, 1984:Appendix B) will take a sample of 4,000 adult males in each of two studies, one testing a megalist and the other a reverse record check. A postenumeration survey will be run

simultaneously, with the idea that it may be used to augment either of the two procedures (since they will be used here to help count the particular population of men ages 18-40).

In the megalist study, several record sources will be merged to create a megalist with which to search for people missed by the census pretest. The following sources may be used:

(1) The 1983 Internal Revenue Service Individual Master File;
(2) Unemployment records;
(3) Immigration and Naturalization Service files;
(4) Comprehensive Employment and Training Act (now Job Training Partnership Act) files;
(5) Draft registration files;
(6) Driver's license files; and
(7) Other lists, e.g., police blotters or records of local hospital admissions.

The merged list will have to be unduplicated. (For a possible method for merging these lists, see Kadane and Lehoczky, 1976.) If sampling from the lists is used, the problem of duplication will certainly be reduced significantly. In addition, to use dual-system estimation techniques, either the merged list will have to be representative of the specific population of interest, or the nonrepresentativeness of the merged list will have to be estimated.

In the reverse record check study, a block sample of the 1980 census with maximum overlap with the pretest census area will be drawn. The census microfilm will then be scanned for records of males ages 13-35 and the information transcribed. Using the address register, 1980 addresses will be obtained. These people will then be traced and matched to the census pretest.

At the conclusion of each half of this pretest, these two methods of enumerating hard-to-count groups will be compared with respect to overall costs, the number of people found that were missed in the pretest census, etc. The major objective is to determine if one or both procedures are feasible and also to assess the relative strengths and weaknesses of each procedure.

The panel feels that the megalist half of this test has not been described in great enough detail. It is not explained how the difficulty in eliminating duplication in such massive lists will be resolved. It is unclear how it will be determined that the final megalist is "representative." In addition, many of the lists proposed for use (e.g., police blotters and unemployment records) have been tried previously with poor results (see Bureau of the Census, 1976:2-8).

The planned reverse record check does not mirror the performance of a reverse record check in the decennial census, primarily because there is no accounting for groups missed in the previous census. Finally, it is unclear how one would assess the validity of the results.

Recommendation 4.3. We recommend that the Bureau of the Census not proceed with the proposed pretest on hard-to-count groups, unless more clear-cut goals and procedures can be developed. However, nonfield test research on multilist or composite list methods should continue.

For example, research is needed on the relative advantages of various alternative approaches to the use of administrative lists for the purpose of increasing coverage or coverage evaluation. One approach is to merge the lists, or samples from the lists, and match to the census. Another approach is to separately match all the lists, or samples from the lists, to the census, and to each other. Finally, a third approach is to sequentially match the lists, or samples from the lists, pairwise to the census, as described in Ericksen and Kadane (1983). These possibilities and other aspects of megalist methodologies need to be examined, although not necessarily through field tests. The Census Bureau is already investigating one crucial aspect of megalist methodology in the current research on matching (see Childers and Hogan, 1984).

The Forward Trace Study

The Forward Trace Study (Hogan, 1984:Appendix C) is designed to test various methods for tracking people from their 1980 census addresses to their current addresses. The purpose is to determine which tracing method would be most cost-effective to use in any reverse record check planned for the 1990 decennial census.

The Forward Trace Study began in October 1981 by taking a sample from the 1980 census supplemented by a sample of missed persons derived from the PEP. Two other supplemental parts of the sample to be added later are subsamples of births and immigrants. The approximate sample sizes for the four sub-samples are:

(1) 1980 census	11,900
(2) People missed	4,000
(3) Immigrants	2,700
(4) Births	2,700

Three different tracing methods are being examined: (1) periodic tracing with periodic personal contact, (2) periodic tracing with initial personal contact, and (3) tracing only at the end of the period. At the end of the period, an independent household interview will be conducted at the traced addresses to estimate within-household misses and certain types of whole-household misses. The three different tracing procedures will be compared for cost and completeness, especially for hard-to-enumerate groups. One concern is that the people subject to the more intensive tracing procedures may become sensitized to the census, and therefore may be enumerated with greater frequency than the general population. This reverse correlation bias would make it difficult to use dual-system estimation, which often makes use of the independence of the sample and census.

The success of the reverse record check in Canada has suggested the use of a similar procedure in the United States. However, there are major differences that may reduce the efficacy of this methodology in the United States. Some of these are cultural differences in the populations, differences in immigration and emigration rates, both legal and illegal, and the time lag between censuses, which is every 10 years in the United States compared with every 5 in Canada. The Forward Trace Study principally addresses the difference in frequency of the American and Canadian censuses.

The panel feels that the Forward Trace Study is well thought out and likely to yield significant information as to the feasibilty of using a reverse record check to evaluate the completeness of coverage of the 1990 decennial census.

Recommendation 4.4. We recommend that the Bureau of the Census proceed with the Forward Trace Pretest as planned, because it should yield valuable information.

The Reverse Record Check Pretest

The fundamental idea to be tested in the proposed reverse record check pretest (Hogan, 1984:Appendix D) is the possibility of using a pre-enumeration survey to match to the census in order to measure coverage. One of the difficulties with a standard reverse record check is the length of the intercensal period, which makes tracing difficult. Presumably, if the tracing is attempted closer to the time of the census, fewer difficulties in tracing would be experienced. However, with a pre-enumeration survey, one cannot create as complete a sample as is possible with a true reverse record check, in which one of the components of the created sample is a representation of people missed in the previous census.

There are two parts to this pretest. After a pretest census area is identified, a sample for the reverse record check test would be taken from the 1980 census. Household clusters would be assigned randomly to the two parts. Stratification based on minority percentage and other variables related to undercount would be used to ensure balance. For Part A, 1980 census questionnaires would be looked up. For Part B, a house-to-house pre-enumeration survey would be conducted. Tracing for both samples would begin immediately after the interviewing for Part B was completed.

One year after both processes are finished, the two lists would be matched to the 1990 census pretest. Unmatched people would be followed up. The total sample would include approximately 6,000 people: 3,000 for the pre-enumeration survey-based reverse record check and 3,000 for the 1980 census-based reverse record check.

The panel feels that Part A is virtually identical to tests included in the Forward Trace Study. Part B has some weaknesses of design that should cause it to have a much lower priority with respect to other needed testing. The one-year separation between the first contact for the PES and the time of the census pretest is short, given that in the decennial census the separation would be likely to be two years or longer (Hogan,

1984). The deficiency of the coverage achievable in this pretest compared with a true reverse record check is a matter of concern. That is, how could one include some representation of people not counted in the pre-enumeration survey? This representation underlies much of the benefit of the reverse record check methodology. The Census Bureau's research plan notes that the major advantage of this test is the identification of troublesome subgroups for the reverse record check. However, the panel believes that the Forward Trace Study should be able to provide much of this information.

Recommendation 4.5. We recommend that the Bureau of the Census not proceed with the proposed reverse record check pretest, since it will add little if any information to what the Forward Trace Study will provide.

OTHER RECOMMENDATIONS RELATED TO COVERAGE EVALUATION

The panel has considered some of the issues that need to be addressed if the results of coverage evaluation programs are to be useful in modifying census population counts. The panel has two recommendations in this area, one related to research on the feasibility of developing coverage estimates for small geographic areas and the other related to research on the feasibility of developing timely coverage estimates.

Recommendation 4.6. We recommend that the Bureau of the Census perform research as soon as possible on the feasibility of the development of models for subnational estimates of under- and overcoverage.

This recommendation has several aspects. First, we suggest starting with the national age-race-sex undercount estimates derived from demographic analysis for 1980 and deriving from them, through synthetic and related means, state-level estimates. (For the purposes of this discussion, we use the term "synthetic estimate" to indicate any procedure that estimates undercoverage for demographic groups in small areas by carrying down the estimates derived for these groups for larger areas.) Comparison of the synthetic estimates with the "direct" PEP-derived undercount estimates for states should then be made to see whether the results shed light on the feasibility of using synthetic estimates based on national demographic estimates of the undercount to produce state and substate undercount estimates.

The following approach should be explored as well. First, the United States should be divided into two (or three) blockings of about 20-60 relatively homogeneous and not necessarily contiguous domains (Tukey, 1981). Then, using the first blocking, a regression model should be estimated, using from three to six covariates, which fits the PEP undercount estimates derived for the domains. The same should also be carried out for the second blocking (and perhaps the third), attempting to use a different set of covariates. Estimates for substate regions would make use of synthetic techniques based on the regression estimates for the

homogeneous domains. Then the undercount estimates for the two (or three) models should be compared in a variety of ways. It would be interesting to see whether the substate regression estimates summed to the state-level PEP estimates. The effect of these estimates on redistricting or reapportionment could also be examined. The difficulty with this approach is that there are no "true" values. Nevertheless, this type of investigation would provide some clues on model robustness.

A third possibility was discussed but not uniformly supported by the panel. Several areas could be specially chosen for a census pretest that represent a wide diversity of values for some covariates that are considered strongly related to the undercount. Coverage estimates could then be made for these areas, presumably by using a variety of coverage evaluation techniques, including the PEP augmented by the use of administrative lists. A regression model using the above covariates would then be fitted to the PEP estimates for the majority of these regions, setting aside a validating sample. This procedure could assist in assessing the feasibility of a modeled undercount adjustment. At the same time, demographically based synthetic estimates could be developed and compared with the regression estimates. A major problem with this approach is that the census pretest would be carried out, by necessity, for a relatively limited region, and the results could not be generalized for use across the entire United States. There are other serious problems related to the generation of PEP-type estimates for small clusters.

The panel makes one additional recommendation that relates to the previously discussed concern regarding the time limitation inherent in any adjustment program. The basic idea of the recommended research is to examine the possibility of: (1) the use of earlier months (e.g., December 1989 and April 1990), instead of April and August, as the survey months for the PEP or (2) the fast matching of people "forward traced" prior to the census.

It is important to clarify the distinction between the research the panel is calling for here, which includes the possibility of a pre-enumeration survey, and the recommendation for the cancellation of the reverse record check pretest, which includes a test of a pre-enumeration survey. The panel is in favor of the testing of a pre-enumeration survey taken as close to the census as possible, possibly between one and four months prior to the census, to consider as the basis for coverage estimates derived using PES methodology. However, as the time period between survey and census lengthens, dynamic factors such as population growth and redistribution of the population due to migration cause pre-enumeration surveys taken much sooner to be less worthwhile for purposes of coverage evaluation using PES methodology. Thus, the one- or two-year separation between the survey and the census under test in the reverse record check pretest is not recommended by the panel, as stated in Recommendation 4.5. Similarly, the panel is in favor of testing procedures to expedite the completion of reverse record checks, especially for the fast matching of people, as stated in Recommendation 4.4. However, the loss of the representation of people missed in the previous census resulting from the use of a pre-enumeration survey taken one or two years before the census is too large to justify the gain of a higher percentage of people successfully traced.

Recommendation 4.7. We recommend that the Bureau of the Census explore the logistical problems, through a field test if necessary, involved in conducting a PEP, or a type of reverse record check, that could supply subnational estimates of coverage by December 31 of the census year or April 1 of the following year.

5. ISSUES IN ADJUSTMENT, IMPUTATION, AND ESTIMATION

The panel directed part of its attention to a multifaceted topic encompassing the issues of estimation, imputation, and adjustment. These topics are related. Imputation makes use of a model (often only implied) and is therefore a form of estimation. Any adjustment methodology would also need to make use of statistical estimation in order to combine census data and the information from coverage evaluation programs. The central idea identified by the terms adjustment, estimation, and imputation is the modification or enhancement of the responses elicited in the census.

Currently, the Census Bureau adjusts the responses obtained from the census primarily in three ways: (1) hotdeck imputation, in which responses randomly selected from similar respondents are used to fill in missing information on incomplete questionnaires, (2) iterative proportional fitting, described below, to weight the sample so that selected aggregates of long-form responses agree with corresponding aggregates of short-form responses, and (3) the imputation of whole persons on a random basis for housing units believed to be occupied but for which there is no information about the occupants. These three types of modification are consistent with the point of view held by the Census Bureau that the information produced be internally consistent, a term defined below.

More generally, adjustment and/or imputation can take on a variety of forms due to the multiplicity of purposes for which the census (or modified census) data are used. These purposes are as diverse as providing population counts for apportionment and redistricting, information as inputs to various fund allocation programs, data for market research and local planning, and data on small groups and small areas for various other needs. Thus, the issues of adjustment and imputation have many sides, and their discussion can take many forms.

The above factors introduced a degree of complexity into our discussions of the issues surrounding adjustment and imputation. The panel decided to use this interim report to detail research areas and issues for further investigation, with the expectation of arriving at recommendations and theoretical or procedural advances in the final report. In the remainder of this chapter, we provide a framework for further research on the topics of adjustment and imputation of census data.

MAJOR ISSUES

The panel identified four issues as central to deliberations on the topics of adjustment and imputation: (1) the consistency of the information produced by the Census Bureau, (2) the use of ancillary data sets, (3) approaches to statistical estimation that should be considered, and (4) operational constraints. In what follows we discuss each of these issues and their relationship to adjustment and imputation with respect to decennial census data.

Internal Consistency

Internal consistency refers to the idea that estimates released to the public should, to the maximum extent possible, satisfy various relationships that would be evidenced were all census questionnaires complete and accurate. For example, one of the ways in which census data are released to the public is in the form of cross-tabulations or contingency tables. If there were no nonresponse to the census questionnaires, the elements of every table would add to the totals of that table. This is an example of internal consistency.

There exists a continuum on which the position of complete internal consistency represents one extreme. This extreme almost certainly implies in practice that any methodology that adjusts for nonresponse take the form of some kind of imputation--that is, construction of additional pseudorespondents to be added to the raw census data file and replacement of each and every respondent's missing data items with imputed values. Complete internal consistency at least implies that a consistent imputation must be theoretically possible.

Advocates of the other extreme view, which could be called "handling each possibility for adjustment as a separate issue," would argue for gross adjustment and estimation procedures, rather than individual pseudorespondent imputation. This argument proceeds from the assertion that the population counts are merely numbers, not people, and as such are amenable to any appropriate mathematical process. Thus, in the example given above on contingency tables, the elements of a table need not add to its totals. One issue to be explored is under what conditions there are advantages to departing from internal consistency.

Ancillary Data

Ancillary data are data collected in other programs that provide information similar to the information asked for on the decennial census questionnaires. Such data include information collected from coverage and content evaluation programs and also information collected by other government agencies, e.g., the Internal Revenue Service.

The panel considers an important area for investigation to be the listing and examination of ancillary data sets available to the Census Bureau. This examination might include investigations into their quality, costs of use, any legal and social constraints on their use such as

confidentiality, and how these sources of data might be used to augment census data. In addition, we consider the design of new ancillary data sources for the modification of census data to be within the purview of the panel.

The use of ancillary information introduces an additional concept of consistency--that of consistency or near consistency with respect to values developed from the use of data collected in other programs. For example, data from coverage evaluation programs can give additional information as to the values for the totals of a contingency table. If the values derived from census responses for these totals differ greatly from the values derived from the coverage evaluation program, it may be said that a type of consistency has been violated. Certainly, this is not the same type of consistency as mentioned before, since different data collection schemes will have different universes, data definitions, reference periods, etc., that would preclude insisting on any strict form of consistency.

Approaches to Statistical Estimation

As a result of an inquiry into the value of consistency, it may become apparent that some type of estimation model, different from that implicit in (hotdeck) imputation, is desirable. At this point, four different approaches to a solution of this problem are believed to have promise: (1) iterative proportional fitting, (2) model-based estimation, (3) multiple imputation procedures, and (4) a hierarchical Bayesian approach.

Iterative proportional fitting (Bishop et al.,1975) is a method for forcing the elements of a contingency table to add to the row and column totals. Thus, if a total provided by a coverage evaluation program is believed to be extremely accurate, all lower-level counts from the census could be modified so that they add to it.

An example of model-based estimation (Cassel et al., 1983) models nonresponse with linear models. Variables are selected that are considered to be linearly related to the nonresponse mechanism. For example, a model of this type would be able to assign a probability of nonresponse to groups of respondents. Then, the responses are reweighted to compensate for the missing information. These models are non-Bayesian, that is, they are derived from observed frequencies.

Multiple imputation procedures (Rubin, 1978) attempt to avoid the possibility of a nonrepresentative imputation by repeating the imputation, at the same time providing an estimate of the variance due to imputation. One major advantage of multiple imputation is that it can be accomplished with minor changes to software that is currently used for one-time imputation.

Finally, the hierarchical Bayesian approach (Ericksen and Kadane, 1983) provides a framework for optimally combining estimates with unknown but estimable precision. This approach would allow one to combine row and column totals produced for a contingency table from census data, with row and column totals derived for the contingency table from ancillary data, given that one could estimate the relative precision of the two totals.

The panel intends to compare these approaches in terms of their ease of implementation, considering cost and time constraints, as well as in terms of the validity of the assumptions that underly each approach. A critical issue to be addressed is that of the appropriate criterion or figure-of-merit to be used in assessing the goodness of the adjustment procedure. Kadane (1983) in adducing loss functions for each of the various uses of the census, and the recommendations of Tukey (1983) on yardsticks of imperfection, provide some directions for research.

Operational Constraints

The important factors of time, cost, and staff requirements for the various approaches, as mentioned above, will be considered in assessing the strengths and weaknesses of the various approaches to adjustment and imputation. For example, many current procedures, including imputation, are conducted under the operational constraint that the computation require no more than a few passes through the census data file. In addition, current estimation procedures are often interpretable as simply a reweighting of existing records. This interpretation facilitates the implementation of these forms of estimation. New developments that do not satisfy these operational constraints may have increased costs that may argue against their use.

The issues of privacy and confidentiality present legal and philosophical constraints on adjustment and imputation, especially in the release of small-area data. However, for small areas it is convenient to create the desired cross-tabulations from data files of individuals rather than from estimates based on available, and less sensitive, higher-level cross-tabulations. In this area the notion of "error inoculation," that is, the introduction of random noise to avoid disclosing information, is under examination.

ADDITIONAL AREAS IN NEED OF RESEARCH

Three related issues, which may not be among those normally suggested by the terms adjustment, imputation, and estimation, are issues the panel plans to examine.

The first issue for investigation is the development of a manual for census data users, with references to data items and sources that can be used to check and validate the user's analysis of the data and/or possibly adjust the published census data. This manual could be an extension of information currently provided in Census Bureau user guides and file documentation (Bureau of the Census, 1982b; 1983c).

The second issue for research is the estimation of means and totals for characteristics appearing only on the long-form--that is, not collected on a 100 percent basis. This causes some small areas to have estimates with high sampling variablity. There exist methods to reduce this variability by the use of information for more aggregated regions, in effect borrowing some stability at the cost of increases in bias. This issue is separate from those of adjustment and imputation; it involves the

applicability of regression estimates and empirical Bayesian methodology (Fay and Herriot, 1979).

The third issue identified in need of research is a reconsideration of the mode of presentation of census data. One alternative is the mode used in the Australian census (Doyle, 1980), in which adjusted population totals to be used for purposes of political representation are published by state, but data on characteristics are not altered. If adjusted figures are provided for selected uses, information could be provided to the user that would indicate how adjustment could be made for other uses of census data. This issue encompasses the presentation of census data in the form of public use microdata files as well as tables. The problem of the appropriate form of public use microdata files has two dimensions. The first concerns the benefit of providing raw data only versus providing raw and imputed data. (The Census Bureau currently flags which data are imputed and which are not.) The second dimension concerns the benefit of providing data only versus providing data and procedures or programs for aggregation, tabulation, and/or adjustment. Finally, we are aware that the constraints imposed by the requirements of privacy and confidentiality are a critical factor to consider with regard to public use files.

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