

GAO

Report to the Chairman, Committee on  
Post Office and Civil Service, House of  
Representatives

March 1991

1990 CENSUS  
ADJUSTMENT

Estimating Census  
Accuracy - A Complex  
Task



143425

RELEASED

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United States  
General Accounting Office  
Washington, D.C. 20548

General Government Division

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March 11, 1991

The Honorable William L. Clay  
Chairman, Committee on Post Office  
and Civil Service  
House of Representatives

Dear Mr. Chairman:

This report responds to the Committee's request that we review the Census Bureau's procedures to estimate the accuracy of the census counts in the 1988 dress rehearsal, the final precensus test. The basic procedures used in the dress rehearsal are currently being used in the Bureau's review of the actual 1990 census. The report focuses on the post enumeration survey, which is the key census activity for a possible adjustment. The report provides information to illustrate the complex and difficult nature of this survey and related activities that the Secretary of Commerce will use in making his decision on adjusting the census counts.

As arranged with your office, we plan no further distribution of the report until 30 days from the date of this letter unless you publicly announce its contents earlier. At that time, we will send copies to other appropriate congressional committees; the Secretary of Commerce; the Director, Bureau of the Census; and the Director, Office of Management and Budget. Copies will also be made available to other interested parties upon request.

The major contributors to this report are listed in appendix III. If you have any questions concerning this report, please contact me on 275-8676.

Sincerely yours,

L. Nye Stevens  
Director, Government Business  
Operations Issues

# Executive Summary

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## Purpose

Decennial census results are used for such important purposes as reapportioning the House of Representatives and redrawing congressional, state, and municipal legislative district lines. However, the census historically has undercounted the population, especially black persons. According to the estimate most often cited by the Bureau of the Census, in 1980 the white and nonblack undercount was 0.7 percent while the black undercount was 5.9 percent. Such undercounts can create inequities in political representation and the distribution of federal funds. Because of public concern about the undercount, the Bureau has been studying whether adjustment can improve census counts.

The House Committee on Post Office and Civil Service asked GAO to describe the Bureau's experience with the 1988 dress rehearsal post enumeration survey (PES) and to identify the major challenges confronting the 1990 PES. The PES is the primary methodology the Bureau is using as a basis for possibly adjusting the 1990 census counts; it compares responses from households interviewed several months after Census Day with census questionnaires from the same housing units to determine whether each person was correctly counted, missed, or double-counted in the census.

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## Background

Since 1950 the Bureau has assessed the accuracy of its census counts. After the 1980 census, the Bureau intensified its research into a possible means of adjusting the counts in the 1990 census. The effort culminated in the final test of procedures in the dress rehearsal in St. Louis, East Central Missouri, and Eastern Washington. In 1987 the Commerce Department decided that it would not adjust the 1990 census counts, but a lawsuit filed by New York City and others resulted in the Department's agreement to reconsider its decision. The agreement, incorporated in a court-approved stipulation and order, set a deadline of July 15, 1991, for the Department to publish adjusted 1990 census data if the Secretary decides to make an adjustment.

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## Results in Brief

The dress rehearsal demonstrated a number of major hurdles to completing a high-quality 1990 PES. First, it confirmed that successfully matching PES and census records—the foundation upon which undercount estimates are based—is extremely difficult. It also confirmed that because the undercount is statistically small, even a small percentage of matching errors might significantly distort undercount estimates. Accurate matching will be an even greater challenge for the 1990 PES than in the dress rehearsal because the Bureau must implement

some new and untested procedures. Further, unlike the dress rehearsal, the 1990 PES is nationwide and decentralized, which places additional pressure on the Bureau's ability to successfully manage matching and other PES activities.

The dress rehearsal also confirmed that because of the difficulties in successfully completing matching and other operations, careful, thorough assessments of the PES data quality are vital. The Bureau's assessments of the 1990 PES are intended to show the degree to which the PES undercount estimates are reliable. As such, the assessments form a critical part of the data that the Secretary will need to make an adjustment decision.

A final factor complicating adjustment is the July 15, 1991, decision deadline, which puts severe time constraints on the Bureau's efforts. According to both the Department and Bureau, there is only a 50-percent chance that they can meet the agreed-upon deadline.

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## Principal Findings

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### Matching Poses Major Challenges for the Bureau

The dress rehearsal confirmed that matching is one of the most critical and difficult aspects of the PES. GAO reviewed the Bureau's dress rehearsal match determinations in a randomly selected 375 (10 percent) of the households in which one or more persons in the household were identified as a nonmatch by the Bureau. On the basis of the review, GAO found that PES or census data may be incomplete, inaccurate, or conflicting. For example, in 40 households the same person provided different or conflicting information in the census and PES about household members. In such cases it can be difficult to determine which information is correct.

Even when data are adequate, PES and census data may be improperly matched. Highly accurate matching is important because matching errors in even a small percentage of cases significantly affect undercount estimates. For example, a Bureau evaluation found that without matching errors in the dress rehearsal, the estimated undercount in St. Louis would have been 4.6 percent rather than 5.8 percent, and in East Central Missouri, the estimated net undercount would have been 3.5 percent, not 4.7 percent.

The nationwide scope and the higher number of units involved in the 1990 PES may create more complications than in the dress rehearsal PES. For 1990, the Bureau visited and completed questionnaires for about 170,000 housing units nationwide, in contrast to about 11,000 units in the 1988 dress rehearsal. PES activities in 1990 employed many more people; for example, as many as 850 clerks were employed for matching at the 7 processing offices compared with 50 clerks at the 1 processing office in the dress rehearsal. Conflicting match decisions were adjudicated by as many as 12 PES technicians in each processing office, instead of 2 as in the dress rehearsal.

Because the dress rehearsal was done in a limited geographic area, the Bureau was unable to test its ability to follow up and manage matching efforts for individuals who moved between Census Day and the PES from locations covered by a different Bureau processing office. Managing and controlling the flow of documents between processing offices and the additional research needed to attempt to match individuals who moved also complicated 1990 PES matching efforts. (See pp. 13-15.)

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### Careful Assessments Needed to Determine Quality of Undercount Estimates

The usefulness of the undercount estimates depends on the type and amount of error in the PES. To identify such error in the undercount estimates, the Bureau plans to do 18 assessments of the quality of the 1990 PES. The most important assessment will evaluate the overall effects of errors in the PES. The preliminary results of the dress rehearsal overall error assessment showed that the estimated true net undercount for St. Louis was between 4.0 and 8.5 percent. Likewise, the true net undercount for East Central Missouri was estimated to be between 3.9 and 10.9 percent. (See pp. 16-17.)

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### PES and Related Activities May Not Be Completed in Time for Adjustment Decision

The challenge of estimating the error in the census is compounded by the tight schedule required to meet the court-ordered deadline for an adjustment decision. According to the Bureau, the deadline forced it to compress the original PES schedule, thereby putting the quality of the PES at risk. For example, unlike in the dress rehearsal, the Bureau collected PES data at the same time it was collecting some basic census data. Overlapping PES and census data collection could contribute to respondent confusion and hostility, which hampers data collection and complicates the match determinations. The Bureau's assessments of the PES should indicate some of the effects of respondent confusion and hostility.

The Department and the Bureau have consistently stated that there is only a 50-percent chance that adjustment activities will be completed by the agreed-upon deadline. To date, the Bureau generally has been able to accommodate delays in the PES and other census-related operations. However, the Bureau still faces challenges to meeting the deadline. For example, PES time constraints precluded the Bureau from incorporating into the usual PES process all persons added to the count in the final phases of the census. These persons accounted for less than 1 percent of the census count. However, the effect that not fully including these persons in the PES will have on the quality of the undercount estimates depends on the degree to which these persons are concentrated in PES areas and whether they have characteristics different from other persons in the areas. (See p. 21.)

The Bureau also may not have sufficient time to finish assessing the quality of the PES by the adjustment decision deadline. However, it plans to provide the Department with preliminary results of its analyses on an ongoing basis.

The Department has announced that the Bureau will finish the PES and its assessments even if the studies are not done by the decision deadline. GAO agrees that all aspects of the PES should be completed, since undercount estimates of the 1990 census could prove valuable for the population estimates the Bureau prepares between censuses and for planning future censuses. (See p. 22.)

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## Agency Comments

GAO obtained the views of responsible Department and Bureau officials on its findings and incorporated their comments where appropriate. Their comments were mainly technical clarifications.

# Contents

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<b>Executive Summary</b>		<b>2</b>
<hr/>		
<b>Chapter 1</b>		<b>8</b>
<b>Introduction</b>	Adjustment Question Has Been Contentious	9
	Methodologies to Determine Accuracy of Census Counts	11
	Objectives, Scope, and Methodology	12
<hr/>		
<b>Chapter 2</b>		<b>14</b>
<b>The Post Enumeration Survey and Related Activities Pose Difficult Challenges for the Bureau</b>	Matching Is Difficult but Vital for Success of PES	14
	Careful Assessments Essential for Adjustment Decision	16
	Conclusion	17
<hr/>		
<b>Chapter 3</b>		<b>19</b>
<b>Completing the PES and Related Activities to Meet Deadline for Adjustment Remains in Doubt</b>	Adjustment Deadline Requires Risky PES Time Schedule	19
	New and Untested Procedures Pose Additional Risk to PES Schedule	20
	Late Additions to 1990 Census Counts Complicated	21
	Matching and Follow-Up Efforts	
	Time Allowed to Assess Quality of Adjustment Efforts	22
	May Be Insufficient	
	Conclusions	23
<hr/>		
<b>Appendixes</b>	Appendix I: An Overview of the Planned 1990 PES Methodology	26
	Appendix II: Cases Illustrating Difficulties in Doing a PES	31
	Appendix III: Major Contributors to This Report	33
<hr/>		
<b>Figure</b>	Figure 1: Blacks Have a Higher Estimated Percent Undercount Than Whites and Other Nonblacks	9



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**Contents**

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**Abbreviations**

DSE      Dual System Estimation  
PES      Post Enumeration Survey

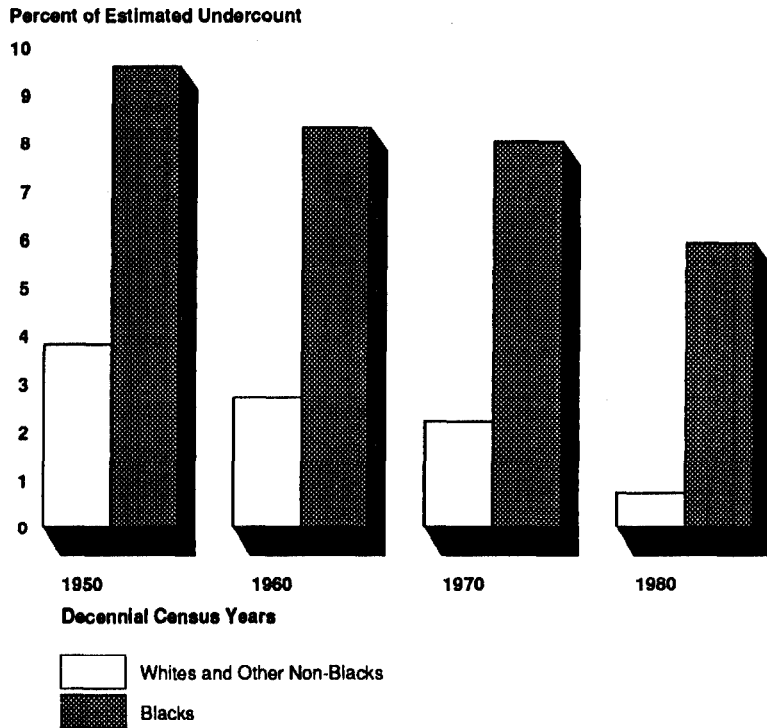
# Introduction

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Decennial census data are used for a wide variety of vitally important purposes. Foremost among these are reapportioning the House of Representatives and redrawing congressional, state, and municipal legislative district lines. Census data are also used extensively during the following decade for allocating billions of dollars of federal and state funds to political subdivisions and by both the public and private sectors in making a wide range of policy, economic, and operating decisions.

The Census Bureau has long recognized that its decennial census counts are not completely accurate. Some people are missed completely. Others are mistakenly counted twice; for example, at both of two residences. Since 1950, Bureau evaluations have consistently identified a net census undercount of the population. The undercount rate has declined with each census, but still remains disproportionate by race. The most often cited estimates by the Bureau show that the overall net census undercount has declined from 4.4 percent of the population in 1950 to 1.4 percent in the 1980 census. However, the disproportionality of the undercount remains. For example, as shown in figure 1, blacks historically have been undercounted at a higher rate than whites and other nonblacks. In 1980, the Bureau's estimate of the white and nonblack undercount was 0.7 percent while the black undercount was 5.9 percent.

**Figure 1: Blacks Have a Higher Estimated Percent Undercount Than Whites and Other Nonblacks**



Source: Bureau of the Census, The Coverage of Population in the 1980 Census (PHC80-E4) Feb. 1988.

## Adjustment Question Has Been Contentious

Undercounts that are not equally distributed among geographical areas and population groups can create inequities in political representation and the distribution of public funds. However, the Bureau has never adjusted census counts to compensate for the historic undercount. For the 1980 census, the Bureau planned to measure the errors in the census counts with a view toward possibly adjusting those counts. However, due mainly to timing concerns, the Bureau significantly reduced its original plans to evaluate the accuracy of the census. Because the Bureau believed that there were limitations in the accuracy of the census estimates derived from its reduced evaluation program, an adjustment using that data could have added more error to the counts than it would have corrected. At that time the Bureau believed that there was no statistically defensible method of distributing the national level of undercount to subnational levels.

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The major reduction the Bureau made in its 1980 evaluation effort was the elimination of a planned post enumeration survey (PES) of about 250,000 households. The Bureau instead completed a smaller matching study. A PES is a matching study in which an independent sample of households are interviewed several months after Census Day, which by law is April 1 in the census year. The information gathered is compared to census questionnaires from those same households to determine whether each person was correctly counted, missed, or double-counted in the census.

The question of whether census counts should be adjusted was the subject of a significant amount of litigation as a result of the Bureau's decision not to adjust the 1980 census. According to the Bureau's Office of the Chief Counsel, 36 lawsuits were filed against the Bureau asking that the Bureau be required to adjust the 1980 census counts. None of the cases was decided against the Bureau.

The debate over adjustment continued when the Bureau was preparing for the 1990 census. After the 1980 census, the Bureau announced an expanded research effort to develop a possible means of adjusting the 1990 census counts. Initially included in that effort were proposals, which were not fully budgeted, to complete a 1990 PES of 300,000 households. However, after the Department of Commerce decided in 1987 that it would not adjust the 1990 census counts, the proposals for the 300,000-household PES were dropped to limit costs. The Department believed that adjustment might introduce more error than it solved and might divert resources needed for the actual census enumeration. The Department instead decided to do a 1990 PES of 150,000 housing units to evaluate the coverage of the 1990 census and assist in developing improved census-taking techniques.

New York City, other localities, and some public interest groups subsequently filed suit against the Department of Commerce and others, asking the court to require the Department to do a full-scale PES and to take the necessary steps to correct 1990 census counts using the most accurate correction methods available.<sup>1</sup> On July 17, 1989, the parties to the suit agreed in a court-approved stipulation and order that all pending motions would be withdrawn, and the Department agreed to vacate its earlier decision not to adjust the 1990 census. The order does not preclude the plaintiffs' rights to future legal actions in this matter.

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<sup>1</sup>City of New York et al. v. Department of Commerce et al. Docket No. 88. Civ. 3474 (U.S. Dist. Ct., EDNY, filed Nov. 3, 1988).

The Department also agreed to do a PES of not fewer than 150,000 households (a number the defendants believed was sufficient) and other procedures necessary to ensure the possibility of producing adjusted counts for the nation's approximately 100 million households. Such adjusted counts would be used for reapportionment, redistricting, and other purposes. As required by the court order, the Department developed guidelines that specified the grounds upon which the Secretary of Commerce will base an adjustment decision. A discussion of the design and mathematical procedures for the PES is included in appendix I.

The Department also established an independent panel by selecting eight experts, four of whom were recommended by the plaintiffs, to make individual recommendations to the Secretary on whether or not to adjust census counts. According to the court order, if the Secretary decides to make an adjustment, corrected counts will be published by July 15, 1991. Both the Department and the Bureau have publicly stated—as recently as September 1990—that they believe there is only a 50-percent chance they will be able to complete the PES and related adjustment activities by the agreed-upon July 15, 1991, deadline. If the Secretary decides not to adjust the counts, the Secretary must publish a detailed statement explaining that decision by July 15, 1991.

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## Methodologies to Determine Accuracy of Census Counts

The Bureau traditionally has estimated the accuracy of the census by using demographic analysis, a comparison between the census enumeration and the estimated population derived from such sources as birth registrations, death records, immigration and emigration data, Medicare files, previous censuses, and estimates of the number of undocumented aliens. The net undercount estimates from the 1950 through 1980 censuses shown in figure 1 are based on demographic analysis. However, because of certain limitations, the most important of which are difficulties in measuring subnational migration, demographic analysis has not been useful for identifying census errors at state and local levels, where accuracy for redrawing congressional and state legislative districts is critical. Even at the national level, difficulties in accurately estimating the number of undocumented residents has reduced the utility of the demographic analysis.

Demographic analyses are helpful in measuring the error in the PES and similar methodologies that rely on matching operations. Demographic analyses assist in identifying the amount of correlation bias, the loss of independence between the census enumeration and the PES that exists because persons who are missed in the census are also more likely to be

missed in the PES. For example, some individuals simply do not want to be counted and will therefore avoid both the census and the PES. Thus, the undercounts identified as part of the PES will tend to underestimate the true undercount. (See app. I, especially pp. 26-27 for a discussion of correlation bias.) The Bureau currently is exploring methodologies that would enable it to combine the results of the PES, its demographic analysis, and the census enumeration to develop adjusted 1990 census counts.

Despite correlation bias, matching studies such as the PES are used to identify census population errors at subnational levels. The Bureau considers the PES to be the key component of its overall evaluation strategy to measure census coverage and possibly adjust the census counts.

The Bureau tested PES procedures during the census test cycle for the 1990 census, including the 1988 dress rehearsal. The dress rehearsal, which was done in three locations (St. Louis, East Central Missouri, and Eastern Washington) was the Bureau's last opportunity to test its census procedures. Only minor modifications are supposed to be made subsequent to the dress rehearsal.

The dress rehearsal PES was generally done at the time when the Department had decided not to adjust the counts. Consequently, it was not done on a production schedule required for meeting a deadline. As a result, the Bureau was forced to make major changes in its PES 1990 operations in an attempt to accommodate the adjustment decision deadline. These changes are discussed in chapter 3.

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## Objectives, Scope, and Methodology

Because of the controversy surrounding the possible adjustment of the 1990 census, the House Committee on Post Office and Civil Service asked us to monitor dress rehearsal PES operations and procedures related to census adjustment. Our overall objective was to illustrate the complex and difficult nature of the PES by describing the Bureau's experience with the PES dress rehearsal and identifying the challenges confronting the Bureau for 1990. Specifically, our objectives were to review (1) the procedures, operations, timing, and results of the dress rehearsal PES and (2) the procedures and schedule for the 1990 PES.

We did not assess the extent to which the Bureau's decision to do a PES with the current sample size of 150,000 households as opposed to the 300,000-household PES that was considered earlier in the decade will

limit the utility of the undercount estimates for the purposes of a possible adjustment. Some of the implications of the Bureau's decision to do the smaller PES will be known when the PES and evaluations of its errors are complete.

To meet our objectives, we reviewed the schedule of PES operations and activities for the 1990 census and compared these to the Bureau's performance during the dress rehearsal in 1988. We examined the Bureau's procedural manuals to determine the methods the Bureau used for matching, time schedules, observation reports, and internal memoranda, and also reviewed other documents, including 1990 PES progress reports through December 1990. We reviewed the dress rehearsal PES results, undercount estimates, the Bureau's evaluations of those estimates, and prior GAO work. We also interviewed Bureau officials responsible for designing, managing, and evaluating PES operations in 1988 and in the 1990 census.

To evaluate dress rehearsal PES efforts to match individuals identified in the PES with the census, we reviewed the match decisions for 1,215 persons in 375 households. The household cases were selected by randomly sampling 10 percent of all households in which one or more persons were not matched in the comparison of PES- and census-counted persons in the three dress rehearsal sites. The results of our sample cannot be projected for the dress rehearsal.

Our audit work was done between July 1989 and December 1990 at Bureau headquarters in Suitland, Maryland, and in the dress rehearsal processing office in Kansas City, Missouri, in accordance with generally accepted government auditing standards. We did not obtain official agency comments on this report. However, we obtained the views of responsible Department and Bureau officials and incorporated their comments where appropriate. Their comments were mainly technical clarifications.

# The Post Enumeration Survey and Related Activities Pose Difficult Challenges for the Bureau

The Bureau faces formidable challenges to complete an accurate PES and associated activities. Like the census, the PES also is subject to error, and even a relatively small percentage of errors can have significant effects on the estimation of the over- or undercount rates. Careful and thorough evaluations are essential to measure the amount of error in the PES and the degree to which the Secretary can have confidence in the over- or undercount estimates when making an adjustment decision.

## Matching Is Difficult but Vital for Success of PES

Matching individuals identified in the PES with census records by using certain key data such as address, name, sex, age, and race is one of the most crucial and difficult aspects of the PES. Generally, incorrect matching determinations can result from two sources: errors caused by incomplete, inaccurate, or conflicting data and errors where a poor match decision was made even though the data were sufficient. In either instance, errors contribute to uncertainty about the accuracy of the PES estimates of census over- or undercount rates.

## Inaccurate, Incomplete, or Conflicting Data Complicate Matching Efforts

One challenge confronting the Bureau is to obtain accurate and complete information to facilitate matching efforts. In our review of match determinations in the PES dress rehearsal, examples of which are included in appendix II, we found that in about 19 percent of the match determinations either the census or the PES had insufficient information to confidently determine if each person was counted or not counted in the census.<sup>1</sup> As a result, the Bureau was forced to make some difficult and potentially arguable match determinations. For example:

- In 40 of the 375 households we reviewed, the same person interviewed as part of the census and the PES provided conflicting information about the household members. In a few other households, different but still knowledgeable respondents also provided different and conflicting information about where household members were living on Census Day. The time interval between Census Day and the PES interview can introduce a problem of correct recall. In such situations, it can be difficult to determine which information is correct. Consequently, the degree to which the resulting match determinations are correct is open to conflicting interpretation.

<sup>1</sup>This calculation applies to households who did not move between the dress rehearsal Census Day and the PES. Our sample of 1,215 persons included about 100 movers, for which complete information could not be obtained because of the limited geographical area covered in the dress rehearsal.



The Bureau estimated that if dress rehearsal Census Day address errors—the inaccurate reporting during the PES of a person's Census Day address—had not occurred, the estimated undercount would have been reduced markedly. Assuming no other sources of error, the undercount estimates for St. Louis would have been 4.2 percent rather than 5.8 percent, a difference of about 28 percent. Likewise for East Central Missouri, the estimated undercount would have been 4 percent as opposed to 4.7 percent, a difference of about 15 percent.<sup>2</sup> (Data for Eastern Washington were not developed due to the limited amount of data from that test site.)

- For 18 of the 375 households, including 5 cited above, the census enumerators and/or the PES interviewers noted that the respondent was hostile and either reluctantly provided information about the household or refused to provide information. Respondent hostility is a major factor that can cause the census and/or the PES to fail to count persons or to improperly classify persons as matched, correctly enumerated, not matched, or unresolved.

In instances where the Bureau is unable to make a decision, the individual is classified as “unresolved.” During the dress rehearsal, the rate of unresolved cases ranged from 1.7 percent to 3.8 percent of all match cases across the three test sites. Unresolved cases later are changed to matched or unmatched using a statistical procedure known as imputation. Imputation assigns a match status based on an examination of the results of similar cases where the Bureau was able to make a determination. While some imputation is unavoidable, it introduces imprecision into estimates of census over- or undercount rates.

The Bureau's decision to reduce 1990 census questionnaire follow-up efforts may have complicated the PES process and may increase the uncertainty of the over- or undercount estimates. To limit census costs, the Bureau decided in 1989 to reduce its follow-up efforts to a 10 percent sample of those short-form questionnaires, which most households received, that failed the Bureau's edit requirements for certain census content data, such as age, sex, and race. To the extent such households are part of the PES sample, the reduced census follow-up will make PES matching more difficult because the Bureau did not obtain the characteristics of some of the persons counted in the census. Because of the reduced follow-up, the Bureau will do more imputations, in which other

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<sup>2</sup>These differences may be reduced in the actual census because the Bureau will attempt to validate the address of movers since the entire country is included in the census.

persons' characteristics are substituted for the missing data. Using more imputations increases the uncertainty of the PES projections of over- or undercount estimates for the various population groups.

### Matching Errors Significantly Affect Undercount Estimates

A second challenge for the Bureau is to control the number of matching errors resulting from an incorrect determination even when sufficient information is available. A Bureau evaluation of the dress rehearsal PES found that the Bureau should have matched more persons. According to this evaluation, if matching errors were eliminated, the undercount for St. Louis would have been 4.6 percent instead of the estimated 5.8 percent, a reduction of 21 percent, and the undercount for East Central Missouri would have been 3.5 percent rather than the estimated 4.7 percent, a reduction of 26 percent.

The nationwide scope and the higher number of units involved in the 1990 PES will challenge the Bureau's ability to maintain the same level of management oversight and uniformity in making matching determinations as in the dress rehearsal PES. For 1990, PES enumerators visited and completed questionnaires for about 170,000 housing units nationwide, about a 15-fold increase over the 11,000 units in the 1988 dress rehearsal.<sup>3</sup> PES activities in 1990 employed many more people; for example, as many as 850 matching clerks were employed at the 7 processing offices compared with about 50 clerks at the 1 processing office in the dress rehearsal—a 17-fold increase in matching clerks. Adjudication of conflicting match decisions were handled by as many as 12 PES technicians in each processing office, instead of 2 as in the dress rehearsal.

### Careful Assessments Essential for Adjustment Decision

The difficulties in successfully completing the PES and the fact that the PES, like all surveys, is subject to a variety of errors, underscores the importance of completing sound and careful assessments of the quality of the PES. The error in the PES must be evaluated before determining if the PES results should be used for adjusting the census counts. The value of the PES estimates will be appreciably reduced if the error in those estimates is considered significant. Thus, assessments of the PES form a critical part of the data the Secretary of Commerce will need to make the adjustment decision.

<sup>3</sup>About 20,000 of these housing units were vacant. As a result, about 150,000 PES household questionnaires were prepared.

The Bureau plans to study its 1990 PES and demographic analysis to determine the quality of those efforts and the degree to which estimates of the census over- or undercount rates appear to be accurate and reliable. The Bureau plans to do 29 studies—18 to evaluate the effects of error that can occur in the PES and 11 to evaluate the Bureau's 1990 demographic analysis. The potential PES errors to be measured include missing data, erroneously reported Census Day addresses, data falsification, errors in matching census and PES records, and other sources of error. The studies of demographic analysis generally will evaluate the effects of errors in the data used in that methodology to independently estimate the population for 1990. We currently are reviewing the Bureau's 1990 PES and demographic analysis assessments as part of a separate effort.

The single most important evaluation that the Bureau has scheduled will assess the overall effects of errors in the PES. Some types of errors—for example, the matching errors discussed on page 16—generally contribute to an overestimation of the true undercount. Other types of errors, for example correlation bias, lead to an underestimation of the true undercount. Total error estimation combines several key sources of error to show whether the coverage error estimates derived from the PES are sufficiently accurate to be used for adjusting the 1990 census for an expected net undercount, especially at geographic levels used for legislative redistricting. For 1990, 9 of the Bureau's 18 studies to evaluate the quality of the PES will be used to form the total error estimate.

Preliminary results of the total error study that the Bureau did as part of the dress rehearsal PES, given certain assumptions, estimated the true net undercount for St. Louis as between 4.0 percent and 8.5 percent with 95-percent confidence.<sup>4</sup> Likewise, the true net undercount for East Central Missouri was estimated to be between 3.9 percent and 10.9 percent, with 95-percent confidence. No error estimates were developed for the Eastern Washington area because that site did not provide a sufficient amount of data for this type of analysis.

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## Conclusion

We found as part of our review of selected dress rehearsal PES cases that incomplete, inaccurate, or conflicting data can make matching extremely

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<sup>4</sup>The 95-percent confidence level means that, in a long series of replications of the PES, the true net undercount rate would fall between lower and upper limits constructed in the same way about 95 percent of the time. For detailed results of the dress rehearsal total error study, see Total Error in PES Estimates of Population: The Dress Rehearsal Census of 1988, Mary H. Mulry and Bruce D. Spencer, (Draft) March 16, 1990.

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**Chapter 2**  
**The Post Enumeration Survey and Related**  
**Activities Pose Difficult Challenges for**  
**the Bureau**

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difficult and leave some determinations open to conflicting interpretation. Other errors, even when sufficient data were available, were made in the matching operation. Due to the nationwide scope and much larger number of units involved, successful matching in the 1990 PES is an even greater challenge for the Bureau than it was during the dress rehearsal. As a result, the PES generally, and matching efforts in particular, require complete, careful scrutiny and thorough assessment to ensure that the Secretary is provided with key data on the extent to which the over- or undercount estimates are accurate and reliable. The Bureau plans to do 18 studies to measure error in the PES.

# Completing the PES and Related Activities to Meet Deadline for Adjustment Remains in Doubt

The Department and the Bureau have repeatedly commented on the difficulties of completing all the activities in the adjustment methodology before the deadline. They have consistently said—as recently as September 1990—that there is only a 50-percent chance that the PES and related activities will be completed by July 15, 1991. In testimony in January 1990, we also discussed the difficulties confronting the Bureau in finishing by the deadline.<sup>1</sup> However, as noted by the Bureau Director, the Bureau has been able to accommodate delays in the PES and other census related operations. Nonetheless, difficult aspects of the PES still confront the Bureau in the remaining months before the adjustment decision deadline.

## Adjustment Deadline Requires Risky PES Time Schedule

In October 1989, the Bureau submitted a plan, including timetables, to the Department for doing the activities necessary to meet the July 15, 1991, adjustment decision deadline. The Bureau noted it was forced to compress the PES schedule and establish time frames that put the quality of the PES at risk.

The collection of PES data while the actual census was still going on is one risk, because overlapping data collection could compromise the quality of both the PES and the census. In the dress rehearsal, PES data gathering was not started until almost all the basic census data collection had been completed. However, to meet 1990 PES deadlines, the Bureau scheduled PES field interviewing to start on June 25, 1990—before all basic census collection activities were completed. As a result, the Bureau interviewed PES households while late census data collection was still underway. These late census data collection efforts, scheduled to begin on June 28, 1990, included (1) checking on the status of the approximately 12 million housing units that were classified as vacant or nonexistent during earlier operations, (2) contacting some households that did not provide complete questionnaire information, and (3) contacting a residual number of households that did not respond to questionnaires and were not completed in the Bureau's initial follow-up of households that did not mail back the census questionnaires.

In practice, enumerators who worked on the census and became aware of the fact that their areas were in the PES blocks may have adjusted their efforts accordingly. While the effect on data quality is not possible to quantify, we believe the enumerators may have worked more or less

<sup>1</sup>Critical Issues for Census Adjustment: Completing Post Enumeration Survey on Time While Protecting Data Quality (GAO/T-GGD-90-15, Jan. 30, 1990).

diligently because they knew their results would be systematically checked. If so, there would be at least two adverse effects on PES results. First, the census results obtained from PES blocks would not be representative of the national census coverage if the enumerators deviated from their normal data collection efforts. Second, respondents who were annoyed or confused by being asked to give information in two Census Bureau inquiries at about the same time might either have provided poorer quality data or refused to cooperate in one or both inquiries. The latter effect would compromise the critical assumption of the Bureau's technique for estimating net census undercount (see app. I), namely that coverage in the census is independent of coverage in the PES. The Bureau's assessments of the PES will measure some of the effects of overlapping census and PES data collection.

Another schedule compression the Bureau made in an attempt to meet the court-ordered deadline was to reduce the time allotted for the major clerical matching operation from 10 to 7 weeks. The Bureau noted that the reduced time for clerical matching could place the quality of PES data at risk. The Bureau was able to complete virtually all clerical matching in the time allowed. However, it will not be clear until the evaluations of PES matching efforts are completed in May 1991 what, if any, effect the compressed schedule had on the quality of the matching process.

After the initial matching operations were completed, some cases needed follow-up interviewing for final resolution. The Bureau had scheduled this interviewing for the period November 9 through December 24, 1990. With the exception of a few outstanding cases in the Detroit and Los Angeles regions, PES follow-up was completed by December 28, 1990. The Bureau completed the remaining cases during early January 1991. During the dress rehearsal PES, the Bureau anticipated problems in staffing and finding people at home during the December holiday period and deferred its follow-up efforts until January, an option that was not realistic under the 1990 PES time constraints.

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## **New and Untested Procedures Pose Additional Risk to PES Schedule**

Some of the major 1990 PES procedures have not previously been tested, which contributes to the uncertainty that the Bureau will be able to meet the adjustment deadline. For example, the Bureau's ability to follow up and manage matching efforts for individuals who moved between Census Day and the PES from locations covered by a different Bureau processing office generally had not been tested. During the dress rehearsal, about 10 percent of persons in the PES sample moved in the 4-month period between the census and the PES. Follow-up on persons who

moved between the census and the PES was limited in the dress rehearsal because of the small geographic area covered by the test.

This was not the case with the 1990 PES. The Bureau's ability to control the flow of documents between the seven processing offices was not tested in the dress rehearsal because only one processing office was used. Matching individuals found in the 1990 PES who had moved since Census Day were difficult because of the additional research and logistics involved in transmitting documents between processing offices. The Bureau's assessment of its PES matching efforts should provide an important indication of the degree to which the Bureau successfully managed mover matching.

Another untested aspect of the 1990 PES is the computer software needed to accommodate the considerably larger PES files from seven processing offices, compared to dress rehearsal files in one office. In late 1990, the Bureau was still developing critical software for processing and estimation, and plans to test it shortly before the time of the first production run. This will provide little opportunity for changes should the software require significant corrections.

In the past, computer software problems have delayed PES operations. For example, during the 1986 Los Angeles test census PES, major delays occurred in estimating the census errors and adjusting the census files.<sup>2</sup> The Bureau attributed these delays, in part, to (1) problems with untested software and (2) keying errors in preparing a computer file of the matching results. Preparation of the PES results necessary for estimation was initially scheduled for 1 day, but subsequently took about 6 weeks to complete. In addition, problems in a computer program for keying in PES questionnaires delayed the dress rehearsal PES about 1 month.

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## **Late Additions to 1990 Census Counts Complicated Matching and Follow-Up Efforts**

The need to rematch census and PES files to include late additions to the 1990 census counts further complicated PES operations. In the dress rehearsal, late additions to the census count were not systematically incorporated into the PES. For the 1990 census, persons were added to the counts as a result of procedures done late in the enumeration phase to improve the completeness and accuracy of the census. For example, the Bureau identified about 321,000 potential additions to its housing unit list as a result of a national recanvassing effort, known as the

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<sup>2</sup>See Decennial Census: Coverage Evaluation and Adjustment Activities (GAO/GGD-87-99FS, July 1987).

Housing Coverage Check, which was not completed until October. The Housing Coverage Check, which was not part of the Bureau's plans for the census, was implemented in July 1990, after the Bureau's research indicated that it had missed housing units when it developed the census address list.

To the extent that these late additions were in PES areas, they needed to be incorporated into the census files used in the PES after the initial matching files were developed and most matching operations were completed. However, not all of these late census data were available in time for complete matching. The Bureau decided that late census data added in late November and December would not be incorporated into the usual PES process. Because of time constraints, field follow-up interviewing was not done. The number of persons added to the census as a result of the late census activities but not incorporated into the complete matching operation amounted to less than 1 percent of the persons counted in the census. However, their influence on the quality of the undercount estimates will depend on whether they were concentrated in PES areas and whether these persons have characteristics different from other persons in the area.

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## **Time Allowed to Assess Quality of Adjustment Efforts May Be Insufficient**

The Bureau has identified the need to complete its assessments of the PES by July 15, 1991, as a major risk to meeting the adjustment decision deadline. As we noted in chapter 2, such assessments form a critical part of the data the Secretary of Commerce will need to decide whether or not to adjust the census counts. The Bureau's schedule requires adjustment activities, including most planned assessments of the quality of the PES, to be completed by mid-May 1991. The Bureau has noted that the scheduled dates for the assessments depend on the planned schedule of activities for the 1990 census and PES being met.

Unfortunately, the total error study depends on the timely completion of the supporting assessments and therefore delays in finalizing the supporting assessments could delay the total error study. At the time we completed our field work in December 1990, the Bureau's schedule called for it to complete the total error study at about the time of the adjustment deadline. However, in February 1991, the Bureau issued a revised schedule that indicated the total error study would be completed by early June 1991. In either case, these dates may be overly optimistic. Data problems could affect the completion date of the Bureau's analysis. For the dress rehearsal, the draft of the results of the total error study was dated March 16, 1990, about 2 years after the dress rehearsal



Census Day. As of December 1990, the dress rehearsal total error study had not been finalized due to higher priorities, according to the Bureau. The Bureau plans to provide to the Department preliminary results of its 1990 PES analysis on an ongoing basis.

The Department stated in its guidelines for a possible adjustment that the assessments of the quality of the PES and related adjustment activities will be completed even if they cannot be done until after July 15, 1991. We believe such data could be useful in determining whether to adjust other data series, such as estimates prepared between censuses. For example, as we recently reported,<sup>3</sup> in fiscal year 1989, 93 federal formula programs involving funds totaling \$27.5 billion used Census Bureau population data, in whole or in part, to determine program eligibility or to distribute funds to state and local governments. Of these 93 programs, 48 used current population estimates to distribute \$10.1 billion, and 45 used 1980 decennial census population data to distribute \$17.4 billion.

One of the continuing objectives of the Bureau's evaluation efforts since 1950 has been to develop improved census-taking techniques. Completing the assessments of the 1990 PES will aid the Bureau in identifying possible future improvements in the census, including adjustment methodologies.

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## Conclusions

The July 15, 1991, deadline for making an adjustment decision forced the Bureau to implement a revised PES schedule that contains risks to the quality of PES data. The Bureau's need to employ overlapping census and PES data collection activities, use untested PES procedures, compress the time allowed for matching, exclude some late census data from being incorporated into the usual PES process, complete PES field follow-up efforts during the December holiday season, and thoroughly assess the quality of the PES and related adjustment effort before the deadline all pose major risks to the quality of the PES.

The importance of the assessments of the 1990 PES and other coverage evaluation efforts is underscored by the Department's commitment, as stated in the guidelines, to complete the assessments even if they are not finished in time for the adjustment decision. We agree that the Bureau should complete its coverage evaluation activities even if they will not

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<sup>3</sup>Federal Formula Programs: Outdated Population Data Used to Allocate Most Funds (GAO/ GGD-90-145, Sept. 1990).

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**Chapter 3**  
**Completing the PES and Related Activities to**  
**Meet Deadline for Adjustment Remains**  
**in Doubt**

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be done by July 15, 1991. The results could be used for future census planning by identifying improvements needed in census-taking procedures and future adjustment activities. The completed assessments, by identifying the estimated error in the census, also would be helpful to preparing estimates made between censuses. Such estimates are used to distribute billions of dollars to state and local governments.



# An Overview of the Planned 1990 PES Methodology

The PES methodology planned for the 1990 census consists of two parts: the survey and the resulting mathematical procedures. The survey includes taking an independent sample of the population and comparing (matching) the information to census records. In this process, the Bureau does field canvassing and computerized and clerical matching of the records. Using the results of this matching, the Bureau will, based on statistical principles, employ formulas to develop coverage error estimates for various population groups and then project the results nationally.

## PES Design and Operations

For the 1990 PES, the Bureau took a stratified random sample of blocks.<sup>1</sup> The sample was designed to be representative with respect to type of place (large metropolitan areas, suburban areas, rural areas); racial and ethnic composition; tenure (whether residents predominantly own or rent their housing unit); and other variables. The PES sample for 1990 consisted of about 170,000 housing units of the approximately 100 million units nationwide and 5,000 block clusters of the approximately 6 million census blocks nationwide.<sup>2</sup>

The Bureau designed its PES sample with the intention of providing sufficient precision for estimates of the "true population" for various subgroupings of the population referred to as post-strata. Thus, by comparing the estimated true population to the census count for each post-strata, the Bureau would be able to estimate the over- or undercounts. For 1990, the Bureau plans to develop estimates for about 1,400 post-strata. The variables used to define the post-strata include the geographic location; place and size; race/origin; age and sex; and, in some cases, tenure (household owner or renter). For example, one post-strata consists of black males, aged 0-9, in the New York City area.

## Field Interviewing

In February and March 1990, experienced Bureau staff members visited each sampled block and were instructed to record the addresses of all housing units. Starting in June 1990, PES interviewers were instructed to visit each sampled housing unit to do a personal interview with a household member and to complete a PES questionnaire. According to the Bureau's procedures, the PES interviewers attempted to complete all

<sup>1</sup>In urban areas, a block is usually equal to one city block. In suburban and rural areas, a block usually begins and ends at some physical or geographic feature, like a road, river, or county boundary line. The Bureau has divided the country into about 6 million census blocks.

<sup>2</sup>A block cluster is either one block or a cluster of several small blocks.

interviews with a household member. However, Bureau instructions said that if this could not be accomplished after repeated visits on different days and at different times, the interviewers were permitted to interview persons who were not household members, such as neighbors and apartment managers.

During the interview, the interviewers obtained information similar to the basic data obtained during the census. For example, they asked the name and characteristics (sex, age, and race) of each person living at the sampled address and whether the occupants own or rent the housing unit. Additionally, special questions were asked to determine where each person in the household was on or about Census Day. Information on others who might have lived at the address on Census Day but no longer resided at the sampled address at the time of the interview was also obtained.

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## **Computer and Manual Matching**

As they were completed, PES interview questionnaires were sent from field offices to processing offices for keying the PES information into computer files. The address keyed for each person was the address where the person reportedly lived on Census Day.

PES and census computer files were then generated for the computer matching operation.<sup>3</sup> Using the information in the PES and census files, the computer assigned one of various codes to each person on each PES block in the file. For example, codes might be "M" (match to both files), "P" (possible match to both files), "N" (PES nonmatch with the census file), "E" (census nonmatch with the PES file), "J" (incomplete PES information to attempt a match), or "K" (incomplete census information to attempt a match).

Clerks in the processing offices reviewed the nonmatch persons to determine if any could, in fact, be matched. They reviewed the actual census and PES questionnaires, as well as other data to help in this determination. The questionnaires or other sources, such as census maps, might have provided additional information that showed that persons did, in fact, match. Multiple clerical groups separately reviewed each nonmatch situation and made match determinations. PES technicians, who are more

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<sup>3</sup>The PES file is the data keyed from the PES questionnaires. The census file contains information obtained during the census for housing units recorded as being on the PES sampled blocks or any surrounding blocks.

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highly trained, reviewed all cases to adjudicate differences in the clerical determinations.

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## Field Follow-Up Operations

To further resolve the nonmatches, the Bureau sent interviewers to revisit housing units to follow up on conflicting, insufficient, or missing data. The follow-up information, however, does not always resolve the nonmatch situations. The follow-up interviewer may not have been able to interview the nonmatch person or another reliable person. The person interviewed may be the nonmatch person or a reliable respondent, but the person may not remember the Census Day address or provide any better information than the initial interview. These cases may be classified as unresolved and are taken into consideration in the undercount estimation formula.

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## Mathematical Procedures

Before any calculations can be made to determine the estimated true population for the various groupings, missing person characteristics must be statistically imputed and unresolved cases statistically resolved. Missing person characteristics such as tenure (owner or renter), race, sex, and age are statistically imputed from data reported for other household members or reported on complete questionnaires from similar households in the geographic area. For unresolved cases, the Bureau uses statistical imputation methodology, which incorporates cases into the formula as matched, correctly counted, or erroneously counted.

The Bureau estimates the true population for each grouping by using the matching codes. To do this, the Bureau uses a methodology called dual system estimation (DSE). Using this methodology, the true population can be estimated by comparing the number of people counted in both the PES and the census and the people counted in only the PES or the census.

We provide an illustration of DSE in a forthcoming report on the Department of Justice:<sup>4</sup> Suppose a game warden is interested in knowing the total number of bears in a preserve. On the first day, she captures 100 bears, ties a ribbon around the neck of each bear, and releases them. On the second day, she again captures 100 bears and observes how many of them have ribbons around their necks. The most extreme outcomes are instructive: If all of the bears captured on the second day have ribbons, the total population is probably small (possibly no more than 100). If

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<sup>4</sup>U.S. Attorneys: Better Models Can Reduce Resource Disparities Among Offices, (forthcoming).

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none have ribbons, the total population is probably large (at a minimum no less than 200).

Generally, the larger the number of ribboned bears that are recaptured (i.e., the larger the number of "matches") relative to the total number captured on the second day, the smaller is the inferred number of bears in the preserve. To be sure, assumptions are required for the validity of any such inference. If the ribbons did not allow all of the recaptured bears to be identified (say, because some bears ate their ribbons), the inference might be faulty. Alternatively, if ribboned bears were more likely to be captured on the second day than unribboned bears (say, because the ribbons impeded escape), the inference might be faulty.

The example illustrates a principal assumption of DSE: whether an individual is counted in the PES is not conditioned by whether the individual was counted in the census. However, violations of this assumption, called "correlation bias," are plausible. If certain people—such as those who wish to avoid being counted—are likely to be omitted from both the PES and the census, then DSEs of total population size are too low ("biased downward") and estimated coverage probabilities are too high ("biased upward").

In other words, the capture/recapture methodology assumes that chances of being found in the PES are not affected by the person's being counted in the census. However, this is not the case. The Bureau's demographic analyses have demonstrated the existence of correlation bias, that is, persons missed in the census are more likely to be missed in the PES than those counted in the census. As a result, the undercount estimates from the PES, while important, could understate the true census undercount.

Using the estimated true population for each grouping derived from the DSE, the Bureau calculates the estimated census error for that grouping, or the percent the grouping was over- or undercounted. The over- and underestimates can then be applied to each block in the nation. For example, if the adjustment factor for black males aged 0-9 living in central cities in the Mid-Atlantic area is 1.02, then for every 100 such people counted in the census in those areas two persons will be added. If the block has only 25 such persons, a half person would theoretically be added. Since a portion of a person is unacceptable, one person will be added using a statistical rounding procedure. If there are no people with

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**Appendix I  
An Overview of the Planned 1990  
PES Methodology**

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those characteristics enumerated in the block in the census, none will be added.<sup>5</sup>

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<sup>5</sup>This illustration is from The 1990 Post Enumeration Survey: An Overview, by Howard Hogan, Bureau of the Census, presented to the Population Association of America Annual Meeting, Toronto, Ontario, May 3-5, 1990.



# Cases Illustrating Difficulties in Doing a PES

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In our review of 375 households in the dress rehearsal, selected by randomly sampling 10 percent of all households in which one or more persons were not matched in the comparison of PES and census-counted persons in the three dress rehearsal sites, we found examples that illustrate respondent hostility and the receipt of conflicting information that the Bureau encounters in doing a PES.

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## Respondent Hostility

Example: The enumerator reported at the time of the PES that the respondent, a grandmother, was hostile, suspicious, and nonresponsive in the interview. However, the enumerator obtained some information about the household from the woman's 5-year-old grandchild. The grandmother had also refused to provide complete information for the census questionnaire when contacted by an enumerator during the census nonresponse follow-up operation. The census enumerated a husband and wife. The PES captured a woman and grandchild. The PES follow-up confirmed the husband was correctly enumerated. For this household, the PES considered two persons (husband and wife) to be correctly enumerated in the census and one person (child) missed in the census. If the grandchild was not a resident of the household, as the census classified the child, the true population was overstated and the undercount was accordingly overstated. Because of the hostility of the grandmother, we believe the number of persons actually residing in the housing unit on Census Day is uncertain.

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## Inconsistent and Conflicting Information

Example 1: The same respondent for the census, the PES, and the follow-up provided different information each time about a member of the household. On an enumerator-completed census questionnaire, the respondent did not list the person; in the PES, the respondent reported the person had been at the housing unit for 5 years; and in the evaluation follow-up, the respondent did not know where the person lived on dress rehearsal Census Day. The person was classified as not counted in the census. That classification contributed directly to a higher estimated net undercount. However, if as a result of the PES the Bureau could not definitively determine where the person should have been counted on Census Day, the person should be classified as "unresolved." That classification could result in a lower estimate of undercount than the classification of not counted.

Example 2: Two knowledgeable respondents provided different information about the same household member. In the PES, the mother said she did not remember if her daughter resided at the housing unit or her own

apartment on Census Day. She thought she listed her daughter on the census questionnaire because she believed her daughter would probably not complete the questionnaire. However, the daughter was not listed on the census questionnaire completed by the mother. In the PES follow-up, the father said his daughter was at the household for several years, including dress rehearsal Census Day. The daughter was classified as not counted in the census. That classification contributed directly to a higher estimated net undercount. If the daughter should have been counted by the PES at her own apartment on Census Day, and was counted there, then the daughter would have been classified as correctly enumerated and would have supported the census count as the true population.

Example 3: Three persons were classified as erroneously enumerated in the census. We believe the circumstances surrounding this case are confusing and could support different determinations. Both the census and PES information were obtained in July 1988. The census respondent, a household member, reported the three persons on an enumerator-completed census questionnaire, but the PES respondent, another household member, did not. The PES follow-up interview in January 1989 reported the three persons had moved in February 1988, about 1 month before the dress rehearsal Census Day. The PES follow-up respondent was not identified. The evidence seems clear that the three persons were not at the household at the time of the PES interview. However, whether or not they were at the household on Census Day is debatable on the basis of the available information. The length of time after Census Day that the information was obtained causes us to wonder if the respondents remembered exactly when the three persons moved.

This "erroneous enumeration" classification reduced the net undercount rate. If these three persons had been at the household on Census Day and had been classified as "correctly enumerated" in the PES, the census count would have been sustained by the PES.

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# Major Contributors to This Report

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## General Government Division, Washington, D.C.

William M. Hunt, Assistant Director, Government Business  
Operations Issues  
Jack Kaufman, Assignment Manager  
Robert Johnson, Senior Statistician  
J. Christopher Mihm, Adviser  
Deborah Washington, Secretary

---

## Kansas City Regional Office

F. John Schaefer, Jr., Evaluator-In-Charge  
Janet M. Chapman, Site Senior  
Hye Yong Meador, Evaluator



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