Census Duplication and Ambiguities of Census Residence

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Abstract

The 2000 Accuracy and Coverage Evaluation (A.C.E.) was designed to measure the net error in the population count of Census 2000. Net census error is affected by both (1) census omissions of persons who are not counted where they should be, and (2) erroneous enumerations of persons inappropriately counted. In 2001, evaluations of the A.C.E. indicated significant errors in the measurement of erroneous enumerations. The evaluation findings guided the U.S. Census Bureau's decision to publish data products from Census 2000 without adjustment, but the initial analysis did not clearly indicate what aspects of the A.C.E. design and implementation had led to its limitations. Previously, Martin, Fay, and Krejsa reported results of a preliminary analysis of patterns of response to individual questionnaire items in both the A.C.E. and a subsequent reinterview of a subsample of households from the A.C.E. These results were integrated with a preliminary analysis of duplications in Census 2000 identified through computer matching.

Our paper extends previous work by incorporating new data, both for the reinterview, where results from an expert clerical review have become available, and for census duplications, where more extensive results have been obtained. We continue to attempt to identify the best features and limitations of the A.C.E. and reinterview questionnaires. Our results show connections between the ambiguity of census residence for some respondents and duplication in the census, where persons with unclear residence status appear differentially susceptible to duplication in the census. The work also compares the reliability and consistency of survey responses with independent evidence obtained from computer matching. These findings should help to identify areas of difficulty in both conducting the census and coverage evaluations.

1. Introduction

In March 2003, the U.S. Census Bureau released the final set of estimates, *A.C.E. Revision II,* of the net error in the population count produced by Census 2000, based on its 2000 coverage survey, the *Accuracy and Coverage Evaluation* (A.C.E.). The final estimate indicated that Census 2000 *overcounted* the U.S. population by .49% (U.S. Census Bureau 2003). The final estimate replaced an earlier one of a 1.18% *undercount* released in March 2001. In other words, the impact of research during the two-year period changed the estimated population based on the A.C.E. by approximately 4.6 million. Both the March 2001 and March 2003 estimates were produced for detailed demographic and geographic groupings. Between these two sets, Thompson, Waite, and Fay (2001) proposed in October 2001 a "revised early approximation" to the A.C.E. findings, providing estimates for three race/ethnicity groups and a national *undercount* of 0.06%. The assumptions and evidence underlying the October 2001 approximation prefigured some but not all of the research later reflected in the final March 2003 estimates.

This sequence of released estimates corresponded to a series of Census Bureau decisions concerning use of the A.C.E. for statistical adjustment of Census 2000 population counts. A 1999 Supreme Court decision had precluded statistical adjustment of the decennial census counts for the purpose of apportioning the House of Representatives. The Census Bureau considered statistical adjustment through the A.C.E. for all other purposes. In March 2001, the Census Bureau released both the A.C.E. estimates available at the time and its recommendation to the Secretary of Commerce not to use the A.C.E. estimates for redistricting purposes. Because the analysis in March 2001 remained quite incomplete, however, the Census Bureau targeted October 2001 for a second decision on possible use of the A.C.E. for non-redistricting purposes. By October, new analysis identified sources of significant errors in the March 2001 estimates, and an approximation offered by Thompson, Waite, and Fay (2001) suggested the possible impact of the errors (U.S. Census Bureau 2001). Subsequent research, including new findings unavailable in October 2001, was incorporated in the A.C.E. Revision II estimates released in March 2003. The Census Bureau decided not to use the final estimates in post-censal population estimates of the current population. Kostanich and Haines (2003) summarized the methods and assumptions of the A.C.E. Revision II effort.

Three sources of evidence were primarily responsible for the large changes in the A.C.E. estimates.

1. *Demographic analysis* (DA) uses demographic accounting methods and related approaches to derive estimates of the total U.S. population by age, sex, and race (Robinson et al. 1993). Preliminary DA results suggested possible problems with the March 2001 A.C.E. estimates. Some results from DA are incorporated into the March 2003 estimates.
2. A *reinterview* study of a subsample of A.C.E. respondents used a different questionnaire to assess the accuracy of A.C.E. data. Results from the reinterview data are incorporated in the March 2003 estimates.
3. Studies of census *duplication* used reported names and dates of births to detect when persons are counted more than once in the census. Results from these studies are also incorporated into the March 2003 estimates.

Our paper examines the reinterview and duplication results, but it shifts the focus from describing their use in A.C.E. estimation to extracting methodological findings on how well each method worked. We continue our previous collaboration (Martin, Fay, and Krejsa 2002), but we use the more extensive evidence now available. Specifically, the effort for the A.C.E. Revision II estimates included completing a clerical review of the entire reinterview sample instead of the subsample we previously analyzed, and new studies of census duplication increased the detection of duplicates. We hope that our findings serve several purposes, including identifying research questions for coverage measurement in the 2010 census. Although the evidence is indirect, it nonetheless suggests some hypotheses about the validity of the A.C.E. and reinterview results.

The next section details the sources of data and sets them in the context of census coverage measurement. We then summarize the results from our previous collaboration and its relation to other research for A.C.E. Revision II.

2. The 2000 A.C.E. and Its Revisions

Following predecessors in 1980 and 1990 (Fay, Passel, and Robinson 1988; Hogan 1993), the A.C.E. in 2000 included:

1. A *P sample* of listed housing units and persons within them, independent of the census enumeration. The P sample provided the means to estimate *census omissions* of persons and housing units.
2. An *E sample* of census enumerations, partially overlapping with P sample. The E sample provided the estimate of *erroneous enumerations,* enumerations of persons who should not have been counted or who should have been counted elsewhere.
3. A specific choice of *dual-system estimator* to combine results from the P sample, the E sample, and the census itself into an estimate of the true population. Dual-system estimates were computed for a set of distinct *poststrata*, a classification of the population by demographic, geographic, and other characteristics.

The 1980 and 1990 experiences provided ample evidence that both the census itself and any attempt to measure net census error would be subject to general problems commonplace in survey research, such as response error and missing data, and errors particular to coverage measurement, such as matching error. Because the 2000 A.C.E. was more closely modeled after the 1990 PES than the 1980 coverage study, important precedents can be found in the 1990 experience.

2.1 The 1990 Post-Enumeration Survey (PES)

The issue of census adjustment in 1990 could be framed as one of determining whether the PES data, although imperfect, would be adequate for the purpose of improving the 1990 Census results. Although 1990 PES estimates were issued in 1991, the final estimates from the 1990 PES were obtained in 1992 (Table 1).

Table 1. Sources and implied logic in the 1992 estimates from the 1990 PES. Data from evaluations and DA were considered as measures of possible bias, but not incorporated directly into the 1992 PES estimates. The total error model, loss function analysis, and other evidence were used to assess whether the biases in the table were acceptable, that is, not so large as to prevent gains from adjustment.

Source	P sample	E sample
1990 PES, corrected	Acceptable biases	Acceptable biases
Reinterview/other eval	Not incorporated	Not incorporated
DA	Not incorporated	

To formalize the argument that a coverage measurement survey could fall short of perfection yet still be useful for census adjustment, Mulry and Spencer (1993 and earlier work) developed (1) a *Total Error Model* to combine information from

evaluation sources, and (2) methods of *loss function analysis* to compare the adjusted and unadjusted counts. A number of studies, including a reinterview of a subsample of 1990 PES respondents and a study of matching error, provided measures of bias used in their analysis.

The Total Error Model attempted to measure the improvement from adjustment over the unadjusted census by estimating a set of *target populations* to represent possible values for the true population. In estimating target populations, the Total Error Model incorporated the evaluation results and, in some cases, sex ratios from demographic analysis (Table 2). (Sex ratios are typically expressed in the form of the number of males per 100 females. Sex ratios by age and race can be used to assess whether the ratio of the number of men to women is as expected in the census or in estimates based on a coverage measurement survey.) The evaluations provided direct estimates of bias only for high-level *evaluation poststrata,* and alternative models were used to disaggregate the biases among the more numerous poststrata used to compute the 1992 PES dual-system estimates.

Table 2. Sources and implied logic in estimating the targets of the Total Error Model for the 1992 estimates from the 1990 PES. Data from evaluations and the sex ratios from demographic analysis were incorporated into the targets. Alternative targets with and without a correction for the sex ratios from demographic analysis were considered. (In addition, a small correction for ratio bias in the dual system estimator was also incorporated.) Alternative methods of distributing the estimated biases from the evaluation poststrata across the 1992 PES poststrata were also considered.

Source	P sample	E sample
1990 PES, corrected	Base with biases	Base with biases
Reinterview/other eval	Correction, assume no bias, but use different distribution methods	Correction, assume no bias, but use different distribution methods
DA sex ratios	Alternatives: With or Without Correction	

2.2 The 2000 A.C.E.

Although different in many details of design, the underlying logic of the March 2001 estimates was comparable to the 1992 PES estimates in the sense of Table 1. Again, the question was not whether the A.C.E. would be free from all error but whether its errors were small enough so that its use for adjustment would produce a net gain in census accuracy.

Evaluation of the March 2001 A.C.E. estimates included several studies, particularly

- A reinterview of approximately 1/10 of the A.C.E. sample, and other studies of the accuracy of A.C.E. measurement;
- A study of census duplication; and
- Demographic analysis (DA).

Findings from the reinterview and duplication study were unavailable in March 2001, and the DA results were only preliminary. The reinterview paralleled an effort in 1990, but it used a questionnaire with more specific questions with the intent to elicit more accurate recall and understanding of information relevant to determining residence on Census Day, April 1, 2000.

The October 2001 decision (ESCAP II) reflected evidence unavailable for the March 2001 decision:

- The reinterview study detected a large net error in the measurement of erroneous enumerations by E sample; and
- The duplication study indicated that the E sample failed to identify other erroneous enumerations, so that the E-sample estimate of erroneous enumerations was further understated.

Fay (2002a) combined the person-level results from the reinterview and duplication study. The analysis was the primary basis for the approximation offered in October 2001 (Thompson, Waite, and Fay 2001).

The March 2003 A.C.E. Rev. II estimates combine

- The 2000 A.C.E. results;
- Clerically revised reinterview data and other studies of A.C.E. measurement;
- A revised computer study of census duplications;
- A new poststratification;

- A methodological change to poststratification involving separate poststrata for the P and E samples; and
- Demographic analysis, specifically, the DA *sex ratios.*

Demographic analysis has consistently shown a national deficit of adult males relative to females, especially for Black men. In the U.S., coverage studies have failed to fully measure the differential male undercount, a deficiency generally attributed to correlation bias, a possible tendency for the census and the coverage study to fail to capture a group of hard-to-count individuals. Researchers have proposed different estimators to incorporate an allowance for correlation bias, including the two-group model (Bell 1999) used in A.C.E. Revision II.

In addition to the October 2001 analysis of E-sample errors (Thompson, Waite, and Fay 2001; Fay 2002a), Hogan (2002) framed the major research directions for the A.C.E. Revision II effort in an internal memorandum. Table 3 summarizes the complex use of A.C.E., evaluation, and DA results to produce the final A.C.E. estimates.

Table 3. Sources and implied logic of A.C.E. Revision II. Reinterview and duplicate data are incorporated into the estimator to correct both the A.C.E. P Sample and E Sample. DA sex ratios are also incorporated into the model. In addition, the A.C.E. Revision II used separate poststrata for the P and E samples. A.C.E. Revision II did not incorporate an allowance for the efficiency of computer methods to identify duplicates. Reinterview data affords an incomplete correction for measurement error in the E sample; it is an open question whether the correction provided to the P sample is complete.

Source	P sample	E sample
2000 A.C.E.	Base with biases	Base with biases
Census duplicates (Mule 2002)	Correction, without allowance for efficiency	Correction, without allowance for efficiency
2000 Reinterview/other eval	Correction, but incomplete (?)	Correction, but incomplete
DA sex ratios	Incorporated through 2-group model	

3. Research Questions and Methods

Our own study involves some but not all of the cells of Table 3. Previously, we (Martin, Fay, and Krejsa 2002) compared A.C.E. results for the E sample to results from the reinterview. We also compared these results with evidence of census duplication based on exact matching by name and date of birth (Fay 2002b). Thus, our previous study examined some aspects of the three cells in Table 3 in the right-hand column pertaining to the E sample itself, without linking the analysis to DA. Our new study returns primarily to these cells, but it comments briefly on recent findings for the P sample.

We begin with the same basic research questions as a year ago, and our introductory sections from that paper remain appropriate. Consequently, we summarize them here. A year ago, we observed that in spite of the extensive evaluation of the A.C.E., the assessment of individual questionnaire items was quite limited, an observation that continues to hold. We also remarked that the A.C.E. depended considerably on the clerical review of interviewer notes in addition to the responses to the standardized questionnaire items.

The temporal sequence of data collection is important to the interpretation of the data. In Census 2000, most households received a questionnaire mailed to their homes on March 13-15 identifying April 1 as Census Day. The questionnaire did not discourage early response, and some replied early. Those not responding by mail were targeted for Nonresponse Followup by enumerations primarily during May and June.

The A.C.E. comprised four primary steps: (1) an initial interview of P-sample households by phone (April 24-June 13) or personal visit (June 18-Sept. 11); (2) a match of the P-sample reports for the composition of the Census Day household (which was not necessarily the composition of the household on the date of the P-sample interview) to the census to identify a preliminary set of matches; (3) an A.C.E. Person Followup (PFU) to check on the status of all unmatched E-sample cases (that is, persons enumerated in the census but not identified in the initial A.C.E. interview) and ambiguous P-sample cases; and (4) use of the PFU results to determine (a) which P-sample cases were Census Day residents, and which of them were omitted from the census, and (b) which E-sample cases in the census were erroneous enumerations.

Although this high-level summary of census and A.C.E. operations suggests the importance of the concept of where a person lives on Census Day, or what their "usual residence" is as of that date, we reviewed past research (including Gerber 1994; Gerber, Wellens, and Keeley 1996; Martin 1999) indicating that this concept was problematic for some respondents. Many of these previous results applied to the concept of current household membership; to this list we should add the problems of recall (Schacter 2001) often posed by coverage measurement surveys. We remarked (p. 2260),

> Mobility and complex living situations have been identified through statistical and ethnographic research as important causes of census coverage errors. Higher rates of omissions and erroneous enumerations for movers reflect several factors. First, errors occur because respondents report as residents people who moved out before or moved in after April 1st. Even for knowledgeable respondents, it may be difficult to recall accurately when a move occurred, and whether it preceded or followed April 1, 2000. Respondents or interviewers may ignore the April 1st reference date. People who move from one residence to another, especially around April 1st, are at risk of being enumerated at both locations, or missed from both, depending on the timing of the move and nonresponse followup attempts. The extended period of enumeration provides the opportunity for respondents to return a mail questionnaire from one location and respond to an enumerator at another.

The paragraph alludes to a logical relationship between census duplication and erroneous enumeration that is critical to our analysis. The design of the A.C.E. led to the classification of census duplications as erroneous in one of two ways. Within the A.C.E. sample blocks, A.C.E. staff searched for instances of duplicate enumerations within the sample blocks and immediately surrounding blocks. The A.C.E. relied on a different process to detect the duplicate enumeration between areas further apart. In general, the A.C.E. interview, and particularly the PFU interview for unmatched census enumerations, attempted to determine if the E-sample person should have been enumerated elsewhere. For example, a college student living in a dormitory on Census Day should have been enumerated there; the A.C.E. design required that when such a student was enumerated in a parent's household, the E-sample was to identify the potential duplication and classify the enumeration at the parent's household as erroneous. Indeed, the general strategy of the A.C.E. was to classify as erroneous any enumeration at the wrong address on Census Day, whether or not the person was correctly enumerated where they should have been.

Thus, with the exception of census duplications within the A.C.E. area of search of the sample blocks and immediately adjacent blocks, a substantial but imperfect relationship should exist between the detection of census duplicates and the A.C.E. E-sample measurement of erroneous enumerations. Logically, the A.C.E. should have captured most of what the duplicate study found: If a person was enumerated in two places, then when the E-sample sampled the person's enumeration in the wrong place, the A.C.E. should have identified the enumeration as erroneous because the sample address was not the person's Census Day address. In instances when the sample address was the person's Census Day address, then the A.C.E. would have generally classified the enumeration as correct. This argument leads to the expectation that a completely successful A.C.E. process should have yielded essentially a 50% rate for erroneous enumerations discovered to be census duplications. The actual rate of erroneous enumerations from the A.C.E. was substantially less for the identified duplicates. An analogous argument applies to the evaluation sample from the A.C.E. for which evaluation data are available. The reinterview results also failed to identify fully the 50% of erroneous enumerations required under the probabilistic argument.

A second aspect of the problem was also logically important. Computer matching can identify some but not all duplicate enumerations, in other words, the efficiency of computer matching is less than 100%. Additionally, some persons could have been erroneously enumerated in the wrong place and omitted from the correct one. Consequently, the reinterview should have identified some erroneous enumerations that the duplicate study missed.

Fay (2002a) provided a provisional approach to combine the findings from the reinterview with the duplicate study. Although different in form, the A.C.E. Revision II estimator also provided a means to integrate the evidence from the reinterview and duplication studies.

Although logical reasons exist for disagreement between the reinterview and detection of census duplication, we (Martin, Krejsa, and Fay 2002) used the degree of agreement between the duplication study and the reinterview as an indicator of validity. We continue that approach here, although now with improved data.

Our previous study excluded the effect of the clerical coding of notes from the A.C.E. and particularly the reinterview. We may now include in the analysis the final coding of the interviewer notes for the reinterview and other improvements in the reinterview data (Krejsa and Adams 2002). Thus, we now can examine the questionnaire items as keyed against the final determinations of enumeration status used in A.C.E. Revision II.

Information on duplication has also expanded. We have available the duplicate results used in the A.C.E. Revision II estimates (Mule 2002), as well as new results using methods (Fay 2003) that extend those used in our previous work. Both approaches identify more census duplicates than before. Further results will follow in the electronic version of this paper.

This paper reports the results of research and analysis undertaken by Census Bureau staff. It has undergone a Census Bureau review more limited in scope than that given to official Census Bureau publications. This report is released to inform interested parties of ongoing research and to encourage discussion of work in progress.

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