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MEMORANDUM FOR   Documentation

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Subject: A.C.E. Revision II: Design and Methodology

The attached documents describe the design and methodology used in preparing the Accuracy and Coverage Evaluation (A.C.E.) Revision II estimates of net coverage. This document consists of the following:

Chapter 1:   Introduction
Chapter 2:   Summary of Accuracy and Coverage Evaluation Revision II Methodology
Chapter 3:   Correcting Data for Measurement Error
Chapter 4:   A.C.E. Revision II Missing Data Methods
Chapter 5:   Further Study of Person Duplication in Census 2000
Chapter 6:   A.C.E. Revision II Estimation
Chapter 7:   Assessing the Estimates

Chapter 1:   Introduction

Donna Kostanich   February 7, 2003

The Accuracy and Coverage Evaluation Survey (A.C.E.) was designed to measure and possibly correct for net coverage error in Census 2000. However, because A.C.E. failed to measure a significant number of erroneous enumerations, A.C.E. did not meet these objectives. The Census Bureau's Executive Steering Committee for A.C.E. Policy (ESCAP) recommended twice **NOT** to correct the census counts.[1] There are however concerns about differential coverage error in Census 2000 data. While the Census 2000 data products will not be corrected, it is possible that improvements could be made to the post-censal population estimates used for survey controls. This is the Bureau's motivation for correcting errors in the A.C.E. data and developing improved estimates of the net undercount. We refer to these as A.C.E. Revision II estimates.   Revised estimates will provide a better picture of Census 2000 coverage to improve operations for Census 2010 and will help design a better coverage measurement program for 2010. This document provides a description of the methodology used to produce the A.C.E. Revision II estimates. The design and methodology of the original A.C.E. is beyond the scope of this document. The reader is referred to "The A.C.E.: Survey Design and Methodology," a comprehensive technical description of the methodology used for the original A.C.E. estimates released in March 2001.

This chapter summarizes the history of the two adjustment decisions and discusses key findings and limitations. It also introduces the key components of the revision and describes the major errors being corrected. The next chapter provides an overview of the revision process and subsequent chapters provide detailed methodology as follows:

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1.1   Background

The original A.C.E. estimates were available in February of 2001, in time to allow for the possibility of correcting Census 2000 redistricting files. The Census Bureau's ESCAP recommended in March 2001 **NOT** to correct the Census 2000 counts for purposes of redistricting (ESCAP I, 2001). The Secretary of Commerce concurred. Given the information available at this time, this decision was not based on any clear evidence that the Census counts were more accurate, but rather concern that there was some yet undiscovered error in the A.C.E. The A.C.E estimate of a 3.3 million net undercount was much larger than the Demographic Analysis (DA)

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[1] The ESCAP recommendations and all supporting analysis are publicly available on the Census Bureau web site under United States Census 2000.

estimate of only 340,000. Further evaluations were conducted over the next six months to examine the reasons for the discrepancy and to determine if other Census 2000 data products should be corrected. The Census 2000 redistricting files, were the first of many other Census 2000 data products scheduled for release such as the Summary File series, SF1, SF2, etc. (See Census Bureau's website: www.census.gov.) The question remained as to whether these other Census 2000 data releases should be corrected.

In October 2001, the ESCAP again decided **NOT** to correct the census counts for other 2000 Census data products. Analysis of A.C.E. evaluation data and a study of duplicates in the Census revealed that the A.C.E. failed to measure large numbers of erroneous census enumerations (ESCAP II, 2001). This error called into question the quality of the A.C.E. survey results. Some of the key findings from the analyses are:

- An evaluation by Krejsa, et. al. (2001) was the first indication that A.C.E. seriously underestimated erroneous enumerations. This analysis revealed an additional net 1.9 million erroneously enumerated persons for those cases that could be resolved. These results are based on an independent reinterview and matching of about 70,000 E-Sample persons. Because of the serious implications of this finding, a further Review Study was conducted.

- The findings from the Review Study by Adams, et. al. (2001) showed that A.C.E. underestimated erroneous enumerations by a net of 1.45 million persons which was smaller than the evaluation figure but still a significantly large amount. This figure does not include unresolved cases, so the estimated amount is probably somewhat higher. This study was based on a sample of about 17,000 persons selected from the 70,000 evaluation sample. Our most experienced analysts reviewed these cases using both the original A.C.E. person followup interviews as well as the reinterview results to determine their enumeration status.

- Mule (2001) showed that Census 2000 suffers from a large number of duplicate enumerations, i.e., persons who were double counted. Mule computer matched census enumerations in A.C.E. block clusters to those across the entire country. The matching used by Mule was conservative in picking up Census duplicates given his requirement for exact matching at the first stage. Within the A.C.E. block clusters, Mule found only 38 percent of the in-scope duplicates that A.C.E. found, leading us to believe that his matching algorithm was underestimating duplicates in the census. Note that A.C.E. was not designed to estimate duplicates outside the search area and this itself was not a design flaw. A.C.E. was, however, expected to determine which census enumerations were erroneous because they were reported at the wrong residence. The design of the A.C.E. would account for duplicates outside the search area. Mule's study did not distinguish which of the duplicate pair was correct and which was erroneous, but one could easily speculate that half of these should be correct and half should be erroneous.

- Feldpausch (2001) examined the A.C.E. enumeration status for E-Sample cases identified by Mule (2001) as duplicates outside the search area. Only 14 percent of the these E-Sample persons that were duplicates of a person in a housing unit were coded as erroneous by A.C.E. This was much less than the expected 50 percent, indicating that A.C.E. underestimated erroneous enumerations due to not perceiving that these E-Sample persons should have been counted at other residences. Note that these results suggest measurement error in the original A.C.E. figures released.

- Fay (2001, 2002) then compared the enumeration status for the E-Sample Review cases to the duplicates identified by Mule (2001) outside the search area. Only 19 percent of the review cases that were duplicates of a person in a housing unit were coded as erroneous by the Review. Again, this was much less than the expected 50 percent, indicating that the evaluation data and the special review did not identify all the erroneous enumerations. Using these data Fay then produced a lower bound on the level of unmeasured erroneous enumerations of 2.9 million.

- There was also evidence that similar problems may have affected our population sample (P sample) which is used to measure the omission rate. A.C.E. evaluation data from Raglin et. al. (2001) show that there are measurement errors in determining residency and mover status.

Using Fay's lower bound on the level of unmeasured erroneous enumerations, Thompson, et. al. (2002) produced a "Revised Early Approximation"of undercount for three race/Hispanic origin groups. These estimates were intended to be illustrative of net undercount and possible coverage differences. The same methodology and data were later used to expand the calculations to seven race/Hispanic origin groups. (Fay, 2002 and Mule, 2002).   These preliminary estimates show a very small net undercount. The data also indicate that the differential undercount has not been eliminated. These results are limited to the extent that they only provide information at the national level for broad population groups. Furthermore, these preliminary approximations were based on a small subset of A.C.E data and only partially correct for errors in measuring erroneous enumerations. Potential errors in measuring omissions were not accounted for.

In summary, the A.C.E. results were not acceptable because A.C.E. failed to measure large numbers of erroneous census enumerations. This was the reason for not using the A.C.E., but this does not mean that there were no other errors in the A.C.E. In particular, there was concern about P sample cases that matched to enumerations suspected of being duplicates. If the E sample case was erroneous, then that match cannot be valid. The extent of this problem had not been quantified at the time of the latest ESCAP decision. The level of other errors was small by comparison and therefore was not a major factor in this decision. See Hogan, et. al. (2002) and Mulry, et. al. (2002) for further information.

1.2 Plans for Revising the 2000 A.C.E. Estimates

Even though the ESCAP recommended twice **NOT** to correct the census counts, they had concerns about differential coverage error in Census 2000 data. They thought it possible that further research resulting in revised estimates of coverage could potentially be used to improve the post-censal estimates. In addition, revised estimates would provide a better understanding of Census 2000 coverage error that could be used to improve census operations for 2010 and would help in developing better methodologies for the 2010 coverage measurement program.

The major objective was to produce improved estimates of the household population that could be used to measure net coverage error in Census 2000. This meant obtaining better estimates of erroneous census enumeration from the E-sample and obtaining better estimates of census omissions from the P-sample. Furthermore, since the national net undercount, as indicated by both DA and the "Revised Early Approximations," was very close to zero and the census included large numbers of erroneous enumerations in the form of duplicates, it was imperative that the revised methodology carefully account for both overcounts and undercounts. Hogan (2002) summarized the major revision issues in the form of the following five challenges:

1. Improve estimates of erroneous census enumerations
2. Improve estimates of census omissions
3. Develop new models for missing data
4. Enhance the estimation post-stratification
5. Consider adjustment for correlation bias.

There were no field operations associated with the A.C.E. Revision II process. Because of the late date, it was not feasible (or practical) to revisit households for additional data collection. Consequently, the revisions were based on data that had already been collected. One aspect of our strategy for revising the coverage estimates involve correcting measurement error using information from the A.C.E. evaluation data. This is referred to as the recoding operation. Another aspect of these corrections involves conducting a more extensive Person Duplicate Study to correct for measurement error that was not detected by A.C.E. evaluations. This is referred to as the Further Study of Person Duplication (FSPD). The estimation method, discussed briefly in section 2, is designed to handle overlap of errors detected by both of these studies to avoid overcorrecting for measurement error.

The recoding operation was designed to improve estimates of erroneous census enumerations and census omissions. It uses the original A.C.E. person interview (PI) and person followup (PFU), the evaluation followup interview (EFU), the matching error study (MES), and the PFU/EFU review study[2] to correct for measurement error in enumeration status, residence status, mover

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[2]The PFU/EFU review study was not a planned evaluation. It was a special study conducted in a subsample of the evaluation data to resolve discrepancies between enumeration status in the PFU and EFU.

status and matching status. This effort involved extensive recoding of about 60,000 P-sample cases and more than 70,000 E-sample cases.[3] An automated computer algorithm was used to recode most of the cases, but many required a clerical review by experienced analysts at the National Processing Center (NPC). The analysts had access to the questionnaire responses as well as interviewer notes which put them in a better position to resolve apparent discrepancies. It was not possible to completely code all cases because of missing or conflicting information, however the number of conflicting cases was considerably reduced.

The duplicate study was designed to further improve estimates of erroneous census enumerations and census omissions. This study used computer matching and modeling techniques to identify E- and P-sample cases which link to census enumerations across the entire country, including group quarters, reinstated and deleted census cases. For the E-sample links this study does not identify which enumeration is correct and which is the duplicate. For P-sample links, this study does not identify whether the correct census day residence is at the P-sample location or the census location. This information is used to model the probability that an E-sample linked case is a correct enumeration or that a P-sample case is a resident on census day.

New missing data models were developed to reflect the different types of missing data now possible as a result of the recoding operation. There were three new types of missing data to deal with: 1) P-sample households that were originally considered interviews but the recoding determined that there were no valid census day residents, 2) cases with unresolved match, enumeration, or residency status because of incomplete or ambiguous interview data, and 3) cases with conflicting enumeration or residency status because contradictory information was collected in the A.C.E. PFU and the EFU interviews and it could not be determined which was valid. A household non-interview weighting adjustment using new cell definitions was used for 1). Imputation cells and donor pools were developed for the second type of missing data based on detailed responses to the questionnaire. For the conflicting cases in 3), there were no applicable donor pools, and probabilities of 0.5 were imputed for correct enumeration status and census day residency status. Fortunately, the recoding operation resulted in a relatively small number of these cases.

The revised estimates incorporate separate post-strata for measuring census omissions and erroneous census enumerations because the factors related to each of these are likely to be different. Our research efforts focused on determining variables related to erroneous enumerations. This is because much of the previous work on developing post-strata focused only on the census omissions, and by default, the same post-strata were applied to the erroneous inclusions. For the E-sample, some of the original post-stratification variables have been eliminated and additional variables have been added. Variable such as region, Metropolitan Statistical Area and type of census enumeration, and tract return rate were replaced by proxy

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[3]These are probability subsamples of the original A.C.E. P- and E-samples and in the context of A.C.E. Revision II are called revision samples but they are in fact equivalent to the evaluation followup samples.

status, type and date of census return, and household relationship and size. For the P-sample, only the age variable was modified to define separate post-strata for children aged 0 to 9 and those 10 to 17. This was done because the DA estimates suggested different coverage for these groups. The estimated correct enumeration rates and estimated match rates are used to calculate Dual System Estimates (DSEs) for the cross-classification of the E and P post-strata.

The A.C.E. Revision II DSEs include an adjustment for correlation bias. Correlation bias exists whenever the probability that an individual is included in the census is dependent of the probability that the individual is included in the A.C.E. This form of bias generally has a downward effect on estimates, because people missed in the census may be more likely to also be missed in the A.C.E. Since the intent of the A.C.E. Revision II is to estimate the <u>net</u> coverage error, it is important to carefully account for errors of omissions and errors of erroneous inclusions. In previous coverage measurement surveys, the erroneous inclusions were assumed to be much smaller than omissions. Consequently, not adjusting for correlation bias had the effect of understating the net undercount and relative to the census was a correction that was in the right direction but just not big enough. In the presence of large numbers of overcounts, this assumption is no longer valid and it's possible that a correction might not even be in the right direction when the estimate is close to zero. For example, if there is a small true net undercount, we could estimate an overcount because the DSE would underestimate population in the presence of correlation bias. Estimates of correlation bias were calculated using the "two-group model" and sex ratios from Demographic Analysis (DA). The sex ratio is defined as the number of males divided by the number of females. This model assumes no correlation bias for females or for males less than 18 years of age; and that Black males have a relative correlation bias that is different from the relative correlation bias for Nonblack males. The correlation bias adjustment is also done by three age categories: 18-29, 30-49, and 50 and over with the exception of Nonblack males 18 to 29 years of age. This is because the A.C.E. Revision II sex ratios for Nonblacks 18-29 exceed the corresponding modified DA sex ratio and is likely a result of a data problem. This model further assumes that relative correlation bias is constant over male post-strata within age groups.

The DSEs, adjusted for correlation bias, are used to produce coverage correction factors for each of the crossed post-strata. These factors are applied or carried down within the post-strata to produce estimates for geographic areas such as counties or places. This process is referred to as synthetic estimation. The key assumption underlying this methodology is that the net census coverage, estimated by the coverage correction factor is relatively uniform within the post-strata. Failure of this assumption leads to synthetic error.

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