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**Analysis of Questionnaire Errors
in Survey Measurements of Census Coverage**

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Analysis of Questionnaire Errors in Survey Measurements of Census Coverage

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In recent decades, U.S. censuses have produced relatively accurate population counts, but the considerable importance of the results has driven efforts to study and possibly correct the errors of coverage that occur. The 2000 Accuracy and Coverage Evaluation (A.C.E.) attempted to measure the net error of the census, originally with the intention of correcting the census counts for all purposes other than the apportionment of the House of Representatives. In turn, the accuracy of the A.C.E. was assessed by several evaluation studies, including a reinterview (the Evaluation Followup or EFU). Although many of the evaluations implied that the A.C.E. had been generally successful, the reinterview indicated that the A.C.E. had seriously underestimated some types of erroneous enumerations in the census, including persons who lived elsewhere on Census Day. In October 2001, the U.S. Census Bureau decided not to incorporate the A.C.E. findings into Census 2000 results.

Despite extensive evaluation of the A.C.E., so far there has been little detailed assessment of how the questions in the follow-up and reinterview instruments contributed to the different results of the two surveys. In part, this reflects the way the interview data were actually used. Interviewers were encouraged to, and did, record extensive notes describing residence situations. The notes were heavily relied on by the analysts and clerks who determined final residence status. Information from questionnaire responses and interviewers' notes was clerically integrated into summary codes for analysis. The summary codes were the basis for official A.C.E. coverage estimates and the analyses that informed the October 2001 decision.

In this paper, we take a different approach, and analyze the recently available responses to individual questionnaire items designed to measure where people lived on Census Day, April 1, 2000. Our objective is to identify and clarify particular sources of error and bias, and to provide a basis for improving the design of future coverage measurement instruments. We link reports given in A.C.E. interviews (including follow-ups conducted as part of the A.C.E.) with the more detailed information provided in reinterviews (EFU) in order to examine the consistency of reporting. We also introduce independent, auxiliary evidence of census duplications, available from a special study conducted to evaluate the quality of coverage estimates. We focus here on measurements of mobility; a more complete paper (available

from the first author) includes additional analyses of other coverage measurements.

We first briefly review sources of coverage error and the Census Bureau's coverage measurement methods and describe the sources of our data.

The Census Design and Sources of Coverage Error

Following recent decennial censuses, Census 2000 attempted to enumerate all people living in the United States on April 1, 2000. Most of the population was enumerated by questionnaires mailed to their homes March 13-15, 2000. People who did not respond by mail were enumerated during nonresponse followup by enumerators who visited their homes in May and June.

In the census, the Census Bureau attempts to enumerate each person at his or her "usual residence" on April 1st, 2000, defined as the place where a person lives or sleeps most of the time. The usual residence principle is modified by 31 residence rules which apply to special circumstances: for example, people who on April 1st are staying in most types of institutional settings or group quarters (GQs), such as college dormitories, homeless shelters, etc., are enumerated there, even if they also have another residence. The instructions on the census form describe the most common situations, but respondents often find the rules self-contradictory and the terminology confusing (see, e.g., Gerber, Wellens, and Keeley, 1996).

Two basic errors affect the census population total: *omissions* of persons who should be counted, and *erroneous enumerations* of people who should not be counted, such as fictitious enumerations or people counted more than once. The A.C.E. defines omissions and erroneous enumerations with respect to a small geographic area, typically a block and the immediately surrounding blocks. Under this approach, people counted in the wrong block are classified as omitted from where they should have been counted and erroneously enumerated where they were counted.

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.

Because movers are more difficult to locate, census enumerators (and follow up interviewers) must frequently rely

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on reports from landlords and other proxy respondents, who may not be knowledgeable about a household that has moved out. Proxy respondents produce higher coverage error rates than household respondents (Griffin and Moriarity, 1992). Even within a household, there may be no consensus about whether a person lives there or has moved out (Hainer, 1987; Gerber, 1994), and household respondents may assume that an individual who is frequently absent has another residence (Gerber, 1990). In a 1993 national survey, household respondents' reports that individuals had moved out were frequently disconfirmed in subsequent reinterviews, suggesting low reliability of reporting about individuals' moves (Martin, 1999).

Coverage Measurement

The A.C.E. attempts to measure census omissions and erroneous enumerations through a sample survey. An independent sample of the population, the *P sample*, was interviewed to estimate omissions. A sample of census enumerations, the *E sample*, was selected to measure erroneous enumerations. Following the precedent of 1990, the A.C.E. overlapped the P sample and E sample by selecting them from the same sample of blocks.

The A.C.E. comprised several operations, four of which are critical in the analysis that follows.

1. An initial interview of P-sample housing units (HUs) was conducted by phone (April 24-June 13) or by personal visit (June 18-Sept. 11), using a laptop-computer-assisted instrument. The interview established both the current residents and, if different, the Census Day residents of the sampled housing units.
2. P-sample people were matched to the census. If the initial interview established the Census Day address and if the P-sample person matched a person enumerated in the census, then the P-sample person was considered matched to the census and the corresponding E-sample person was classified as a correct enumeration. Thus, because they were matched, the majority of E sample enumerations required no separate field work.
3. Some ambiguous P-sample cases were sent to the *A.C.E. Person Followup* (PFU), which also followed up all unmatched E-sample cases, in order to identify erroneous enumerations, and a small number of matched E-sample cases with unresolved residence status. Interviews were conducted in person in Oct.-Nov., 2000.
4. Followup results were used to reclassify some P sample and some E sample cases, and the results of matching P sample and E sample were used to produce population estimates.

The Measurement Error Reinterview was an evaluation of the A.C.E. based on independent reinterviews of a sample of E-sample and P-sample people in Jan.-Feb. 2001. The response rate was about 97%. The reinterview was administered in person using the Evaluation Followup (EFU) questionnaire, which differed from the PFU questionnaire by including more specific questions to identify living situations likely to be missed or misclassified, or to which particular residence rules applied. Raglin and Krejsa (2000) describe

the development and testing of the instrument. (Both PFU and EFU used paper and pencil questionnaires preprinted with name and address information for sample households. In both surveys, a single household member responded for others, with proxy reports from landlords, neighbors, etc. allowed when household members could not be located.

The chart below summarizes the four stages of data collection of interest in this analysis.

Data Collection	Universe	Date
Census	People in all U. S. HUs and GQs	3/13/00 - 6/26/00
A.C.E. initial interview	People in independent sample of HUs	4/24/00 - 9/11/00
A.C.E. followup interview (PFU)	Selected P and E sample people	10/17/00 - 11/23/00
Reinterview (EFU)	Subsample of P and E sample households	1/01 - 2/01

Somewhat unexpectedly, the reinterview showed that a much larger fraction of the E-sample had been erroneously enumerated than had been estimated on the basis of the A.C.E. initial and follow up interviews. After assessing coding and other sources of discrepancies, a review confirmed 1.45 million additional erroneous enumerations that had not been identified by the A.C.E. (Adams and Krejsa, 2001). The instruments were reviewed as well to identify features that might produce the discrepant results (Martin, 2001). The conclusion was that the more extensive and detailed questioning in the EFU probably identified errors that the PFU missed, but may have overidentified erroneous enumerations in some situations. The later reinterview date may also have resulted in more recall errors.

Methods and Analysis

We analyze detailed (keyed) item responses to identify questionnaire sources of differences between A.C.E. and the reinterview, in particular their identification of erroneous enumerations. We focus entirely upon E-sample cases, that is, people who were enumerated in the census (either correctly or incorrectly) and were selected into the A.C.E. sample. We examine both E-sample cases that did not match to a P-sample person (nonmatched cases) and those that did (matched cases), although we have more information about the former.

We draw on two sources of evidence to examine the quality of the questionnaire data. For the nonmatched cases, we examine the consistency of reporting in the follow-up (PFU) and reinterview (EFU) instruments. Analysis is restricted to 37,825 nonmatched cases that were enumerated in the census, were not identified in the initial round of A.C.E. interviews, but were followed up in PFU and reinterviewed in EFU.

A second source of evidence is from a study (Fay, 2002; see also Mule, 2001) conducted to directly identify duplicates in Census 2000. Exact matching of first and last names and birth dates was conducted for all people enumerated in the census--that is, everybody in the census was compared with

everybody else--and duplicate links were flagged. Enumerations that exactly match have a high probability of being duplicates. The method understates duplications in the census, because exact matching fails to identify a duplicate when names are misspelled or birth dates are missing or incorrect. The duplicate study may also contain some false matches, causing an overstatement of duplicates.

The duplication rates provide evidence independent of both surveys, which we use to assess the quality of the questionnaire classifications. We expect to find higher duplication rates for people whose responses indicate they were enumerated in error at a sample address.

Results: Mobility

The follow-up and reinterview instruments followed different questioning strategies to determine where movers should be enumerated.

The PFU questionnaire did not directly ask whether a person had moved, but asked, as its first question on the topic of residence, item 4a: “Did you live at [Census address] on Saturday, April 1, 2000?” The question required immediate recall, did not clarify the intended meaning of “live at,” and may have erroneously identified as residents some people who were regarded as permanent or long-term residents but did not currently reside in a household. On the other hand, some people who might have met the “usual residence” criterion may not have been reported as living there because it wasn’t their permanent address.

In contrast, the EFU instrument began by asking whether the sample address was the usual residence on the day of the reinterview, then reconstructed Census Day residence by asking when moves in or out of the sample address occurred. It defined “usual residence” and used a calendar to help respondents recall dates of moves.²

Percentages in the tables are weighted and Ns are unweighted. VPLX (Fay, 1998) is used to estimate standard errors, given in parentheses in the tables.

Tables 1a-1c separately present the results about Census Day residence from the follow-up and reinterview surveys. Table 1a presents follow-up (PFU) results for nonmatched E-

sample cases. (Since most matched cases were not followed up, PFU results are not available for them.)³ “No” responses to the PFU question indicate probable errors, because these people were enumerated at a sample address where they said they didn’t live. Col. 1 identifies which categories are considered Census Day (CD) residents⁴, col. 2 shows the percentage reporting in each category, and col. 3 shows the percent in each row duplicated in the census.

Table 1a. Census Day residence according to PFU: E sample nonmatches (N =37,825)

Responses to “Did you/NAME live at [Census address] on Sat., April 1, 2000?”	(1) CD resident?	(2) Percent	(3) % dupli- cated
1. Yes	Yes	81.0 (1.02)	4.4 (.23)
2. No	No	9.6 (.51)	16.6 (1.36)
3. Don’t know, refusal	Unknown	.9 (.11)	8.0 (2.42)
4. Missing data	Unknown	8.5 (.94)	3.6 (.64)
Total		100.0	

Table 1a shows that 81% reported in PFU that they lived at the sample address on Census Day, 9.6% said they did not live there, .9% did not know or refused to answer the question, and data were missing for 8.5%. This is a high rate of missing data. Over one third is due to respondents who had never heard of the person being asked about, and who therefore could not answer the question. (Many of these cases were eventually coded as fictitious enumerations.) The question was also supposed to be skipped for some housing units located outside the search area. Finally, interviewers may have erroneously skipped this and other questions they were supposed to ask, as occurred in the Dress Rehearsal PFU (Keeley, 2000).

People who moved and lived elsewhere on Census Day but were enumerated at a sample address are at risk of being enumerated at both places, and we should observe higher rates of duplication for them if their interview reports are accurate. Conversely, people who said they lived at a sample address and didn’t move should be at less risk of being enumerated more than once. As expected, the rate of duplication is much higher (16.6%) for non-residents (who according to PFU are erroneous enumerations) than for residents (4.4%), thus supporting the validity of the classification produced by the question. The duplication rate may seem low for people identified as non-residents. However, we do not expect all cases identified as errors by the questionnaire to turn up as duplicates, even if the

²The EFU questions were:

1. I’d like to ask you some questions about (your/Name’s) current residence. Is [census address] your/Name’s usual residence now--that is, where (you/he/she) lives(s) and sleep(s) most of the time?
- 2a. IF NO: I’d like you to use this calendar to help you answer the next few questions. We’re going to be talking about the time since the beginning of the year 2000. When did (you/Name) move out of [census address]?
- b. IF DK: Did (you/Name) move out before or after (date of initial ACE interview)? It is highlighted on the calendar.
- c. IF DK: Did (you/Name) move out before or after Sat., April 1, 2000?
- 3a. (I’d like you to use this calendar to help you answer the next few questions. We’re going to be talking about the time since the beginning of the year 2000.) Now I’m going to ask you about when (you/Name) moved IN to [Census address]. Did you/Name move in to (address) since the beginning of the year 2000?
- b. IF YES: When did (you/Name) move in?
- c. IF DK: Did (you/Name) move in before or after (date of initial A.C.E. interview)? It is highlighted on the calendar.
- d. IF DK: Did (you/Name) move in before or after Sat., April 1, 2000?

³1,327 matched cases which were followed up in PFU due to uncertain residence status are dropped from the tables below.

⁴Additional information (about GQ stays and alternative residences) is needed to make a final determination of where a person should be enumerated in the census.

questionnaire measurements were flawless, because not all duplicates have been identified, and a case enumerated in error may appear nowhere else in the census. In addition, the item may have overidentified non-residents.

Similarly, Tables 1b and c present reinterview results for nonmatched (1b) and matched (1c) cases. Responses to EFU items 1-3d were coded into the 5 categories shown. Table 1b shows EFU results for the same cases presented in Table 1a.

Table 1b. Census Day residence according to EFU: E sample nonmatches (N=37,825)

Moves as reported in EFU questions 1-3d	(1) CD resident?	(2) % (.77)	(3) % (.23)
1. Didn't move; or moved in before and out after April 1	Yes	79.2 (.77)	4.4 (.23)
2. Moved in on uncertain date; moved out or died after April 1, or didn't move out	Yes?	3.4 (.38)	5.3 (1.10)
3. Moved out or died before, or moved in after April 1, or never lived there	No	10.5 (.47)	13.5 (1.14)
4. Moved out on uncertain date, not resident at time of EFU interview	Unresolved	1.3 (.14)	14.4 (3.00)
5. Missing data	Unknown	5.7 (.37)	5.4 (.71)
Total		100.0	

Based on their EFU responses, we classify 79.2% of nonmatched cases as Census Day residents (row 1), 3.4% as probable residents, although there is some uncertainty about the date they moved into a sample address (row 2), and 10.5% as non-residents, because they moved out or died before April 1st, moved in afterwards, or never lived there (row 3). Residence is unresolved or unknown for 7% (rows 4 and 5), because they moved out on an uncertain date or data are missing entirely. Uncertain residence status may reflect recall problems due to the passage of time.

The duplication rates support the validity of the EFU classifications of nonmatched cases. The 13.5% duplication rate for non-residents is significantly higher than the rates for residents (4.4%) or probable residents (5.3%).

Comparing table 1b with 1c (below) shows that 97.2% of matched cases were residents or probable residents (rows 1 and 2 combined), compared with 82.6% of nonmatched cases. This is consistent with the assumption that the matched cases were correct enumerations. Nonetheless, the reinterview identified 1.7% non-residents among the matches, as verified by a high duplication rate (11.9%).

Table 1c. Census Day residence according to EFU: E sample matches (N=27,738)

Moves as reported in EFU questions 1-3d	CD resident?	% (.31)	% dup. (.18)
1. Didn't move; or moved in before and out after April 1	Yes	95.6 (.31)	2.5 (.18)
2. Moved in on uncertain date; moved out or died after April 1, or didn't move out	Yes?	1.6 (.14)	2.6 (1.23)
3. Moved out or died before, or moved in after April 1, or never lived there	No	1.7 (.21)	11.9 (3.47)
4. Moved out on uncertain date, not resident at time of EFU interview	Unresolved	.2 (.06)	14.3 (13.46)
5. Missing data	Unknown	1.0 (.16)	1.4 (.46)
Total		100.0	

Thus, the evidence from duplications is generally consistent with the classifications produced by both the PFU and EFU questionnaires. People who reported in either PFU or EFU that they didn't live in the housing unit where the census enumerated them were more likely to have been duplicated in the census. For EFU, this holds true both for matched and nonmatched cases.

Table 2 examines the consistency of reporting in the two surveys. For each row defined by responses to EFU questions, the columns represent the fractions in the PFU who said they lived, or didn't live, in sample households. (Simplified labels are used for EFU categories, which correspond to rows 1-4 in table 1b.) Missing data are dropped from tables 2 and 3.

Table 2. Consistency of reporting Census Day residence in follow-up interviews and reinterviews: E sample nonmatches

EFU residence	PFU residence			N
	Resident	Non-resident	Total	
1. Resident	94.4% (.44)	5.6% (.44)	100%	28,502
2. Probable resident	93.9% (1.46)	6.1% (1.46)	100%	1,056
3. Non-resident	52.2% (2.03)	47.8% (2.03)	100%	2,931
4. Unresolved	73.2% (5.86)	26.8% (5.86)	100%	360

Most (94.4%) people identified as residents in EFU (row 1) were also reported in PFU as having lived there. Although the rate of inconsistency is fairly low (5.6%), it accounts for many

discrepancies because of the large base. Probable residents (row 2) were also reported consistently, but non-residents were not. Only 52.2% of EFU non-residents (row 3) were reported as non-residents in PFU. This high rate of unreliability indicates that one or both sources may have high rates of error in identifying non-residents.

Table 3 presents duplication rates for matched and nonmatched cases, and for the latter, for the cross-classification of PFU and EFU responses. Comparison of cols. 1 and 2 shows that duplication rates were generally higher for the nonmatched cases, which were followed up in PFU, than for the matched cases, all of which were considered to have been enumerated correctly in the census and were not followed up. Yet, the matched cases identified by EFU as non-residents or unresolved residence had high rates of duplication. The assumption that these cases do not require followup should be reexamined.

Table 3. Rates of duplication for E-sample people, by match status and responses to EFU and PFU questions

EFU residence	Matches		Nonmatches	
			PFU residence	
	(1) Total	(2) Total	(3) Resident	(4) Non-resident
1. Resident	2.5 (.18)	4.4 (.23)	3.8 (.23)	14.6 (1.67)
2. Probable resident	2.6 (1.23)	5.3 (1.10)	5.7 (1.23)	2.5 (1.93)
3. Non-resident	11.9 (3.47)	13.5 (1.14)	9.6 (1.18)	19.6 (2.27)
4. Unresolved	14.3 (13.5)	14.4 (3.00)	12.7 (3.42)	20.4 (9.32)

Table 3 shows that cases identified as non-residents by either survey are at greater risk of duplication in the census. Col. 4 shows results for people who, according to PFU, did not live at the address on Census Day. The rate of duplication in this column is high in all but row 2. (Rows 2 and 4 in this column have very small effective sample sizes, as evidenced by the estimated coefficients of variation.) In row 1, the estimated duplication rate, 14.6%, is significantly greater in col. 4 (PFU non-residents) than the corresponding value (3.8%) in col. 3 (PFU residents), partially supporting the validity of PFU results. Similarly, in row 3 (“not resident” in EFU), the rate 19.6% is significantly greater in col. 4 than the 9.6% in col. 3, again suggesting that the PFU response adds information in this instance.

The results also confirm that the EFU information helps to predict duplication. For matches in col. 1, the rate of duplication of 2.5% for row 1 (residents in EFU), is significantly less than the corresponding value of 11.9% in row 3 (non-residents in EFU). With the exception of col. 4, all such comparisons of row 1 to row 3 values are significant. That is, the EFU classification helps identify duplications among total matched cases, total nonmatched cases, and

among people identified as residents by PFU.

Generally, both PFU and EFU responses contribute information about census errors. If a case was identified as a non-resident by *either* survey, high rates of error were observed.

Conclusions

The results indicate high levels of unreliability in measurements of moves in and out of households. (The more complete paper finds similar problems of unreliable identifications of second residences and stays in group quarters.) The A.C.E.’s requirement for precise and accurate measurements is not met by either instrument.

Measured against the criterion of duplication rates, both questionnaires produced valid classifications. Neither questionnaire was clearly superior to the other, in terms of ability to identify errors. Identification of enumeration errors appears to have been greatly enhanced by taking into account information from both surveys, because each questionnaire added information about errors that were not identified by the other. Neither questionnaire could be said to represent a “gold standard” for reporting accuracy.

The reliability of reporting moves is low, and affected by high rates of proxy reporting for people who move out. In EFU, which included direct questions about when moves had occurred, there was a good deal of uncertainty about whether moves occurred before or after the census. EFU’s more detailed questions about moves appear to have identified additional erroneous enumerations among matched as well as nonmatched cases.

Our analysis suggests that the problems of accurately measuring residence status need more intensive research and development than has been devoted to them. The difficulties arise in part from the complexity of people’s living situations, including multiple residences and mobility among them. More basic research is needed to understand sources of error, such as recall error and lack of knowledge on the part of proxy respondents, and to devise questions and categories that can be reliably and accurately reported. Intensive questionnaire design research and testing are needed to improve the quality of coverage measurements.

The results question whether matched cases identified as residents in an initial interview can be assumed to represent correct enumerations that do not require follow-up. The EFU identified small but significant numbers of erroneous enumerations among the matched cases, and these specific cases had high rates of duplication.

The complicated, overlapping, and counterintuitive census residence rules make it difficult to measure coverage accurately. The rules need to be simplified and empirically evaluated. In both surveys, high rates of “don’t know” and missing data for some questions suggest that the level of detailed information required to apply the rules frequently exceeds respondents’ knowledge, especially proxy respondents. The goal should be to create a simpler scheme that can be understood and implemented by interviewers and respondents.

We remind the reader that our results are preliminary. We have not (yet) analyzed the data which incorporate information from clerical coding of interviewers’ notes, and which were the

basis of official estimates of coverage of Census 2000. Thus, our results cannot be generalized to the final A.C.E. estimates. Additional analyses of those data are planned for the future. However, we suggest that a goal for an improved questionnaire for coverage measurement should be to reduce reliance on expensive, time consuming and labor-intensive clerical coding operations. Rather than relying on coded interviewers' notes as the basic data for coverage measurement, accurate classifications should be produced by the standardized questions in the instrument, with a reduced need for intervention and interpretation by analysts and clerks.

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