

Comparison of the Characteristic Imputation in 2000 Census to the Accuracy and Coverage Evaluation Survey for Matched Persons

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Introduction

For the 2000 Census, a characteristic imputation operation ensured that each person in a housing unit on the census roster had a value for the relationship to householder, sex, age, Hispanic origin, race, and tenure questions on the Census Short Form.

This study is an attempt to determine how close the imputed values for the core demographic characteristics in 2000 Census are to the “target” as represented by data for these same items reported by the same households and persons in the Accuracy and Coverage Evaluation (A.C.E.) Survey (Fenstermaker and Kostanich, 2003). Closeness of the comparison between the 2000 Census and the A.C.E. Survey characteristics is assessed by a statistical measure of agreement.

2000 Census Operations

The U.S. Constitution mandates an enumeration of persons in the U.S. every 10 years for the apportionment of the 435 seats in the House of Representatives among the 50 states. The 2000 Census is an enumeration of all 281.4 million persons residing in all 115.9 million living quarters in the 50 states and the District of Columbia. Seven questions on name, relationship to householder, age, sex, race, Hispanic origin, and tenure are asked of each person residing in each living quarters on April 1, 2000 primarily via a mail out/mail back paper questionnaire.

The Edits & Allocations (characteristic imputation) procedure (Cresce and Philipp, 2001) for the 2000 Census Short Form data consisted of a mixture of iterative edit and imputation procedures. The procedures were as follows: 1) validity edits of individual item values in a

person record, 2) consistency edits among items within a person record (e.g., age vs. date of birth), 3) consistency edits of a particular item among persons in a household, 4) item imputation using a person’s name as a predictor (e.g., sex from first name, Hispanic origin from the surname), 5) within household imputation using rules describing valid combinations of values for relationship to householder, sex, and age among household members, 6) allocation of race or Hispanic Origin responses based on the distribution of reported responses within the household, and 7) hot-deck imputation of an entire person or an entire household record from a nearby household.

The 2000 Census Characteristic Imputation procedure used the Hundred-percent Census *Unedited* File (HCUF) as input and produced the Hundred percent Census Edited File (HCEF) as output. The HCEF provides the Census portion of the input data for this study.

A. C. E. Survey Operations

The A.C.E. Survey employed a sample (n = 721,734 persons) of the 2000 Census housing unit Population referred to as the P-sample. In the Summer of 2000, following an independent (from the Census enumeration) sampling of clusters of census blocks and an independent housing unit address listing operation in the selected block clusters, a separate staff of experienced Census Bureau Field Representatives conducted computer-assisted personal interviews (CAPI) of the P-sample households. The purpose of these interviews was to establish an independent roster of persons who lived at the A.C.E. sample address on both Census Day, April 1, 2000 and on the A.C.E. Interview Day.

The A.C.E. Person Matching operation (Childers, 2003) attempted to link persons listed on the P-sample roster to the 2000 Census roster of persons on the HCUF. This Person Matching operation was conducted by computer (Winkler, 1995; Jaro, 1989) with a clerical review. To be included in

¹ This report is released to inform interested parties of (ongoing) research and to encourage discussion. The views expressed on (statistical, methodological, technical, or operational) issues are those of the author(s) and not necessarily those of the U.S. Census Bureau.

the A.C.E. Person Matching operation, *both* the P-sample person and the Census person were required to have a full name and two other characteristics. Primarily name, but also address, date of

birth, age, sex, race, Hispanic origin and relationship to householder were used to match persons between the P-sample and the Census.

Following the Person Matching and field follow-up operations, the A.C.E. Missing Data Characteristic Imputation procedure (Ikeda, 2001) imputed sex, age, Hispanic origin, race and tenure for P-Sample persons missing those characteristics on the A.C.E. data set.

Methodology

In order to provide a means to assess the quality of the 2000 Census Characteristic Imputation procedure, a procedure was needed to link a Census person whose data items had been *imputed* to the same person whose data items had been *reported* in the A.C.E. Survey. The A.C.E. Person Matching operation discussed in the preceding section had already provided this link. The A.C.E. Person Matching had produced a file of P-sample persons matched to Census persons on the HCUF. The next step was to retrieve Census *imputed* values contained on the HCEF to produce the complete analysis data set for this study. The final data set contained 578,691 matched persons.

Incidentally, studies of the Person Matching operation employed in the earlier census coverage surveys have shown consistently (Belin and Rubin, 1995; Jaro, 1989) that the computer matching procedure is of very high quality. Further, Bean (2001) found that the entire 2000 Census A.C.E. Survey Matching operation (including both computer and clerical matching) had 0.2% false matches. False matches represent a critical component of potential bias in this study. Therefore, it is reasonable to assume that approximately 99.8% of the P-sample person matches used as the foundation for the current comparison study are **true matches of the same person**.

Analysis File

The variables chosen to represent the core demographic items of this study were those variables whose categories are assumed to be equivalent on both data files and had individual imputation flags available on both data files. Specifically, the items and item values that satisfied the availability constraints were:

<u>RELATIONSHIP</u>	<u>SEX</u>	<u>AGE</u>	<u>RACE</u>
HOUSEHOLDER	MALE	0-4	WHITE ONLY
SPOUSE	FEMALE	5-9	BLACK ONLY
CHILD		...	ASIAN ONLY
PARENT		75-79	AIAN ² ONLY
SIBLING		80-84	NHPI ³ ONLY
OTHER RELATIVE		85+	SOR ⁴ ONLY
NON-RELATIVE			2+ RACES

<u>HISPANIC ORIGIN</u>	<u>TENURE</u>
NON-HISPANIC	OWNER
HISPANIC	RENTER

Item Response Status

The imputation flags provide the details on the “level of item imputation.” Zajac (2003) identifies four classifications or levels of imputation for Short Form data items in the 2000 Census. The first, and most desirable level is *no imputation at all* in which the answer to the item is as “reported” by the respondent and where the response passed all edits. The remaining three levels, “Assignment,” “Allocation” and “Substitution”, are types of imputation.

- AN *ASSIGNMENT* IS PERFORMED WHEN A RESPONSE FOR A DATA ITEM IS EITHER MISSING OR INCONSISTENT WITH OTHER RESPONSES, AND AN ITEM VALUE *CAN* BE DETERMINED BASED ON PROVIDED INFORMATION FROM THAT SAME PERSON.
- AN *ALLOCATION* IS PERFORMED WHEN A RESPONSE FOR A DATA ITEM IS EITHER MISSING OR NOT CONSISTENT WITH OTHER RESPONSES, AND AN ITEM VALUE *CANNOT* BE DETERMINED BASED ON PROVIDED INFORMATION FROM WITHIN THAT SAME PERSON OR HOUSING UNIT. AN ALLOCATION USES A RESPONSE FROM ANOTHER PERSON WITHIN THE HOUSEHOLD OR FROM A PERSON IN A NEARBY HOUSEHOLD.
- A *SUBSTITUTION* OCCURS WHEN ALL THE SHORT FORM CHARACTERISTICS FOR *EVERY* PERSON IN THE HOUSEHOLD ARE EITHER MISSING OR NOT CONSISTENT WITH OTHER RESPONSES. TO REMEDY THIS, A NEARBY HOUSING UNIT OF THE SAME SIZE WITH COMPLETE SHORT FORM DATA IS SELECTED FROM THE HOT DECK TO REPRESENT THE HOUSEHOLD.

Comparisons

Comparisons of data responses were classified as follows:

1. ALL CENSUS AND ALL A.C.E.
2. REPORTED CENSUS AND REPORTED A.C.E.
3. **IMPUTED CENSUS AND REPORTED A.C.E.**
4. REPORTED CENSUS AND IMPUTED A.C.E.
5. IMPUTED CENSUS AND IMPUTED A.C.E.

Comparison 1 includes all person matches, whether “Reported”, “Assigned” or “Allocated”. Comparison 1 represents the sum of Comparisons 2 – 5.

² American Indian or Alaska Native
³ Native Hawaiian or Pacific Islander
⁴ Some Other Race

Comparison 2 (Reported Census and Reported A.C.E.) provides a starting point for subsequent comparisons. Any discrepancies among data for the reported items are assumed to represent data collection, response, or data processing differences between the two processes.

Comparison 3 (Imputed⁵ Census and the Reported A.C.E.) **is the main focus of this paper** and is intended to provide an assessment of the quality of the Census Characteristic Imputation.

Comparison 4 (Reported Census and Imputed A.C.E.) is intended to provide an assessment of the quality of the A.C.E. Survey imputation.

Finally, Comparison 5 (Imputed Census and Imputed A.C.E.) is intended to investigate the similarities and differences between the 2000 Census and the A.C.E. Survey imputation methods.

Results

The rates of missing items and edit failure for the Census Short Form characteristics shown in Table 1 ranged from 2.0% of cases for Sex to 5.5% for Tenure. For all items, the imputation rates in the A.C.E. Survey were lower than the rates for the same characteristics in the Census.

TABLE 1. IMPUTATION RATES BY ITEM IN CENSUS AND A.C.E. (%)

	REL.	SEX	AGE	RACE	HISP.	TENURE
CENSUS ⁶	2.57	1.98	5.08	3.96	4.37	5.48
A.C.E. ⁷	1.75 ⁸	1.71	2.47	1.43	2.35	1.92

In the 2000 Census, approximately 70% of the households’ data collection mode was *self-response by mail* to a paper questionnaire. For the approximately 30% of Census household non-respondents to the paper form, data collection resorted to a *personal household visit* by a census enumerator.

In the A.C.E. Survey approximately 63% of A.C.E. households had a data collection mode of computer-aided

⁵ The Census *imputed* status in Comparisons 3 and 5 is comprised of the “Assigned” and “Allocated” imputation statuses. “Substituted” persons cannot be included because A.C.E. matched persons must be real persons.

⁶ (Zajac,2003), Table 2., p.12.

⁷ Un-weighted counts (Cantwell, et al, 2001), Table 3a., p. 18.

⁸ The Relationship item was not imputed by A.C.E. The Relationship item *missing* rate was calculated directly from the A.C.E. data set by the author using an algorithm analogous to the one employed by Cantwell to produce the imputation rate for the other items

personal interview. The remaining 37% of households had a computer-assisted *telephone interview*.

The rates in Table 1 agree with the results in Tourangeau (2000)⁹, that, in general, item imputation rates are lower in interviewer-administered surveys such as the A.C.E. than in self-administered surveys like the Census.

Measure of Agreement

Each comparison is characterized by a measure of inter-rater agreement, Kappa (Agresti, 1990). In the current context, the K statistic is employed to measure inter-rater agreement of a demographic classification of a person where one “rater” is the Census data collection, editing, and imputation operation and the other “rater” is the A.C.E. Survey data collection, editing, and imputation operation.

The K statistic is calculated as follows:

$$K = \frac{\sum \pi_{ii} - \sum \pi_{i+} \pi_{+i}}{1 - \sum \pi_{i+} \pi_{+i}}$$

For instance, consider a cross-tabulation of the A.C.E. item responses by the Census item responses (see Table 2). The sum of diagonal entries of the cross-tabulation, $\sum \pi_{ii}$, represents the proportion of agreement among responses to that item. Consequently, K measures the proportion of agreement adjusted for the marginal distribution of item responses.

When the agreement is equivalent to complete independence then K = 0, and when there is perfect agreement K = 1.0. Negative values of K occur when the agreement is weaker than that expected by chance.

⁹ See Table 10.4 on p. 299.

TABLE 2. A.C.E. REPORTED HISPANIC ORIGIN BY CENSUS REPORTED HISPANIC ORIGIN

	A.C.E. REPORTED		TOTAL
	NON-HISPANIC	HISPANIC	
CENSUS REPORTED			
NON-HISPANIC	470146 0.8584	4997 0.0091	475143 0.8675
HISPANIC	4393 0.0080	68180 0.1245	72573 0.1325
TOTAL	474539 0.8664	73177 0.1336	547716 1.0000
$\sum \pi_{ii} = 0.9829$			$K = 0.9257$
			$SE(K)^{10} = 0.0008$

Comparability of Reported Responses between A.C.E. and the Census

The first question we are trying to answer is whether the baseline quality of the demographic characteristics collected in the A.C.E. Survey is comparable to the same data collected by the 2000 Census (see Table 3, second column). Any discrepancies among data for the reported items are assumed to represent data collection mode and instrument design differences between the two processes or response or data processing anomalies.

For Sex, Age, Hispanic origin and Tenure the inter-rater agreement is, respectively, $K = 0.95, 0.95, 0.93$ and 0.91 . Relationship has a lower agreement at $K = 0.69$ and Race falls in-between at $K = 0.79$.

TABLE 3. SUMMARY OF AGREEMENT AND NUMBER OF CASES BY ITEM AND BY RESPONSE STATUS IN THE CENSUS AND A.C.E. SURVEY

NOTE: SUMMARY OF AGREEMENT: KAPPA SE [KAPPA]

CENSUS :	ALL	REP.	IMP.	REP.	IMP.
A.C.E. :	ALL	REP.	REP.	IMP.	IMP.
RELATIONSHIP	569490 ¹¹ .68 .0008	562288 .69 .0008	7202 .35 .0067	NA NA	NA NA
SEX	578691 .94 .0005	565276 .95 .0004	5035 .85 .0075	8293 .02 .0110	87 -.15 .1051
AGE	567912 .93 .0003	550960 .95 .0003	16952 .41 .0041	NA NA	NA NA
HISPANIC ORIGIN	578691 .91 .0008	549145 .93 .0008	17963 .72 .0074	11056 .55 .0120	527 .37 .0544
RACE	578691 .77 .0008	555423 .79 .0008	17065 .32 .0059	5581 .32 .0104	622 .24 .0300
TENURE	578691 .89 .0006	548270 .91 .0006	20202 .55 .0061	9591 .46 .0098	628 .43 .0394

Regarding the agreement on the Relationship item, 14.8% of the P-sample Matched Person cases exchanged the role of Householder and Spouse between the A.C.E. and the Census. Since the relationship question (in both the Census and the A.C.E.) is worded: ‘In whose name is this house owned or rented?’, the difference is likely due to dual ownership/rentership between spouses (Bibb, 2004).

An additional finding regarding the Relationship item is that 1.0% of the persons reported *Sibling* or *Parent* in A.C.E. but reported *Child* in the Census.

Incidentally, for background, the *All A.C.E. vs. All Census* column of Table 3 compares all $N = 578,691$ P-sample matched persons. This column is included in the table to act as check of the next column, *Reported A.C.E. vs. Reported Census*. In particular, note that for each data item the K measure is slightly lower for the *All A.C.E. vs. All Census* column than it is for the *Reported A.C.E. vs. Reported Census* column. This is to be expected because the last three columns involving imputation reduce the level of agreement for the *All* cases group as compared to the *Reported* column.

Agreement of Census Imputation

The second, and most important, question we are trying to answer is whether the characteristic *imputation* in the 2000 Census for the core demographic items was consistent with the

¹⁰ The estimated standard error of the estimated Kappa statistic is calculated by SAS® using the asymptotic variance from a large-sample Normal Distribution.

¹¹ $N = 569,490$ for the Relationship item because 9,201 of the 578,691 A.C.E. P-sample Matched Persons in the study were found to be actually residing in Group Quarters (rather than in a Household) during the 2000 Census and therefore did not have a Relationship (to Householder) defined.

same data items *reported* for the same person in the A.C.E. Survey (the “target”).

In the Table 3 *Reported A.C.E. vs. Imputed Census* column for Sex, Hispanic Origin and Tenure, respectively, K equals 0.85, 0.72 and 0.55. Race has a K = 0.32. Relationship has a K = 0.35. Age has K = 0.41.

For a more detailed exposition of Census imputation quality, the *Reported A.C.E. vs. Reported Census* columns as well as the *Reported A.C.E. vs. Imputed Census* of Table 3 are further classified, in Table 4, into a separate row for each particular Census imputation procedure. Specifically, the unshaded rows of Table 4 collectively correspond to the second column of Table 3 while the shaded rows of Table 4 collectively correspond to the third column of Table 3. In Table 4, the shading becomes progressively darker as the response status changes from 1) no imputation (Reported), 2) imputation based on deterministic assignment using rules (Assigned), and 3) imputation based on random allocation from a hot-deck (Allocated).

The K values tend, for the most part, to decrease steadily as the shading gets darker (i.e., as response status changes from Reported to Assigned to Allocated). Referring to Table 4, except for the Hispanic Origin item, where MULTIPLE RESPONSE GIVEN UNIQUE ORIGIN has 1) a K that is 0.21 lower than ALLOCATED FROM WITHIN HH and 2) a K that is 0.20 lower than ALLOCATED FROM HOT DECK USING SURNAME, the K values for the Reported rows are all greater than the K values for the Assigned rows which are all greater than the K values for the Allocated rows.

Among rows within a particular response status, however, the following five points should be noted. First, when householder and spouse are excluded from the As REPORTED item K increases by 0.10. Second, for Assigned sex using first name to inform the imputation (FROM FIRST NAME) instead of surmising the sex from other household occupants (VALUE EDITED FOR HH CONSISTENCY) increases agreement by 0.31. Third, among As Reported age responses DATE OF BIRTH (DOB) ONLY is superior, by 0.15, to AGE ONLY. Fourth, among As Reported Hispanic origin responses MULTIPLE RESPONSE GIVEN UNIQUE ORIGIN has a K that is 0.46 lower than the AS REPORTED SINGLE ORIGIN. Finally, for Allocated race ALLOCATED FROM WITHIN HH raises agreement over ALLOCATED FROM HOT DECK by 0.32.

TABLE 4. CHARACTERISTIC MEASURE OF AGREEMENT BETWEEN REPORTED A.C.E. AND CENSUS BY CENSUS DETAILED RESPONSE CATEGORY FOR A.C.E. P-SAMPLE MATCHED PERSONS
= REPORTED = ASSIGNED = ALLOCATED

	K	SE[K]	N
RELATIONSHIP			
AS REPORTED FROM CODE BOX ¹²	.69	.0008	554,878
AS REPORTED FROM WRITE-IN	NA ¹³		7,410
VALUE CHANGED FOR HH CONSISTENCY	.34	.0118	1,905
PERSON IN GQ OR ON GQ FORM	NA		45
ALLOCATED DUE TO CONSISTENCY CHECK	NA		1,105
ALLOCATED FROM HOT DECK	NA		4,147
			569,490
SEX			
AS REPORTED	.95	.0004	565,276
FROM FIRST NAME	.90	.0065	4,610
VALUE EDITED FOR HH CONSISTENCY	.59	.0649	154
ALLOCATED DUE TO CONSISTENCY CHECK	.02	.1038	242
ALLOCATED FROM HOT DECK	.10	.0640	29
			570,311
AGE			
AS REPORTED	.95	.0003	533,893
DATE OF BIRTH (DOB) ONLY	.91	.0036	6,542
AGE ONLY	.76	.0044	10,525
INCONSISTENT AGE AND DOB	.71	.0052	8,196
ALLOCATED FROM HOT DECK	.12	.0044	8,756
			567,912
HISPANIC ORIGIN			
AS REPORTED SINGLE ORIGIN	.93	.0008	547,716
MULTIPLE RESPONSE GIVEN UNIQUE ORIGIN	.47	.0453	1,429
ASSIGN ORIGIN FROM RACE CODE	NA		964
ALLOCATED FROM WITHIN HH	.68	.0120	6,692
ALLOCATED FROM HOT DECK USING SURNAME	.67	.0187	7,923
ALLOCATED FROM HOT DECK WITHOUT SURNAME	.21	.0319	2,384
			567,108
RACE			
AS REPORTED	.79	.0008	555,423
CODE CHANGED THRU CONSISTENCY EDIT	NA		6
CLASSIFIED FROM HISP. ORIG. RACE RESPONSE	NA		85
ALLOCATED FROM WITHIN HH	.51	.0092	5,640
ALLOCATED FROM HOT DECK	.19	.0073	11,334
			572,488
TENURE			
AS REPORTED	.91	.0006	548,270
ASSIGNED BY CONSISTENCY CHECK	.81	.0105	3,458
ALLOCATED FROM HOT DECK	.50	.0069	16,744
			568,472

Agreement of A.C.E. Imputation

The third question we are trying to answer is whether the

¹² AS REPORTED [EXCL. HHER OR SPOUSE] .79 .0016 205,872

¹³ NA – Not Applicable refers to the fact that a Kappa measure could not be calculated for these cases because not all responses were represented by either the Census or the A.C.E. These rows are included in the Table 4. so that the total count for each characteristic in Table 4. corresponds to the sum of the 2nd and 3rd column counts for the same characteristic in Table 3.

characteristic imputation in the A.C.E. Survey for the core demographic items was consistent with the same data items reported by the same person in the 2000 Census (the “target”).

Referring back to the Table 3 *Imputed A.C.E. vs. Reported Census* column for Sex, Hispanic Origin, Race and Tenure, respectively, K equals 0.02, 0.55, 0.32 and 0.46. When one compares these results item by item to the adjacent *Reported A.C.E. vs. Imputed Census* column discussed in the preceding section, we see a large decrease in inter-rater agreement for Sex and Hispanic origin. A smaller decrease is found for Tenure. The inter-rater agreement for the Race item in the two columns is statistically equivalent.

For each item except race the inter-rater agreement of *Imputed Census* with the *Reported A.C.E.* is higher than that of the *Imputed A.C.E.* agreement with the *Reported Census*.

Consistency of A.C.E. Imputation and Census Imputation

The fourth question concerns how the A.C.E. imputed results compare to Census imputed results for the same person.

In the Table 3 *Imputed A.C.E. vs. Imputed Census* column for Sex, Hispanic Origin, Race and Tenure, respectively, K equals -0.15, 0.37, 0.24 and 0.43. When one compares these results item by item to the adjacent *Imputed A.C.E. vs. Reported Census* column, the inter-rater agreement is statistically equivalent for all items except Hispanic origin.

Discussion

Overall, the results of this study replicate those found in Farber, (2001) who investigated the consistency, within A.C.E. poststrata, of imputed and non-imputed values of tenure, age/sex, and race/Hispanic origin in the 2000 Census E-sample to corresponding values for matching A.C.E. P-sample persons.

It should be noted, that accurate imputation of missing characteristics at the aggregate level is the goal of Census Characteristic Imputation rather than accurate imputation of the characteristics for each person.

Referring again to the *Reported A.C.E. vs. Reported Census* column of Table 3, only Relationship and Race have measures of agreement below 0.90. The discrepancies among responses to the relationship and race items could be attributed to differences in data collection mode between the two inquiries. Specifically, 14.8% of the matched persons

exchange the relationships of householder and spouse. One could surmise that the dual ownership/rentership among spouses led to one spouse becoming the householder by responding to A.C.E. survey personal interview while the other spouse became the householder by filling out the Census questionnaire.

Further, when all persons with a Relationship of Householder or Spouse are removed from the comparison, the Kappa increases only by 0.10 to 0.79. This relatively modest level of agreement between *Reported* responses for Relationship in the two surveys could arise a general lack of understanding of the item. For instance, 1.0% of the persons reported as *Sibling* or *Parent* in A.C.E. but reported as *Child* in the Census. Perhaps, this result reflects a respondent mistaking, for example, the relationship to householder as the Parent relationship.

The response discrepancy for Race arose, most notably, because 4.5% of the persons reported *SOR* or *Two or more Races* in A.C.E., but reported *White* in the Census. This discrepancy could be attributed to A.C.E. interviewer eliciting more detailed information than had been elicited by the self-administered Census questionnaire or to Hispanic respondents confusing Race with Hispanic origin.

Biemer et al (1991) refers the foregoing differences collectively as measurement error.

Comparing columns in Table 3 it is clear that a reported response is much better than an imputed one. Among the three columns of Table 3 that concern *imputation* it is also clear that, overall, Census imputation was superior to A.C.E. imputation (Ikeda, 2001). For the sex and Hispanic origin items, the superiority of the Census imputation is due to the use of person name as a predictor (see next paragraph). The A.C.E. Imputation procedure did not employ person name as a predictor¹⁴ (Ikeda, 2001). For the race item only, the Census and the A.C.E. survey imputations were equally inconsistent with K = 0.32 for both.

Referring again to Table 4 for an illustration of the performance of specific Census imputation procedures several conclusions can be made. First, when the Census imputation

¹⁴ For the imputation of the missing Sex item, the A.C.E. Imputation procedure (Ikeda, 2001) did the following: 1) For Householder|Spouse: imputed the sex opposite that of the Spouse (if Spouse sex item not missing), 2) Imputed sex from the distribution of households with similar relationship configurations, or 3) Imputed sex from the distribution of all households.

For the imputation of the missing Hispanic Origin item, the A.C.E. Imputation procedure did the following: 1) Imputed Origin from the within-household distribution of (non-missing) Origin response(s), or 2) Imputed Origin from the nearest previous household with the same *Race*.

employed informative auxiliary information about the individual person or about the household the consistency of the imputation increased significantly. For instance, for Sex, FROM FIRST NAME had $K = 0.90$ whereas ALLOCATED FROM HOT DECK had $K = 0.10$. Further, when Hispanic origin was ALLOCATED FROM HOT DECK USING SURNAME the measure of agreement with A.C.E. Reported was $K = 0.67$. On the other hand, when Hispanic origin was ALLOCATED FROM HOT DECK WITHOUT SURNAME the $K = 0.21$. In addition, imputing race and Hispanic origin, when available, from other members of the household is better ($K = 0.51, 0.68$, respectively) than imputing randomly from a hot-deck ($K = 0.19, 0.21$, respectively).

Second, Date of Birth is more accurate than age in years.

Finally, noting the various ALLOCATED FROM HOT DECK rows in Table 4., a random hot deck, in general, that does not use auxiliary information for person-level characteristics is not very effective. All these rows have a $K \leq 0.41$ a level of agreement which is closer to complete independence than it is to perfect correspondence.

More research on stochastic imputation is needed to really see if the hot deck can be improved on.

Study Limitations

Only A.C.E. P-sample Matched Persons are in the comparison; we cannot compare unmatched persons.

References

Agresti, Alan. (1990), *Categorical Data Analysis*, New York: Wiley-Interscience.

Bean, Susanne L. (2001) "ESCAP II: Accuracy and Coverage Evaluation Matching Error". A.C.E. REVISION II Memorandum Series #PP-5, October 12, 2001.

Belin, Thomas R. and Rubin, Donald B. (1995), "A Method for Calibrating False-Match Rates in Record Linkage", *Journal of the American Statistical Association*, **90**, 694-707.

Biemer, Paul P., Groves, Robert M., Lyberg, Lars E., Mathiowetz, Nancy A., and Sudman, Seymour (1991), *Measurement Error in Surveys*, New York: Wiley.

Bibb, Julie, K. (2004), Personal Communication, U.S. Census Bureau, Washington, DC.

Cantwell, Patrick J., McGrath, David, Nguyen, Nganha, and Zelenak, Mary Francis (2001) "Accuracy and Coverage Evaluation: Missing Data Results". DSSD Census 2000 Procedures and Operations Memorandum Series #B-7*, February 28, 2001.

Childers, Danny R. (2003), *Accuracy and Coverage Evaluation: Technical Documentation*, Chapter 4, Field and Processing Activities. DSSD 2000 Census Procedures and Operations Memorandum Series #Q-85-4, April 18, 2003.

Cresce, Arthur R. and Philipp, Dan E. (2001) "CENSUS 2000 100% IMPUTATION SPECIFICATIONS (Final)", Internal Bureau of the Census Memorandum, April 12, 2001.

Farber, James (2001) "Accuracy and Coverage Evaluation: Consistency of Post-Stratification Variables". DSSD Census 2000 Procedures and Operations Memorandum Series #B-10*, February 28, 2001.

Fenstermaker, Deborah A. and Kostanich, Donna L. (2003) *Accuracy and Coverage Evaluation: Technical Documentation*, Chapter 2, Accuracy and Coverage Evaluation Overview. DSSD Census 2000 Procedures and Operations Memorandum Series #Q-85-2, April 18, 2003.

Ikeda, Michael M. (2001) "Accuracy and Coverage Evaluation Survey: Specifications for the Missing Data Procedures; Revision of Q-25". DSSD Census 2000 Procedures and Operations Memorandum Series #Q-62, July 9, 2001.

Jaro, Matthew A. (1989), "Advances in Record-Linkage Methodology as Applied to Matching the 1985 Census of Tampa, Florida", *Journal of the American Statistical Association*, **84**, 414-420.

Tourangeau, Roger, Rips, Lance J., and Rasinski, Kenneth (2000), *The Psychology of Survey Response*, Cambridge, UK: Cambridge University Press.

Winkler, William E. (1995), "Matching and Record Linkage", in B.G. Cox et al. (Ed.) *Business Survey Methods*, New York: Wiley, Chapter 11, 374-403.

Zajac, Kevin J. (2003) "Analysis of Imputation Rates for the 100 Percent Person and Housing Unit Data Items from Census 2000", Census 2000 Evaluation B.1.a, July 2, 2003.