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Handling of Household and Item Nonresponse in Surveys

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Abstract: *For the 2000 Census, the U.S. Census Bureau will select a quality check, also known as integrated coverage measurement (ICM), sample to improve Census estimates. The ICM sample is subject to missing data due to household and item nonresponse. This paper discusses alternative methods researched to deal with nonresponse in the ICM sample. These methods include no adjustment for household nonresponse and no item imputation, use of Census short form characteristics to perform household nonresponse adjustment, substitution of Census data for ICM missing items, and alternative hot deck imputation procedures.*

Keywords: *noninterview adjustment, imputation, logistic regression, hot deck*

1 Introduction

As in any other data collection process, ICM sample data is also missing in some cases due to either whole household noninterview or nonresponse to one or more characteristics for an interviewed person. In this paper, we discuss and attempt to integrate research related to 1) noninterview adjustment for whole household noninterviews and 2) imputation methods to handle missing demographic characteristics (item) for persons. Section 2 presents an overview of the 1995 Integrated Coverage Measurement (ICM) sample design, procedures for handling missing data, and the estimation methodology used for Census Plus (C^+) and Dual System Estimation of the total population. Sections 3 and 4 describe methodological research for handling whole household nonresponse and characteristic nonresponse, respectively. In Section 3, we also discuss how the methodology impacts the allowable nonresponse rate in ICM for the 2000 Census. Summary and conclusions are presented in Section 5.

2 Background

2.1 1995 ICM sample design

The Bureau conducted the 1995 Census Test in three sites: Oakland, CA; Paterson, NJ; and Northwest Louisiana. The ICM sample, consisting of block clusters (single blocks or groups of blocks, generally with 30 or more housing units), was selected separately for each site.

The ICM methodology used three separate rosters: the R-Sample, the P-Sample, and the E-Sample. The R-Sample which tries to obtain a „true" roster from the ICM blocks was created for all three sites and was used in Census Plus estimation. Census Plus estimates are calculated based on the assumption that the R-Sample is the „truth" for the ICM blocks. The P- and E-Samples were only created for the Oakland and Paterson sites and were used in Dual System Estimation (DSE). DSE tries to obtain a roster from the ICM blocks independently of the Census. The independent roster called the P-Sample and the Census roster called the E-Sample are matched and the results of the matching are used to estimate the number of persons missed by both rosters. The E-Sample is also used to adjust the Census for erroneous enumerations. Further details on DSE and Census Plus estimation can be found in Schindler (1996).

In 1995, the ICM collected information for both DSE and Census Plus in a single interview. Initially, an independent ICM roster was collected, and then matched during the interview to a preliminary Census roster. Census Plus combined the preliminary Census roster and the independent roster into a „true" household roster. DSE used the independent roster to form the P-Sample. An overview of the 1995 ICM sample design and operations is given in Mulry and Singh (1995).

2.2 Outline of procedures for handling missing data

2.2.1 Noninterview adjustment

Whole-household noninterviews in the R- and P-Samples are accounted for by using a noninterview adjustment. Noninterview adjustment is not applied to the E-Sample since it is used only to make adjustments for erroneously enumerated persons in interviewed households.

The noninterview adjustment is done using block cluster x type of structure. The type of structure categories are: (1) one family detached house, (2) one family attached house, (3) building with two or more apartments, and (4) mobile home or trailer, boat, tent, van, etc., and other. If predefined criteria are not met at the block cluster level, block clusters are

collapsed according to predefined rules to control mean square error. For details, see Ikeda and Petroni (1996).

2.2.2 Characteristic imputation

Some persons in interviewed households are missing demographic characteristics required to assign persons into estimation post-strata. Missing characteristics are filled in using an imputation procedure. The 1995 ICM used a different method from the 1990 Post Enumeration Survey (PES) to impute missing characteristics. We describe both methods below along with the 1995 Test Census imputation method.

1990 PES imputation method

The item nonresponse imputation method used in the 1990 Census is a hot-deck imputation procedure that fills in values for the missing data in the P- and E- Samples. Certain information about other household members is used in the hot-deck procedure when such information is available. When information on other household members is unavailable, the hot-deck procedure imputes values based on either a previous household with reported values or the distribution of reported values in the entire file. Tenure is imputed first, followed by race, Hispanic origin, sex, and age.

When information on other household members is unavailable, race and Hispanic origin imputations use values from a previous reporting household. Tenure is imputed from a previous reporting household.

The sex and age imputations use values based on the distribution of reported values in the entire file. If one spouse reports sex and the other doesn't, the nonreporting spouse's sex is imputed as the opposite sex of the reporting spouse. For any other cases of missing sex, the imputation is based on the reported sex distribution by household size.

Missing age is imputed based on household size. One-person households with missing age are imputed from the age distribution of all reporting one-person households based on marital status. Households of two or more people have missing ages imputed from the age distribution of all other reporting individuals in households of two or more people with similar relationships to head of household, marital status and age of head of household as the individual with missing age. For more information on the 1990 imputation method, see Diffendal and Belin (1991).

1995 Test ICM imputation method

The 1995 ICM Methodology imputes missing data similarly for all three ICM samples. We impute tenure using the previous household with nonmissing tenure and sex of married householder (spouse of householder) as opposite to that reported for spouse of householder (married householder). We use the Flexible Matching procedure to impute race, sex of unmarried persons, age, and Hispanic origin (Ikeda and Petroni 1996). The Flexible Matching procedure is a hot deck imputation which identifies matching variables and uses the variables to match an incomplete record with a complete record (Williams 1995a, 1995b).

1995 Test Census imputation method

We use a two part imputation process for the 1995 Census methodology. For part one, we first edit reported Census responses for race, age, and date of birth within a household. Then, within households we edit household relationships based on age, reported relationships, and sex. When relationship is missing we allocate it based on other available data. Next, we allocate age based on relationships and ages of other persons in the household. We assign missing race (Hispanic origin) based on relationships and race (Hispanic origin) of other persons in the same household if at least one person in the household reports race (Hispanic origin). Otherwise, we assign the race of all persons in the household to be the race of the householder of the closest previous neighbor with identical Hispanic origin. We base the Hispanic origin of all persons in the household on race.

For part two, we use hot deck imputation to substitute the nearest previous responding unit having the same race, Hispanic origin, and household size. The Census Bureau determines household size during data acceptance processing. We take race and Hispanic origin to be the race and Hispanic origin of the first person in the household reporting the items. When no one in the household reports race or Hispanic origin, we use race or origin of the nearest previous responding unit. We set initial cells in each matrix by a cold deck procedure (Spencer 1995).

2.3 ICM estimation

We discuss below two estimation methods namely the Dual System Estimation and the Census Plus.

2.3.1 Dual System Estimation

For the 1995 Test Census, the Bureau used the P- and E-Samples to obtain the DSE estimate as follows:

$$\hat{N}_{..} = \left\{ \frac{[(N_c^* - \hat{II})\ (1 - \hat{EE}/\hat{N}_e)]\hat{N}_p}{\hat{M}\, N_c^*} \right\} N_c^* = AF_d\, N_c^*$$

where

$\hat{N}_{..}$ = population estimate

$\hat{N}_P$ = weighted P-Sample total

N_c^* = Census estimate based on ICM and non-ICM blocks

$\hat{II}$ = estimated number of whole-person Census imputations

$\hat{EE}$ = estimate of E-Sample insufficient information for matching cases and erroneous enumerations

$\hat{N}_e$ = weighted E-Sample total

$\hat{M}$ = estimate of P-Sample matches

AF_d = DSE adjustment factor

See Wolter (1986) for theoretical understanding.

2.3.2 Census plus estimation

The Bureau used the R-Sample to estimate the Census Pluc (C^+) population total as:

$$\hat{N}_{..} = \frac{\hat{R}}{\hat{N}_c} N_c^* = AF_c\, N_c^*$$

where

$\hat{R}$ = weighted R-Sample total

$\hat{N}_c$ = weighted total based on Census enumerations in ICM blocks

AF_C = C^+ adjustment factor

3 Methodological research for handling whole household noninterviews

The Census Bureau pursued three whole household noninterview research projects. We discuss briefly these research efforts and their outcomes.

3.1 Treating noninterview household persons as not captured

The research was motivated from the point of view of reducing data processing time and effort. An attractive alternative is to treat persons in noninterviewed households as not captured in the P-Sample. Under this alternative, we do no household noninterview adjustment for the P-Sample. Petroni, Kearney, Town and Singh (1995) calculated 357 national level estimates using the original and the alternative DSE definition of capture along with percent differences between the alternative and original estimates. In this study, we used the 1990 PES data and the 1990 noninterview household adjustment method. The 1990 PES and 1995 ICM noninterview household adjustment methods are similar.

Results suggested differential affects on particular race and tenure groups. As a result, we recommended to not drop noninterview adjustments.

3.2 Reducing household noninterviews

Petroni, Kearney, and Gbur (1996) studied effects of differential noninterviews on C^+ and DSE estimates for the 1995 ICM test in Oakland. The focus of the study was whether the large difference in noninterview rates of the P- and E-Samples could introduce bias into comparison of C^+ and DSE methodology. They analyzed data from this study to see how changes in noninterview rates affect C^+ and DSE.

For a given household, the Census Bureau collected data for both procedures simultaneously using one computer assisted personal interviewing instrument. The instrument was expected to do equally well in obtaining interviews for both procedures. The instrument contained Census rosters which were to be displayed to the interviewer after collection of an independent household roster. The independence between the roster obtained during the ICM interview and the Census roster is critical for the P-Sample. However, interviewers could sometimes view the Census roster before obtaining the independent household roster. Thus, since the independence of the initial roster was lost due to the design of the instrument and incorrect implementation of collection instructions, we had to treat such households as noninterviews for the P-Sample, but not for the R-Sample. For Oakland, the P-Sample noninterview rate was 15.06%. The R-Sample rate was 8.54%. For details, see Ikeda and Petroni (1996).

Our weighting approach to handle household noninterviews implicitly assumes that the average noninterviewed housing unit is similar to the average interviewed housing unit with respect to the characteristic(s) being estimated at the level we calculated the adjustment. As noninterview rates increase, actual difference in interviewed and noninterviewed households can increase bias. Hence, because R- and P-Sample nonresponse rates differed, comparison of C^+ and DSE estimates could be contaminated. As a result, the Bureau mounted two research efforts: first, increase the interview rates for

both samples through a field followup (Method 1); second, make the sample more comparable by treating P-Sample households that were classified as noninterviews due to the instrument problem as noninterviews in the R-Sample too (Method 2). The P-Sample household noninterview rate for the second method is the same as the original rate. The Oakland noninterview rates for the R- and P-Samples respectively are provided in the C^+ and the DSE headings of Table 1.

For Oakland, we conducted both research endeavors and for Paterson, only the second. We compared the recomputed Census Plus and DSE adjustment factors to the original (production) factors. Selected factors for C^+ and DSE are presented in Table 1. Basically, the comparison shows that lowering versus raising noninterview levels does result in significant differences in C^+ and DSE factors.

Table 1 shows that for C^+, Method 2 factors for total persons and total owners respectively are about one half percentage point and one percentage point higher than original factors. There are three percentage points fewer persons estimated with Method 1 compared to Method 2 and owners is short by seven percentage points. Most of the Method 1 factors for C^+ are lower than the original (production) factors. In general, there is a little difference between Method 2 and the original factors for the C^+. Both the Method 2 and original factors are very different from Method 1. For DSE, Method 1 factors are higher than original factors. The maximum observed difference between Method 1 and the Original factors occurred for Hispanic renters and is about four percentage points.

Differences between the Method 2 factors and the original factors are larger in Oakland than Paterson. This is to be expected, because of the higher noninterview (NI) rates in Oakland. The original Patersons rates were 2.18% for R-Sample and 8.49% for P-Sample. We examined factors for 56 groups based on race/ethnicity, tenure, age and sex. All of the Method 2 Oakland factors are within 5% of the original factors, most (52 of 56 for both Census Plus and DSE) are within 3% of the production factors, and a substantial majority (41 of 56 for Census Plus, 44 of 56 for DSE) are within 2% of production factors.

Table 1 shows that increasing the response rate had different effects on C^+ and DSE as compared to original factors. For C^+, factors decreased while DSE factors increased. C^+ factors are more affected by 10 percentage point reduction in noninterview rate (from Method 2 to Method 1) than DSE factors. This could mean that either DSE estimates are more robust to the noninterview rate as compared to C^+ or the 3% households (5.58%-2.38%) which could not be interviewed for DSE were very different from the interviewed households. Further evaluation of C^+ for the three Methods shows that a 5%

Table 1: C^+ and DSE Adjustment factors for different household noninterview (NI) rates for Oakland

Characteristics	C^+ Estimate By NI Rates			DSE Estimate By NI Rate	
	Method (NI Rate (%))			Method (NI Rate (%))	
	Method 1 (2.38)	Original (8.54)	Method 2 (13.7)	Method 1 (5.58)	Original (15.06)
	(1)	(2)	(3)	(4)	(5)
Total	0.978	1.005	1.010	1.108	1.087
Owner	0.964	1.026	1.034	1.074	1.060
Renter	0.988	0.989	0.992	1.135	1.107
Black	0.934	0.950	0.958	1.121	1.105
Owner	0.968	0.987	0.985	1.091	1.097
Renter	0.915	0.928	0.942	1.138	1.109
Non-Black/Non API Hispanic	1.163	1.132	1.148	1.245	1.203
Owner	1.220	1.212	1.246	1.203	1.176
Renter	1.130	1.086	1.091	1.269	1.219
API	0.891	0.976	0.967	1.083	1.075
Owner	0.877	0.981	0.978	1.046	1.034
Renter	0.900	0.972	0.958	1.109	1.104
All Others	0.998	1.039	1.042	1.035	1.007
Owner	0.915	1.021	1.035	1.027	0.999
Renter	1.114	1.064	1.053	1.046	1.019

Note: Adjustment factors for Method 1 are in Columns (1) and (4), for Method 2 in Column (3) and for the original are in columns (2) and (5).

Source: Petroni, Kearney, and Gbur (1996)

drop from 13.7% to 8.54% in noninterview rates did not make as large difference on estimates as the next 6% drop from 8.54% to 2.4%. This suggests that obtaining response for the tail end of the respondents is very important to reduce bias.

3.3 Classifying households into noninterview cells using Census data

Ikeda (1996) studied the effect of using data from the Hundred Percent Edited Response File (HERF) households to assign R-, and P-Sample noninterviewed households into noninterview adjustment cells. With this approach data from matching HERF households was obtained for 1995 ICM R-Sample and P-Sample housing units. The HERF data was used to help define noninterview adjustment cells and the R-Sample and P-Sample noninterview adjustment weights were used in the calculation of new HERF based C^+ and DSE poststrata estimates.

The production noninterview adjustment system which used adjustment cells defined mostly by block cluster x type of structure was rerun using the pseudo-cluster code (crossed with the ICM sample selection stratum) instead of the block cluster code. Pseudo-cluster codes were defined by household size, tenure, and race categories.

The new and the original C^+ and DSE estimates and adjustment factors are presented in Table 2. The overall Census Plus estimate for Oakland decreases from 334,493 (production) to 331,849 (HERF based). Census Plus estimate for owner poststrata tend to decrease somewhat more than Census Plus estimates for renter poststrata (although Asian/Pacific Islander owners and renters decrease by similar proportions). The overall DSE estimate for Oakland increases from 361,550 to 366,137. DSE estimates for renter poststrata tend to increase somewhat more than DSE estimates for owner poststrata (although Hispanic owners and renters increase by similar proportions).

The C^+ and DSE factors based on field followup operations (Method 1 in Table 1) were compared with factors in Table 2. Differences between factors of race/origin x tenure from the Method 1 and production C^+ were in the same direction as the difference between the HERF based and production C^+ factors. However, the Method 1 differences were considerably larger (about 10% of the production compared to less than 2%).

The differences between the Method 1 and production DSE race/origin x tenure factors (see Tables 1 and 2) tended to be in the same direction as the differences between the HERF based and production DSE factors. However, all three sets of DSE factors were close to each other. Note that none of the differences between the Method 1 and production DSE race/origin x tenure factors were significant at the 0.10 level.

Table 2: Production and HERF based Census plus and DSE adjustment factors for Oakland

Postratum	C^+ Estimates		C^+ Adj Factors		DSE Estimates		DSE Adj Factors	
	Prod	HERF	Prod	HERF	Prod	HERF	Prod	HERF
Black Owner	50542	49989	0.9874	0.9766	56158	56470	1.0972	1.1033
Black Renter	79169	79471	0.9277	0.9312	94665	96618	1.1092	1.1321
Black	129711	129460	0.9501	0.9482	150823	153089	1.1047	1.1213
Hispanic Owner	21175	20693	1.2117	1.1841	20542	20836	1.1755	1.1924
Hispanic Renter	32645	32719	1.0858	1.0882	36663	37394	1.2194	1.2437
Hispanic	53819	53412	1.1321	1.1235	57205	58230	1.2033	1.2248
API Owner	22829	22520	0.9813	0.9680	24051	24149	1.0338	1.0380
API Renter	31248	30636	0.9717	0.9526	35520	36231	1.1045	1.1266
API	54077	53155	0.9757	0.9591	59571	60379	1.0748	1.0894
Other Owner	55512	54666	1.0212	1.0057	54306	54375	0.9990	1.0003
Other Renter	41374	41156	1.0637	1.0581	39645	40064	1.0192	1.0300
Other	96886	95822	1.0389	1.0275	93951	94438	1.0075	1.0127
Owner	150057	147867	1.0258	1.0108	155058	155830	1.0600	1.0653
Renter	184436	183982	0.9891	0.9867	206492	10307	.1074	1.1279
Oakland	334493	331849	1.0052	0.9973	361550	366137	1.0866	1.1003

Source: Ikeda (1996)

Similar analysis was performed for Paterson (NJ) and Northwest Louisiana. The results were similar to those obtained for Oakland (CA). However, the differences between HERF based factors and production factors were smaller due to lower noninterview rates in production in these sites.

These two studies conclude that using HERF data to classify noninterviewed households into noninterview adjustment cells brought estimates closer to the Method 1 estimates. Therefore, if an alternative source of good quality is available to provide data on nonresponding households, it is desirable to use it at least to assign these noninterviewed households to appropriate noninterview cells.

4 Methodological research for handling characteristic nonresponse

Characteristic nonresponse is also called item nonresponse. Research in this area for ICM included 1) evaluation of disagreement of imputed and nonimputed characteristics between R-Sample and Census; 2) excluding persons in interviewed households with missing characteristics (item) from estimation; 3) substituting missing items in P-, R-, and E-Samples with those reported in Census; 4) replacing P-, R- and E-Sample person data with Census data reported for that person. A brief summary is presented below.

4.1 Disagreement of imputed and nonimputed characteristics between R-Sample and Census

Since the Census and R-Sample used two different methods for handling missing data, Petroni (1996a and 1996b) investigated the disagreement of characteristics (imputed or non imputed) between R-Sample cases linked to the Census unedited file (CUF) and 1995 Census cases from the HERF. Petroni examined differences in reported and/or imputed race, tenure, age, origin and sex for Oakland. She revealed that there are large disagreements (3%-12%) for race, tenure, origin, and sex in reported and/or imputed characteristics for matched persons. Reported and/or imputed race for Oakland shows that even if the differences in reported and/or imputed race at the micro level were large, in general, 60%-80% of these differences canceled out at the macro level. Similar results hold for tenure, sex and age.

Results from these studies suggest that for the Census Plus estimation methodology we may need to be concerned about response variation and consistency in data collection between ICM and Census even more than about differences in imputation. We pursued three research efforts to get more insight into the effect of disagreement in characteristics between ICM and Census on the C^+ and DSE estimates.

4.2 Persons with missing characteristics treated as not captured in the P-Sample

For this study we treated persons with missing characteristics in interviewed households as not captured in the P-Sample and, hence, excluded them from DSE. Petroni, Kearney, Town and Singh (1995) calculated 357 national level DSE estimates. They compared the original DSE estimates to estimates for the alternative definition of captured persons for race/ethnicity (nonHispanic White, Black, nonBlack Hispanic, Asian and Pacific Islanders, and American Indians), age (0-17, 18-29, 30-49, 50+), sex (Male and Female), and regions (Northeast, South, Midwest, West). The categories in the parenthesis define subgroups of the corresponding group.

They found that:

- A significant percent of alternative estimates differ by more than two percent from the original estimates.
- For all groups except region, the alternative subgroup estimates differ in closeness to the original estimates.
- For all subgroups, except American Indians on Reservations, most estimates for alternative definition are higher than the original estimates.
- For all groups except region and race/Hispanic origin, the subgroups have roughly the same percent of estimates that are higher than the original estimates.

Also, comparison of total person estimates by region, tenure, race/Hispanic origin, sex, age and age by sex showed that estimates from the alternative definition are higher than the original estimates but all are within two percent of the original estimates. Because of the differential effects on total person estimates by region, tenure, race/Hispanic origin, sex and age, it was recommended to treat persons in interviewed households with missing characteristics as captured in the P-Sample.

4.3 Replacement of P-, R-, and E-Sample person imputed data with Census data

To examine the impact of different ICM and Census imputation methods, we linked R-, P-, and E-Sample persons to Census persons and replaced R-, P-, and E-Sample imputed data by Census data (which may or may not have been imputed). Where there was no link, we kept the ICM imputed data. We recomputed DSE adjustment factors when only E-Sample imputed data were replaced with Census linked data, and when both P- and E-Sample imputed data were replaced with Census linked data. We also recomputed C^+ adjustment factors. Table 3 summarizes these factors for Oakland (see columns 3-5).

Table 3: 1995 Dual system and Census plus estimation adjustment factors* for Oakland, California

Characteristics	Original Factors		Factors After Replacing ICM Imputed Data With Census Data			Factors After Replacing ICM Data With Census Data		
	DSE	C^+	DSE Only E Replaced	DSE P and E Replaced	C^+	DSE Only E Replaced	DSE P and E Replaced	C^+
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Oakland	1.0600	1.0052	1.0868	1.0871	1.0052	1.0872	1.0834	1.0069
Owner	1.0600	1.0258	1.0594	1.0587	1.0290	1.0587	1.0599	1.0201
Renter	1.1074	0.9891	1.1081	1.1095	0.9865	1.1096	1.1019	0.9965
Black	1.1047	0.9501	1.1053	1.1062	0.9488	1.1054	1.0991	0.9600
Owner	1.0972	0.9874	1.0981	1.0967	0.9924	1.0952	1.0951	0.9929
Renter	1.1092	0.9277	1.1096	1.1118	0.9226	1.1115	1.1015	0.9402
Hispanic	1.2033	1.1321	1.1977	1.1967	1.1408	1.1978	1.2012	1.1287
Owner	1.1755	1.2117	1.1664	1.1648	1.2253	1.1672	1.1796	1.1954
Renter	1.2194	1.0858	1.2159	1.2152	1.0917	1.2155	1.2138	1.0900
API	1.0748	0.9757	1.0770	1.0777	0.9724	1.0802	1.0602	1.0189
Owner	1.0338	0.9813	1.0301	1.0301	0.9741	1.0306	1.0284	0.9987
Renter	1.1045	0.9717	1.1110	1.1121	0.9711	1.1160	1.0832	1.0335
Other	1.0075	1.0389	1.0089	1.0091	1.0382	1.0084	1.0142	1.0063
Owner	0.9990	1.0212	1.0012	1.0009	1.0240	1.0014	1.0018	0.9987
Renter	1.0192	1.0637	1.0196	1.0204	1.0582	1.0181	1.0315	1.0170

* We use the term adjustment factor loosely. Technically the term implies a factor that would be applied to a Census count to produce an estimate. In this sense, the only adjustments are at the poststratum level. That is, technically the above are not adjustment factors, but these factors minus one represent coverage rates.

Source: Petroni, Kearney, and Ikeda (1996)

For both methods, most of the DSE factors were numerically close to the original method factors. All new alternatives result in substantial differences in factors for 50+ male and female renters. For C^+, Table 3 shows that the alternatives provided approximately the same adjustment factors as the original C^+ factors.

4.4 Replacement of P-, R-, and E-Sample characteristics with Census data

To examine whether differences in data reported for the ICM and Census could be responsible for the differences in DSE and C^+ adjustment factors, we replace R-, P-, and E-Sample data by Census data when ICM and Census data disagreed regardless of whether differences were due to imputation. Again, we recomputed both C^+ and DSE adjustment factors when only E-Sample data are replaced with Census linked data and DSE factors when both P- and E-Sample data are replaced with Census linked data. These factors are presented in Table 3 (see column 6-8).

We compared the original and resulting adjustment factors to analyze the impact of different ICM and Census imputation procedures and the impact of disagreement of Census and ICM reported data. The results for these three methods were similar to those in section 4.3. This is because the large differences in reported/imputed characteristics at the micro level reduce significantly at the macro level and, hence, the adjustment factors at the post-strata level are not affected significantly.

4.5 Comparison of 1990 PES and 1995 ICM imputation methods

One simulation study (Dorinski et al. 1996) compared and evaluated two imputation methods - one used in 1990 and another used in 1995 - for DSE estimation. The items imputed in both the 1990 Census and the 1995 Census Test are tenure, race, Hispanic origin, sex and age. Thus we focus on these items when evaluating the methods. However, the 1990 Census imputation method allows hot-decking based on missing values for relationship and marital status, so we included those items when simulating missing data. The 1995 Census Test did not include group quarters, so we excluded group quarters records from the 1990 E-Sample data file for this study.

To evaluate the two imputation methods, Dorinski et al. compared two measures of success: the number of correct imputations each method produces, or the „closeness" of the marginal distributions produced by each imputation method to the reported marginal distributions. The number of correct imputations is a micro-level measure, while the „closeness" of the marginal distribution to the reported distribution is a macro-level

measure. The focus of the ICM samples is to produce accurate results at aggregate levels so that differential undercounts may be examined. Thus, Dorinski et al. first compared the „closeness" of the marginal distributions to evaluate the methods. Secondarily, they looked at the number of correct imputations each method produces.

Overall, the 1990 method of imputation performs better for the characteristics studied. However, for Hispanic origin, the 1995 method produces slightly better marginals, but fewer correct imputations. Sex imputation also had some problems in both 1990 and 1995 methods.

Further analysis (Dorinski 1996) showed that most of the errors in the 1990 sex imputation occurred when imputing the sex of single householders. Most households with two or more persons are married-couple households, with the husband being listed as the householder almost all the time. This causes the sex distribution of reporting householders to be predominantly male. However, householders who are single tend to be female, so using the overall sex distribution of all reporting householders causes most single householders to be imputed as male. Dorinski suggests that the 1990 sex imputation method for householders based on the presence of a spouse in the household will provide better overall imputation than the 1990 PES imputation method. Sex imputation method for householder should be divided into married householder, householder with no spouse in a single person household, and householder with no spouse in a two or more person household. Householders in each group should be imputed based on the distribution of all reporting householders in that group.

5 Summary and conclusions

From the noninterview adjustment studies, we conclude that we should use the noninterview adjustment to handle whole household noninterviews. Even though the use of Census reported data on the HERF have potential to improve ICM estimates, the improvements were not significant. However, if the nonresponse rate is higher, use of the HERF should be researched. C^+ results show clearly that reducing the last few percent of the household noninterview affected estimates significantly. It is not so obvious for DSE estimates since the noninterview rate dropped to only 5.4%. Reducing nonresponse rates affected C^+ and DSE differently. In general, estimates for C^+ decreased while they increased for DSE when nonresponse was reduced. We believe that, generally, the best approach for handling noninterviews is to reduce the noninterview rate to as low as practical. With a low noninterview rate, a simple adjustment will work as well as a more complex one.

The discrepancy in unimputed and imputed characteristic in the ICM sample and the

Census is large at the micro level. However, the discrepancy at the aggregate level is significantly reduced due to canceling out of some micro-level discrepancies. These discrepancies may have a larger affect on C^+ than on DSE estimates. Results from these studies suggest that for the Census Plus estimation methodology we may need to be concerned about response variation and consistency in data collection between ICM and Census even more than about differences in imputation. The comparison of 1990 and 1995 imputation methodologies showed that, in general, 1990 and 1995 methods provide approximately the same marginal distribution for imputed characteristics except for sex. However, the 1990 method produces more correct imputations. Therefore, we should use the 1990 type imputation for the 2000 Census. For the sex imputation, the 1990 sex imputation method for householders should be divided further by 1) householder with spouse present, 2) householder in a single person household, and 3) householder without spouse in two or more person households.

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