

Evaluating the 2010 Census Nonresponse Followup Reinterview

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Abstract

The 2010 Nonresponse Followup Reinterview was designed to identify enumerators who intentionally or unintentionally did not follow data collection procedures. This was achieved by revisiting a sample of Nonresponse Followup cases and comparing data from the two interviews. The 2010 Census was the first full census where Nonresponse Followup Reinterview utilized the Matching, Review, and Coding System (MaRCS) – an innovative automated application which facilitated this data comparison through computer matching and clerical matching. The MaRCS reports also provided unprecedented insight and control of the Nonresponse Followup Reinterview program.

This paper focuses on the results of the 2010 Census Nonresponse Followup Reinterview program, providing an overview of the reinterview design, the reinterview results, and possible ways to further improve the reinterview program.

Key Words: Reinterview, quality control, falsification

1. Introduction

Nonresponse Followup (NRFU) was a paper operation where enumerators visited all housing units that did not return their 2010 Census forms in order to collect all demographic data needed for the 2010 Census. The NRFU Reinterview (RI) was a quality control operation, also on paper, designed to detect and deter enumerator errors and data falsification in NRFU. A sample of each NRFU enumerator's completed cases was selected for NRFU RI, where separate RI enumerators revisited the original NRFU respondents to independently collect a subset of data items for comparison with the NRFU data. Vitrano (2009) describes the NRFU and NRFU RI operations in detail.

The NRFU RI was conducted concurrently with NRFU, beginning May 3, 2010 (two days after the start of NRFU) and ending July 31, 2010 (three weeks after the completion of NRFU). Results of the NRFU RI were used to provide feedback to NRFU enumerators who made mistakes and terminate NRFU enumerators found falsifying data or intentionally not following procedures. In order for this to be successful, it was imperative that the RI results be determined quickly after the NRFU interview.

The Matching, Review, and Coding System (MaRCS) was a new web-based application used to assign final outcomes to the NRFU RI cases. This system was imperative to the

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

NRFU RI program because it selected additional cases for a targeted RI (increasing the odds of catching mistakes and falsification), automatically compared the NRFU and RI data to determine a final RI outcome (reducing the RI coding workload for the offices), allowed office staff to review all completed NRFU cases (to make better decisions regarding enumerator falsification), and provided managers with reports on RI progress and results. The MaRCS coding effort began May 19, 2010 and ended August 9, 2010, which was nine days after NRFU RI to allow for data capture of the paper forms.

This report presents the specific NRFU RI procedures, results, limitations, and current plans to improve the NRFU RI for future censuses.

2. Methods

2.1 Nonresponse Followup Reinterview Procedures

All completed NRFU interview forms were returned to the Local Census Office (LCO) for check-in and shipping to data capture centers. At check-in, the Operations Control System (OCS) required clerks to key critical data items from the questionnaire and used those keyed data to determine if the NRFU case was eligible for RI. A case was eligible for NRFU RI only if it was a complete NRFU interview (not a noninterview) and the unit status was occupied, vacant – usual home elsewhere, or empty mobile home site. These criteria were used because noninterviews were monitored through NRFU and all cases with the remaining verifiable unit statuses (vacant – regular, demolished, nonresidential, and uninhabitable) were sent to a separate Vacant Delete Check operation for verification. The duplicate unit status was not verified through RI or Vacant Delete Check due to operational constraints that made this verification impossible.

2.1.1 Reinterview Selection

The NRFU RI sample was not designed to estimate the quality of the NRFU data collected but was designed only to identify enumerators who made mistakes or falsified data. This was accomplished with four different RI selection types:

1. Random – a four percent systematic sample stratified by enumerator and starting with one of the first three eligible cases checked in. This sample was selected immediately at NRFU check-in and was designed to select at least one case for every enumerator who worked on NRFU.
2. Outlier – targeted RI for enumerators whose work differed significantly from all work within their crew leader district. The MaRCS identified these cases once per week based on all NRFU data received that week.
3. Supplemental – additional RI manually selected by the LCO staff. The MaRCS allowed LCO staff to review the NRFU data and select these cases.
4. Rework – additional RI automatically selected to rework **all** cases completed by enumerators found falsifying data or intentionally not following procedures.

The weekly outlier RI tests involved statistical comparisons of each enumerator's completed NRFU cases for the given week to all cases completed in the same district for the entire operation. The four indicators used for this test were: proxy respondent rate, missing phone number rate, one-person household rate, and vacancy rate. The proxy respondent rate test is described in detail here, but all four tests were run separately every week using the same methods.

Once a week, MaRCS calculated the proxy test control limit for each crew leader district using the following formula:

$$PTCL_{CLD} = P_{CLD} + Z_{\alpha} \sqrt{\frac{P_{CLD}(1 - P_{CLD})}{n}}$$

Where:

- $PTCL_{CLD}$ = the proxy test control limit for a specific crew leader district.
 P_{CLD} = the proportion of occupied cases² in the crew leader district for the entire production period that were completed with a proxy respondent.
 n = the number of occupied cases the enumerator completed for the outlier week.
 Z_{α} = the standard normal variate such that $(1 - \alpha)$ percent of the cases are expected to fall at or below the control limit. This parameter was set to 3, which means that approximately 99.9 percent of cases are expected to be at or below the control limit.

The MaRCS calculated the percent of each enumerator's occupied cases received during the outlier week that were completed with a proxy respondent. If the enumerator's proxy rate was higher than the proxy test control limit for the enumerator's crew leader district, then the enumerator was flagged as an outlier for the proxy respondent rate test. As with any statistical test, it is possible we flagged some enumerators who followed all procedures correctly and also failed to flag some enumerators who were not following all the correct procedures. In an effort to minimize these errors, we only ran the outlier test for enumerators who completed at least 15 cases for the outlier week.

The MaRCS automatically selected outlier RI cases for all enumerators who failed at least one of the four outlier tests. This was an intelligent targeted selection because only cases with the corresponding indicator properties were selected for outlier reinterview. It was also possible for an enumerator to have outlier RI cases selected in multiple weeks if they failed an outlier test more than once.

2.1.2 Reinterview Data Collection

All RI sample types were enumerated in the same way, and the RI enumerators did not know the RI sample types or any of the original NRFU responses. They simply contacted the original NRFU respondents to determine the following:

1. Whether or not the respondent was contacted for the NRFU interview
2. The housing unit status (Occupied, Vacant, Demolished, etc...) of the NRFU address
3. If occupied, the number and names of people who live at the NRFU address
4. If occupied and the original respondent was not contacted before, full demographic data for everyone living at the NRFU address

² Only occupied cases were eligible for the proxy respondent outlier test, but other outlier tests included vacant addresses, as appropriate.

Just like NRFU, all completed NRFU RI forms were returned to the LCO for check-in and shipping to data capture centers. All NRFU and RI forms were scanned at the data capture center, and the data were delivered electronically to MaRCS. Because a quick turnaround was critical for timely RI coding, the data delivered to MaRCS were not subject to any quality assurance measures at the data capture centers. Therefore, we expected some data capture errors in MaRCS that were later corrected for use in the census tabulations.

2.1.3 Reinterview Outcome Coding

Once all NRFU and RI data were received for the RI-selected cases, MaRCS began a three-stage matching process:

1. Computer Matching – MaRCS automatically compared the NRFU data to the NRFU RI data and assigned a final outcome of Pass to all cases where the NRFU and RI data had the same housing unit status, population counts within one of each other, and at least 50 percent of the roster names matched. Cases that did not match were deferred to the National Processing Center (NPC) for clerical matching.
2. NPC Clerical Matching – NPC clerks used MaRCS to review the NRFU and RI data for cases that did not pass computer matching and assigned a final outcome of Pass to all cases that only had minor data differences that prevented a computer match. Cases that did not match were deferred to the LCOs.
3. LCO Final Coding – LCO clerks reviewed all NRFU and RI data available to them in MaRCS and elsewhere to assign a final RI outcome to all cases deferred to them.

This matching process was subject to various errors. The computer matching algorithm was designed to pass some cases even if they had some data discrepancies, and the NPC and LCO matching stages were subject to human error. It is possible that some cases were passed that should not have, but we used this design because previous testing found it was the most efficient matching algorithm.

The final RI matching outcomes were:

1. Pass – The enumerator followed procedures without critical mistakes.
2. Soft Fail – The enumerator made an honest mistake.
3. Hard Fail – The enumerator falsified data or intentionally did not follow procedures. Once an enumerator received this outcome, all of his/her remaining work was selected for RI as rework.
4. Don't Know/Suspect – The MaRCS clerk is unable to determine a final RI outcome but suspects the enumerator falsified data or intentionally did not follow procedures.
5. Don't Know/No Suspect – The MaRCS clerk is unable to determine a final RI outcome but does not suspect the enumerator of falsification.
6. LCO Relief – The case was deferred to the LCO, but the LCO did not have time to determine a final RI outcome for the case. The MaRCS also automatically set this outcome for cases where the data were received after the MaRCS coding effort had ended, and the case did not pass computer matching.
7. RI Noninterview – The reinterviewer was unable to collect enough RI data for a valid comparison to the NRFU data.

All cases that received an outcome of Soft Fail or Hard Fail were flagged to have the NRFU RI data replace the NRFU data in the census tabulations. The “Don’t Know” outcomes were to be used only as a last resort.

2.2 Data Analysis Methods and Limitations

At the completion of the NRFU and NRFU RI operations, the MaRCS and OCS both produced final datasets containing one record for each case enumerated during NRFU and NRFU RI. Some cases were enumerated more than once, but only the last check-in record was included in the data from the OCS. The MaRCS matched NRFU and RI data only once per case, and the MaRCS data included only the check-in records used for the matching.

For this analysis, we combined the MaRCS and OCS datasets to create one dataset with one record per NRFU case. There were nonmatches from both datasets because, during the operation, MaRCS received data from the data capture centers and not straight from the OCS. This was not the original design but rather a contingency we implemented mid-operation because the originally planned receipt of OCS data did not work as expected. Unfortunately, the data from the data capture centers had expected imperfections because some paper forms were lost or had identification code data capture errors. The result is that some data records are missing check-in date fields while other data records are missing the RI matching outcomes, and it is likely that two such records could represent the same NRFU case.

This dataset of cases was then used to create an enumerator-level dataset with counts of cases for analysis. We relied on the enumerator identification codes from the OCS dataset because they were not subject to the data capture errors that impacted the MaRCS codes. However, some enumerator counts were not completely accurate because the OCS data only contained the last check-in for a case, which may not have been completed by the same enumerator as the first check-in. Due to this uncertainty, we could not analyze RI selections or outcomes by enumerator. We identified the Hard Fail enumerators through detailed examination and correction of the data.

The results presented here exclude records with missing data, as appropriate. For example, we use only the OCS data to determine the total NRFU workload and only the MaRCS data to determine the RI coding workloads. We use only the cases that matched between the MaRCS and OCS datasets for any analysis involving both RI coding results and check-in dates.

3. Results

3.1 Reinterview Selection

Please refer to Table 1 for the distribution of cases selected for RI. Only 67.5 percent of all NRFU cases were eligible for RI, which means the remaining cases were either noninterviews or non-eligible unit statuses as described earlier. We designed the random sample to select four percent of all eligible cases, but we actually selected 4.8 percent of all eligible cases for random RI. This happened because the RI selection was done by enumerator starting with one of the first three cases checked in to guarantee that all enumerators had at least one case selected. The result is that an enumerator who worked only five eligible cases, for example, would have a selection rate of 20 percent while an enumerator who worked 25 cases would have the expected selection rate of 4 percent.

Table 1: NRFU Reinterview Selections

	<i>Cases</i>	<i>Percents</i>
Total NRFU Cases	47,367,647	
NRFU Cases Eligible for RI	31,991,588	67.5% of all NRFU
Selected for RI	1,894,664	5.9% of eligibles
Random	1,525,297	4.8% of eligibles
Outlier	247,511	0.8% of eligibles
Supplemental	14,412	0.1% of eligibles
Rework	107,444	0.3% of eligibles

Source: OCS (Oct 25, 2010) and MaRCS (Oct 22, 2010)

The MaRCS automatically selected 247,511 cases for Outlier RI and 107,444 cases for Rework RI, which we expected to increase our odds of catching enumerator mistakes and falsification. In past enumerations, the outlier enumerators were reported to managers who had to manually select the outlier RI cases, so this automatic selection was a great improvement to the NRFU RI program.

3.2 Reinterview Outcome Results

The NRFU and NRFU RI data were loaded into MaRCS on a flow basis as the forms were data captured. As soon as all data were received for a case, MaRCS began the reinterview outcome assignment with computer matching. We found that 36.6 percent of all coded RI cases did not pass computer matching and were deferred to the NPC. The NPC clerks passed 15.3 percent of all cases, and the remaining 21.3 percent were deferred to the LCOs. This is a great improvement over previous censuses where the LCO staff had to review and assign outcomes to every RI case.

Please see Table 2 for the distribution of final RI outcomes in MaRCS.

Table 2: NRFU RI Matching Outcomes

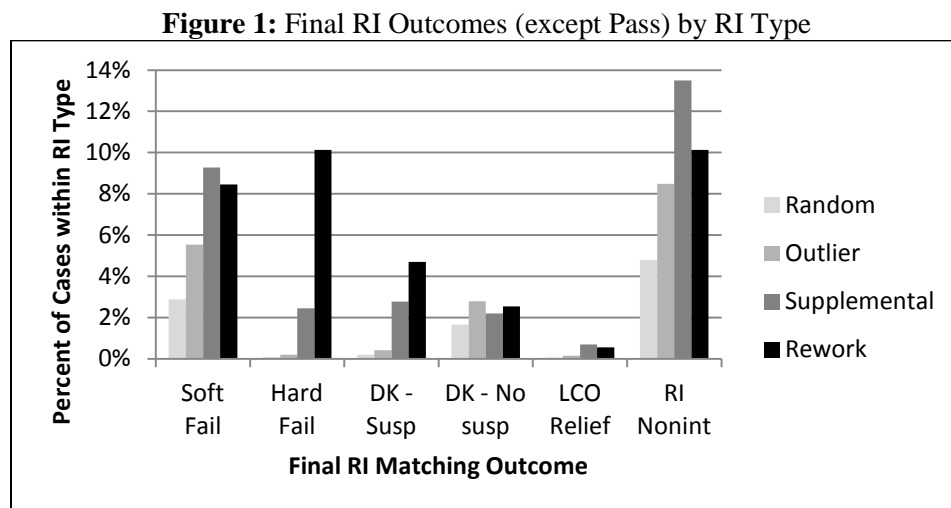
<i>RI Outcome</i>	<i>All</i>	<i>RI Type</i>			
		<i>Random</i>	<i>Outlier</i>	<i>Supplemental</i>	<i>Rework</i>
All	1,894,664 (100%)	1,525,297 (100%)	247,511 (100%)	14,412 (100%)	107,444 (100%)
Pass	1,632,798 (86.2%)	1,358,497 (89.1%)	201,227 (81.3%)	9,798 (68.0%)	63,276 (58.9%)
Soft Fail	68,043 (3.6%)	43,914 (2.9%)	13,712 (5.5%)	1,338 (9.3%)	9,079 (8.5%)
Hard Fail	12,912 (0.7%)	1,188 (0.1%)	489 (0.2%)	353 (2.5%)	10,882 (10.1%)
DK-Suspect	9,586 (0.5%)	3,123 (0.2%)	1,014 (0.4%)	399 (2.8%)	5,050 (4.7%)
DK-No Suspect	35,094 (1.9%)	25,145 (1.7%)	6,903 (2.8%)	315 (2.2%)	2,731 (2.5%)
LCO Relief	1,797 (0.1%)	744 (0.1%)	365 (0.2%)	99 (0.7%)	589 (0.6%)
RI Noninterview	106,925 (5.6%)	73,096 (4.8%)	21,000 (8.5%)	1,945 (13.5%)	10,884 (10.1%)
None	27,509 (1.5%)	19,590 (1.3%)	2,801 (1.1%)	165 (1.1%)	4,953 (4.6%)

Source: MaRCS (Oct 22, 2010)

Out of all 1,894,664 cases selected for RI, we see that 86.2 percent received a final outcome of Pass, 3.6 percent found honest mistakes (Soft Fail), and 0.7 percent found intentional falsification (Hard Fail). Only 0.1 percent of all RI cases received the LCO Relief outcome code, and all but 11 of them were because the data were received after the MaRCS coding effort had ended. This means the LCOs were able to review and code almost all of the cases they received. On the other hand, 1.5 percent of all RI cases never received any RI matching outcome because the data were never received or loaded into MaRCS. This is an unfortunate consequence of paper operations.

We expected the targeted RI types to more efficiently discover enumerator mistakes and falsification than the Random RI cases. One way to measure this is by examining the Pass rates for the different RI types. Table 2 shows that Random RI had the highest Pass rate of 89.1 percent, which implies it was the least efficient at identifying enumerator mistakes and falsification. The Supplemental and Hard Fail Pass rates were at least 20 percent less than the Random Pass rate, but the Outlier Pass rate – 81.3 percent – was almost as high as the Random RI Pass rate.

Figure 1 illustrates these RI outcome rates by RI type. The Pass outcome is excluded so we may better examine the outcomes that found possible mistakes or falsification.



Source: MaRCS (Oct 22, 2010)

We see that Random RI had the lowest percent of all outcomes in Figure 1 because it had the highest overall Pass rate of 89.1 percent. The Supplemental RI found the highest rate of honest mistakes (Soft Fail), while the Outlier RI found the highest rate of Don't Know/No Suspect cases. The Rework RI type had the highest rates of Hard Fail and Don't know/Suspect cases, which implies that enumerators who cheat will cheat more than once. In fact, these 12,912 Hard Fail cases were discovered for only 1,419 enumerators. In other words, only 0.27 percent of the 528,960 enumerators who completed at least one NRFU case were discovered falsifying data or intentionally violating procedures during the NRFU operation.

A surprising observation in Figure 1 is that supplemental cases had the highest rate of LCO Relief and RI Noninterview. These cases were specifically selected by the LCOs, so we'd expect them to make every attempt to complete them. However, this also could be an indication that the types of cases selected for Supplemental RI were for complicated

situations or more difficult original respondents who would be even less likely to respond to yet another interview. It also could reflect over-eager LCOs who wanted to check more cases but simply did not have time.

3.3 Completion Rates

Success of the NRFU RI program depended on our ability to quickly complete the RI and determine an outcome. We tried to complete the RI as soon as possible after the NRFU interview in order to improve respondent recall and reduce incidents of respondents moving before we could interview them again. We also wanted the RI outcomes determined quickly so we could provide feedback for mistakes or take other necessary action for intentional falsification.

3.3.1 Completion rates by Reinterview Stage

Table 3 shows the average and quartiles for the number of days it took for a case to be completed at each stage of the RI operation. These delays are calculated as the number of days between completion of the current and previous stages. Quartiles are presented instead of the standard deviation because all distributions are skewed to the right.

Table 3: Number of Days Before Completion of RI Stages

<i>Reinterview Stage</i>	<i>Mean</i>	<i>1st Quartile</i>	<i>Median</i>	<i>3rd Quartile</i>
NRFU Check-in	-	-	-	-
Reinterview Check-in	16	4	10	24
Computer Matching	15	8	13	19
NPC Clerical Matching	6	2	4	9
LCO Final Coding	4	1	3	6

Source: OCS (Oct 25, 2010) and MaRCS (Oct 22, 2010)

The long delays for reinterview check-in and computer matching were both partially caused by aspects of a paper operation. The reinterview check-in delay includes the time it took before the case was selected as well as how long it took to conduct the reinterview. Most targeted reinterview cases (which includes all RI types except random) were not selected until after the data were captured off the NRFU form, which could add up to ten days to this reinterview check-in time. The completion of the reinterview after selection was also likely affected by the transfer of paper materials to and from the LCOs. The computer matching delays were caused entirely by the data capture process and could be eliminated altogether with automated instruments and electronic data delivery to MaRCS.

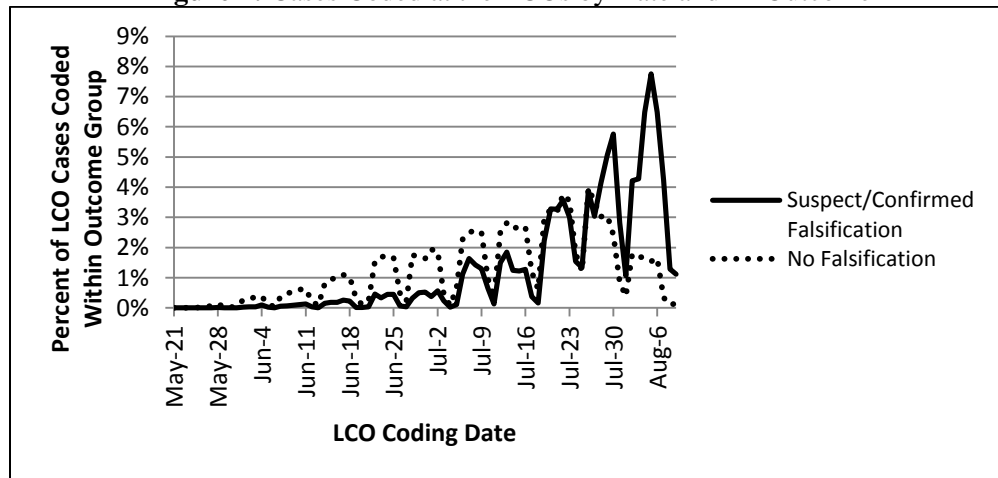
The NPC delay was slightly higher than desired, due mostly to the fact that we did not have a large enough workforce to keep up with the clerical matching workload. We also found that a higher percent of RI cases failed to pass computer matching later in the operation, so NPC received the bulk of their workload later than expected.

The LCO clerks were expected to code all cases within five days of receipt. Table 3 shows that they coded half their cases within three days (less than the expected five days) but also coded 25 percent of their cases in six or more days (longer than expected). It is possible that these delayed cases required more research before a code could be assigned.

3.3.2 LCO Coding Outcomes by Date

The LCO matching was the last stage of the RI coding process, where all cases that appeared to have some sort of issue received their final outcome. It was only after this stage that LCO managers could provide feedback to enumerators who made mistakes and terminate enumerators found falsifying data. There were 397,504 cases deferred to the LCOs, and Figure 2 illustrates the percents of LCO final RI outcomes assigned by date. The solid “Suspect/Confirmed Falsification” line includes the Hard Fail and Don’t Know/Suspect outcomes, and the dotted “No Falsification” line includes all remaining outcomes assigned at the LCO (Pass, Soft Fail, Don’t Know/No Suspect, and LCO Relief).

Figure 2: Cases Coded at the LCOs by Date and RI Outcome



Source: MaRCS (Oct 22, 2010)

Figure 2 shows that, overall, more codes were assigned later in the operation. This is most likely due to delays in previous stages as discussed earlier. Unfortunately, this means that most RI cases that discovered enumerator mistakes were not coded until it was too late to retrain the enumerator. The NRFU close-out was scheduled for July 10, but the offices completed much of their work long before that date. In fact, half of all enumerators had completed all of their cases by June 12. Most LCO outcomes were assigned after this date, so we missed our opportunity to retrain enumerators and possibly improve the quality of their interviews. This also increased the amount of rework because Hard Fail outcomes were not assigned earlier in the enumerators’ workloads.

This also affected the assignment of Hard Fail codes for enumerators intentionally not following procedures. It is extremely difficult to determine if procedural violations are intentional or not, so our procedures assumed the first violation was a mistake. If the enumerator continued to violate the same procedures after retraining, then it was deemed intentional and the case was marked falsified. Without the opportunity to retrain enumerators for the first procedural violation, the LCO managers were reluctant to Hard Fail enumerators who may (or may not) have intentionally violated procedures.

Figure 2 also shows that most of the cases of suspected or confirmed falsification were assigned in the last three weeks of the operation. This could be due to the additional research required before the LCOs could assign such codes, or maybe the enumerators tended to falsify data later in the operation in order to complete all their cases before the closeout date.

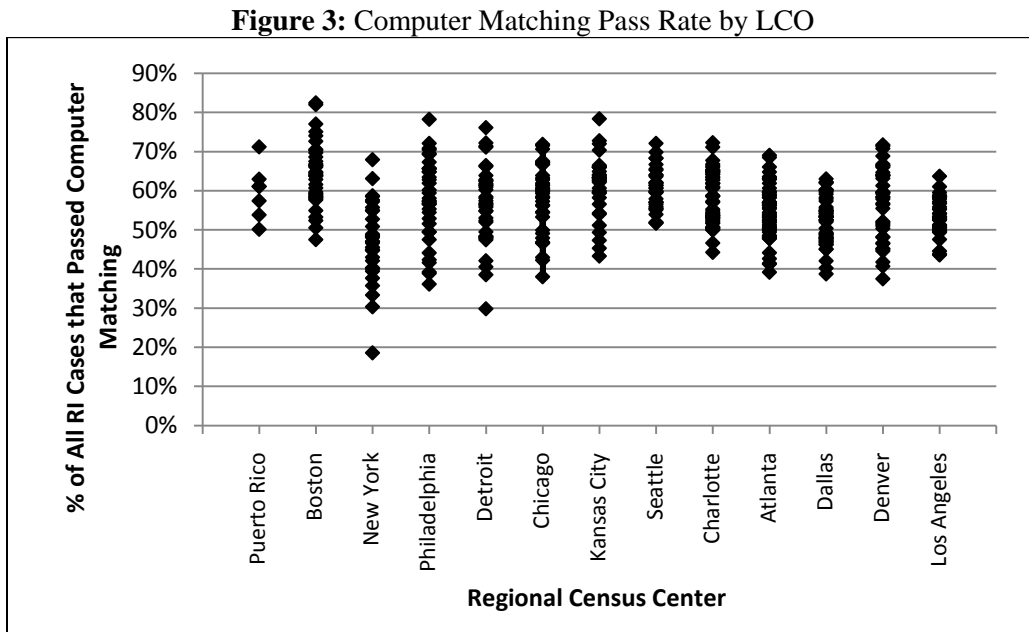
3.4 Reinterview Outcomes by Local Census Office

One enhancement the MaRCS provided during the 2010 NRFU RI was a set of management reports on RI coding results and progress. These reports were designed to help LCO and regional managers monitor their MaRCS coding efforts and not for headquarters to monitor LCO coding trends. Although the national-level coding results seem reasonable, post-operation analysis uncovered some LCOs that appeared not to be following proper procedures.

3.4.1 Data Collection by LCO

One indicator of the quality of data collected during production and RI is the MaRCS computer matching outcome. One obvious reason is that it identifies cases where the NRFU and RI enumerators collected drastically different data for the same address. Another reason is that all MaRCS data were received from questionnaire form scanning with no corrections by keyers. Therefore, the computer matching outcome could be affected by such things as the enumerator's handwriting, handling of the paper forms, and following interview skip patterns on the form.

Figure 3 shows the computer matching Pass rate by LCO. Each point in this plot is the computer matching Pass rate for one of our 494 LCOs, and the LCOs are grouped by their Regional Census Center.



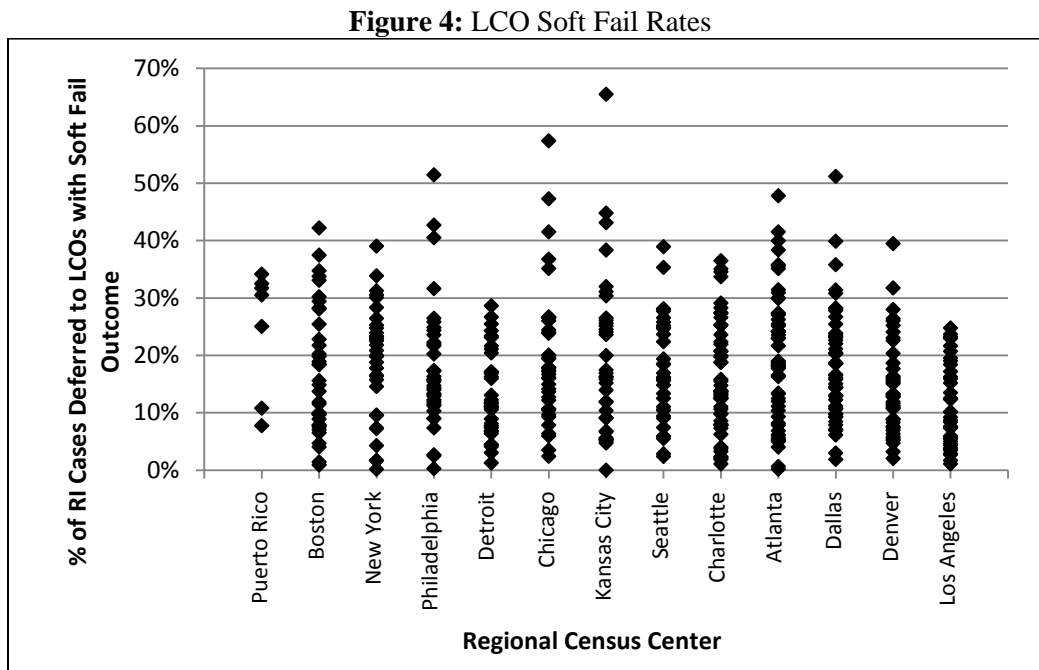
Source: MaRCS (Oct 22, 2010)

The national computer matching Pass rate was 58 percent. But we see in Figure 3 that some LCOs were much higher and some were much lower than this rate. The most alarming observation in Figure 3 is the Brooklyn East LCO (in New York), which had the lowest computer matching Pass rate at 19 percent of all RI cases. This may be related to the LCO-wide procedural violations that were discovered in this LCO. This discovery resulted in an extra effort to completely rework all of the NRFU cases in this LCO. If the plot in Figure 3 had been available to managers during the NRFU RI operation, we may have caught and corrected this issue sooner.

A positive observation from Figure 3 is that all LCOs in Seattle and Puerto Rico had at least half of their RI cases pass computer matching. This indicates consistently good data collection and clear writing on forms for both the production and RI staff in those offices.

3.4.2 MaRCS Coding Procedures by LCO

An important part of the NRFU RI outcome assignment is the LCO's ability to research discrepancies in the data and determine an objective outcome for the case. The RI operation was conducted by a separate quality assurance staff in the LCOs in order to prevent conflicts of interest in this effort. Figure 4 shows the Soft Fail coding rates in the LCOs. As in Figure 3, each point in this plot is the LCO Soft Fail rate for one of our 494 LCOs, and the LCOs are grouped by their Regional Census Center.



Source: MaRCS (Oct 22, 2010)

On average LCOs assigned a Soft Fail outcome to 17 percent of all cases they reviewed, but we see in Figure 4 that the LCO rates varied greatly. Again, we are alarmed to see that Cedar Rapids, IA (in Kansas City) coded absolutely no cases as Soft Fail, and eight other LCOs coded fewer than 10 RI cases as Soft Fail. While it's nice to think that so few honest mistakes were made in the field, it is more likely that these LCOs were not making objective decisions when coding their RI cases in MaRCS. On the other hand, we see some LCOs with unusually high Soft Fail rates. It appears we need to improve the training materials for the LCO MaRCS coding effort to make it more clear which cases should receive these outcomes.

4. Conclusions

The NRFU RI program successfully identified enumerator mistakes and falsification. We identified 68,043 cases (or 3.6 percent of all RI) of enumerator mistakes and 12,912 cases (or 0.7 percent) of falsification. This falsification was discovered for 1,419 enumerators, and most of their work was reinterviewed in order to identify any more cases of

falsification. The fact that about 13,000 Hard Fail cases were discovered for only about 1,400 enumerators indicates that cheaters tend to cheat more than once.

While the NRFU RI was successful, our operations could be improved with an automated instrument. We saw that 1.5 percent of all RI cases did not receive a RI outcome at all, which was mostly due to lost data or data discrepancies that prevented matching. We also experienced delays in the assignment of final RI outcomes, which limited our ability to provide feedback to the enumerators before they completed all of their work. An automated questionnaire (for NRFU and RI) would eliminate these data issues and drastically reduce the delay between NRFU interviewing and RI final coding. The Census Bureau plans to develop automated instruments for the 2020 Census.

Even with a paper operation, the MaRCS significantly improved the NRFU RI program. The targeted RI cases were more efficient than the random RI cases at discovering enumerator mistakes and falsification. The random RI sample was designed to ensure that all enumerators were reinterviewed at least once, but this may not be the best use of our reinterview resources. Some enumerators only worked a few cases before leaving the operation, so their overall data quality impact was much less than an enumerator who worked the entire operation. Further research is needed on possible ways to effectively reduce the random sample in favor of the targeted samples. We also plan to research new methods, such as falsification prediction modeling, to identify Outlier RI cases in an effort to make this sample type more efficient.

The MaRCS also improved the NRFU RI program through computer-assisted RI outcome assignment. Computer matching automatically resolved 63 percent of all RI cases, which means the NPC and LCOs only worked 37 percent and 21 percent of all cases, respectively. This allowed the LCO staff to focus their RI coding efforts on only the cases that appeared to have some sort of mistake or falsification.

The final outcome codes appear reasonable at the national level, but this analysis also discovered LCOs that did not appear to follow proper data collection or MaRCS coding procedures. We should develop reports in the future that allow headquarters to monitor LCO-level results and progress during the operation so we can address issues before work is completed.

Acknowledgements

I would like to thank the thousands of enumerators, clerks, and managers across the country whose hard work led to the success of the NRFU and NRFU RI operations. The understaffed NPC deserves special praise for doing everything possible to keep up with the unexpected MaRCS coding workloads. Finally, I'd like to thank the Gunnison Consulting Group for their flexibility and tireless accommodation of unexpected changes in developing the MaRCS application that so greatly improved our NRFU RI operation.

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