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MEMORANDUM FOR   The Distribution List

From: Arnold Jackson *[signed]*
                                   Acting Chief, Decennial Management Division

Subject: 2010 Census Nonresponse Followup (NRFU) Contact Strategy
                                   Experiment Report

Attached is the 2010 Census Nonresponse Followup (NRFU) Contact Strategy Experiment Report. The Quality Process for the 2010 Census Test Evaluations, Experiments, and Assessments was applied to the methodology development and review process. The report is sound and appropriate for completeness and accuracy.

If you have questions about this report, please contact Elizabeth Compton at (301) 763-6550.

Attachment

2010 Census Nonresponse Followup (NRFU) Contact Strategy Experiment

U.S. Census Bureau standards and quality process procedures were applied throughout the creation of this report.

FINAL REPORT

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Executive Summary

Introduction

A total of 131,704,730 housing units were enumerated in the 2010 Census. Of those in mailout/mailback areas approximately one-third (33.5 percent) did not respond to the initial or replacement mailings (Letourneau 2011). This left approximately 47 million housing units in the Nonresponse Followup workload (Jackson et. al. 2011). These housing units required an enumerator to collect the Census information (using personal visits or phone calls) as part of the nonresponse followup operation.

The objective of this experiment was to understand the effects of reducing the maximum number of Nonresponse Followup contacts in a census environment from the usual six, to either five or four, which could provide large cost savings through a reduction in field work. This will be answered with the following research question: **Can a reduction in the number of contact attempts still maintain the same level of data quality in order to save costs in Nonresponse Followup?** By conducting the experiment in the 2010 Census, the results are more predictive of what to expect in the 2020 Census with regard to the feasibility of reducing the maximum number of Nonresponse Followup contact attempts.

The production enumerator questionnaire consisted of questions designed to procure the same data as the 2010 Census mailout/mailback questionnaires, as well as a "record of contact" section to document information about each contact attempt. In particular, the front page of the questionnaire had space to provide data on up to six contact attempts including mode (personal visit or telephone), date, time, and outcome. Two experimental questionnaires were modified to provide data for up to either four or five contacts, respectively. All content questions were the same as those found on the standard enumerator questionnaires.

Methodology

The contact strategy experiment was carried out using a case-level sample design where a sample of the experimental enumerator questionnaires was systematically inserted into the assignment area binders in the 485 stateside local census offices during the assignment preparation activities (Puerto Rico was excluded from the sample). This design was intended to ensure that enumerators, on average, would receive one experimental questionnaire in each assignment area given to them.

The enumerator training included references to experimental questionnaires and instructed enumerators to use the questionnaire to determine the appropriate maximum number of attempts (both personal visit and telephone) for each housing unit. That is, if the questionnaire for a case contained six contact fields they should have made up to six attempts; if the questionnaire contained five contact fields they should have made up to five attempts; if the questionnaire contained four contact fields they should have made up to four attempts. After either the maximum number of attempts or the third personal visit enumerators were to seek a proxy respondent.

Results

If the experimental questionnaires were successful, there should have been no difference in the percentage of cases being completed, the proxy interview rate, or in the completeness of the questionnaires. Approximately one percent of all Nonresponse Followup cases did not have a defined interview by the final contact attempt. The final cumulative percentage of completed cases was within 0.1 percent for all contact strategies (four-, five-, and six-contacts). Overall, experimental data show that reducing the maximum number of contact attempts neither reduces the number of successfully completed cases, nor inflates the use of proxy respondents.

The expected "final push" to complete cases occurred on the last attempt regardless of the maximum number of attempts on the questionnaire. Whether this was due to extra effort made on the last contact or merely an exaggeration of the tendency for enumerators to make additional, unrecorded attempts is unknown given the methodology employed. Enumerator debriefing results suggest both explanations. Regardless, there is no increase in proxy respondents overall (51.8 percent for the six-contact form, 49.7 percent for the five-contact form, 49.1 percent for the four-contact form).

Enumerators were to make the number of contacts specified on the form, but this does not mean this was always the case, since for the majority of their workload they were accustomed to making up to six attempts. It is possible enumerators could have made the same number of attempts regardless of questionnaire type and did not record the extra contacts. Because of this limitation, we must be cautious when interpreting the results from this research.

Form completeness and item nonresponse were both consistent between all strategies. Although there were some concerns that reducing the number of contact attempts would have an adverse affect on data quality, the evidence did not show this.

These results support reducing the maximum number of contact attempts if savings in enumeration cost can be realized. In order to analyze cost-benefits for a reduced contact strategy, we extrapolated the Nonresponse Followup workload that would have been completed on each attempt, had a uniform strategy been employed (after accounting for enumerator training costs). High-end cost savings estimates for implementation of the experimental contact strategies for the 2010 Census are as follows:

- Savings associated with the use of a five-contact strategy instead of the six-contact strategy were approximately 0.4 percent of the six-contact estimated cost (4.7 million dollars).

- Savings associated with using a four-contact strategy instead of a six-contact strategy were approximately 5.7 percent of the six-contact estimated cost (75.8 million dollars).

However, estimated cost reduction for the four-contact strategy was potentially inflated by imprecise cost data. Detailed cost data by contact were not available for the 2010 Nonresponse Followup operation. The estimated cost per case is an average calculated across all cases and does not take into consideration any differences in cost for telephone calls versus personal visits, initial versus subsequent attempts, or regional variability. Further, it is likely that the average cost per case includes a base price per case with a decreased cost per attempt. So a reduction in one attempt, though calculated as saving 12.56 dollars might only reduce cost $10.00 or $5.00. However, there is evidence enumerators may put more effort into earlier attempts when the maximum attempts are reduced (see Section 5.1), creating an overall decrease in attempts above the expected decrease.

Conclusion and Recommendations

In conclusion, a reduction in the number of contact attempts has the potential to maintain the same level of data quality and save costs in the Nonresponse Followup operation, provided these experimental results hold when implemented at a larger level of geography.

Before full-scale implementation of a reduction in the maximum number of Nonresponse Followup contact attempts it is recommended that an area-level study be conducted. This study was unable to control for a number of factors that could have a significant impact on overall cost savings. Though we found no reduction in data quality, an area-level design in a mid-decade test would eliminate concerns over poor data quality clustering of census data. Area-level implementation would allow for homogeneity of organizational, training, and caseload management, to ensure consistency between enumerators and across field operations.

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1. Introduction

A total of 131,704,730 housing units were enumerated in the 2010 Census. Of those in mailout/mailback areas approximately one-third (33.5 percent) did not respond to the initial or replacement mailings (Letourneau 2011). This left approximately 47 million housing units in the Nonresponse Followup (NRFU) workload (Jackson et. al. 2011). These housing units required an enumerator to collect the Census information (using personal visits or phone calls) as part of the NRFU operation[1].

The objective of this experiment was to understand the effects of reducing the maximum number of NRFU contacts in a census environment. This study was motivated by the potential for cost savings through a reduction in contact attempts to nonresponse households. Historically, enumerators have been required to make up to six contact attempts (not to exceed three personal visits and three telephone attempts) with the household before resorting to "final attempt" procedures, such as contacting a neighbor or landlord. The goal is to determine whether it is possible to maintain a similar level of data quality and realize cost savings while reducing the maximum number of NRFU contacts.

Research Question: Can a reduction in the number of contact attempts still maintain the same level of data quality in order to save costs in NRFU?

2. Background

In Census 2000, over 1 billion dollars was spent on NRFU field work[2], at an average cost of $26.91 per case (Moul 2002). In the 2010 Census, over $1.5 billion was spent on NRFU field work, at an average cost of $33.65 per case (Jackson et. al. 2011). The procedure for NRFU traditionally requires an enumerator to make up to six contact attempts (three personal visits and three telephone attempts) (Burt and Mangaroo 2003). Previously, there has been no formal test to determine whether this maximum number of contact attempts is optimal or whether it provides the best data for the effort expended. Reducing the total number of contact attempts could reduce the cost of the NRFU operation by millions of dollars. After Census 2000, senior census managers and the Office of Management and Budget requested an evaluation to determine if the number of contact attempts could be reduced while maintaining a similar level of data quality.

Researchers used the 2000 Master Trace Sample (MTS) Database to study contact success in relation to contact attempts. As would be expected, completed cases were reduced with each successive contact attempt; however there was an increase in the percentage of cases completed at the sixth and final attempt (Tancreto and Bentley 2004). This could have been due to increased effort on the part of the enumerator, an increase in the use of proxy respondents, or an increase in undocumented attempts (such as an enumerator continuing to make further attempts which are recorded on an info-com or not recorded due to lack of space on the form). Regardless of the reason, it was expected that this same increase in successful cases on the last attempt would occur on the last contact attempt, regardless of the maximum number of attempts on the

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[1] This study did not include other enumerator operations such as Update/Enumerate and Remote Alaska.
[2] Total NRFU field work costs include training, travel, production, and miscellaneous expenses for enumerators, crew leaders, crew leader assistants, and field operation supervisors.

form. The MTS study was purely an observational one and the authors concluded an experiment would be necessary in order to study the effects of reducing the maximum number of contact attempts.

As part of the 2010 Census Program for Evaluations and Experiments (CPEX), an experiment was developed to compare the results from two experimental enumerator questionnaires. For a random sample of NRFU enumerator questionnaires, the "record of contact" section had a maximum of either five contact attempts or four contact attempts. The standard production form (the control group for purposes of analysis) had the traditional maximum of six contact attempts.

It was important to conduct this long-awaited study in the 2010 Census to understand the effects of changing the number of NRFU contacts in a census environment. For example, the potential affect of advertising and higher anticipated response rates would not be reflected in the results if this study were conducted as part of a mid-decade test. By conducting the experiment in the 2010 Census, the results are more predictive of what would occur during implementation in the 2020 Census with regard to the feasibility of reducing the maximum number of NRFU contact attempts.

3. Methodology

3.1 Experimental Questionnaires

The production enumerator questionnaire consisted of questions designed to procure the same data as the 2010 Census mailout/mailback questionnaires, as well as a "record of contact" section to document information about each contact attempt. In particular, the front page of the questionnaire had space to provide data on up to six contact attempts including mode (personal visit or telephone), date, time, and outcome. Two experimental questionnaires were modified to provide data for up to either four or five contacts, respectively.

Figure 1 shows the record of contact panel for the production six-contact questionnaires or D-1(E). Record of contact sections for the experimental four-contact D-1(E)(X2) and five-contact D-1(E)(X1) panels are in Figures 2 and 3, respectively. Other than to the record of contact section, there were no changes on the experimental enumerator questionnaires. All content questions were the same as those found on the standard enumerator questionnaires.

Figure 1. Standard 2010 Census Enumerator Questionnaire Record of Contact Question (D-1(E))

Figure 2. Experimental 2010 Census Enumerator Questionnaire Record of Contact Question for Five-Contact Strategy (D-1(E) X1)
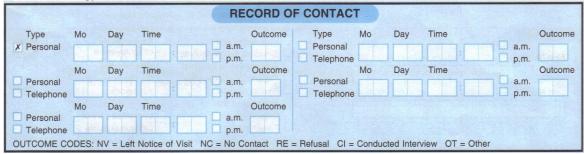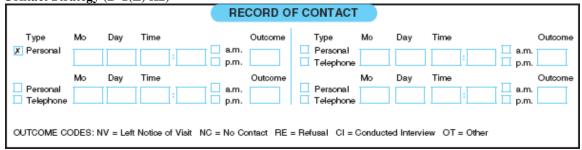

Figure 3. Experimental 2010 Census Enumerator Questionnaire Record of Contact Question for Four-Contact Strategy (D-1(E) X2)

Because the bulk of the enumerators' workload consisted of the standard six-contact questionnaires, researchers were concerned that enumerators would miss the experimental questionnaires. One method for mitigating this risk was to print the record of contact section of experimental questionnaires in a different color from the standard NRFU questionnaires and surround it with a black border, to draw attention and encourage the enumerator to follow the appropriate experimental procedures. Note that due to operational error in the final electronic file for the X1 questionnaire (five-contact questionnaire) sent to the print contractor, the record of contact section was printed in the original blue and not the modified white. From discussion with the field office staff, the black border present on both experimental questionnaires was a sufficiently differential characteristic.

3.2   Summary of Experimental Design

3.2.1 Sample Design

The contact strategy experiment was carried out using a case-level sample design where a sample of the experimental enumerator questionnaires was systematically inserted into the assignment area (AA) binders in 485 stateside Local Census Offices (LCOs) during the assignment preparation activities (the nine Puerto Rico LCOs were excluded from the sample). This design was intended to ensure that enumerators would receive one experimental questionnaire within each AA binder assigned to them. The quantity of AAs per LCO varied, as did the number of cases per AA.

Each LCO received one box of five-contact experimental questionnaires and one box of four-contact experimental questionnaires. The LCOs were instructed that experimental questionnaires

were systematically inserted with the standard D-1(E) enumerator questionnaires into each binder as it was prepared for an AA. The fifth form in the binder was an experimental questionnaire. To distribute the experimental questionnaires systematically across each LCO, binders for odd numbered AAs included five-contact enumerator questionnaires and even numbered AAs included four-contact enumerator questionnaires. LCO's were instructed to continue using production questionnaires in AA binders once all experimental questionnaires were used.

The case-level design enabled analysis of the impact on data quality and cost savings while minimizing operational logistical issues in the field and removing the risk of geographically clustered data quality problems associated with the use of experimental questionnaires. Any negative impact of fewer contacts on data quality was dispersed across all NRFU cases, thereby eliminating the possibility and/or perception of any clustering (e.g., entire geographic or political regions) of data quality loss.

3.2.2 Implementation

As usual during the implementation of a national effort, there was variability in the insertion strategy. Though the majority of LCOs followed the intended insertion pattern, some offices misunderstood the instructions. There were a few incidents where experimental questionnaires were inserted as every fifth questionnaire in an AA (e.g. the 5th, the 10th, etc.), resulting in multiple questionnaires in a single AA. Also, some LCOs used all experimental questionnaires in entire AA binders until running out and then inserted production questionnaires in the remaining binders. Just before NRFU field work and after assignment preparation had begun, a memo was sent to LCOs from headquarters instructing them to switch the insertion of the five-contact questionnaires into the even binders and the four-contact questionnaires into the odd binders (Cafarella 2010). Approximately half of the LCOs prepared binders using the original instruction, while the rest used the revised instructions.

The enumerator training included references to experimental questionnaires and instructed enumerators to use the questionnaire to determine the correct maximum number of attempts (both personal visit and telephone) for each housing unit. That is, if the questionnaire for a case contained six contact fields, they should have made up to six attempts; if the questionnaire contained five contact fields they should have made up to five attempts; if the questionnaire contained four contact fields they should have made up to four attempts. After the maximum number of attempts (personal and telephone) on the form or after the third personal visit, enumerators were instructed to seek a proxy respondent.

3.2.3 Alternative Designs

Several different study designs were considered during the design phase. For these designs, the experiment would have been conducted in entire geographic areas, such as Crew Leader Districts or Field Operations Supervisor areas. The intent was to have all enumerators in an area, to the extent possible, use the same questionnaire for all of their workload. Benefits from this design included accurate cost-benefit analysis and enumerator training that was consistent to the particular strategy being employed. However, after discussions with Field Division, it was

agreed that it would be too difficult to implement an area-level design without significant risks and limitations, including the perceived risk of poorer data quality in entire geographic areas.

3.3 Analysis

In order to analyze the results and determine effectiveness of fewer enumerator contact attempts, we conducted a variety of statistical analyses. These included cross-tabulations of the following measures by strategy (i.e., four, five, or six maximum number of contact attempts).

- Actual number of contact attempts
- Contact outcome
- Contact mode
- Respondent type (i.e., household member or proxy)
- Item nonresponse rates / form completeness
- Cumulative total of defined interviews at each contact number
- Distribution of contact outcomes at each contact

The analysis also included a cost-benefit component to judge the tradeoffs between the likelihood of more proxy responses and lower quality data with the decrease in costs.

3.3.1 Effective Sample Size

Approximately 1.2 million experimental questionnaires were sent out to the LCOs, yet not all experimental questionnaires sent to the field provided data for analysis (effective sample size was approximately one million for all experimental questionnaires). One reason for the reduction in sample is that smaller LCOs received the same number of questionnaires as larger LCOs. In these instances, excess questionnaires were left remaining and never used. Another cause of sample loss was inherent in the assignment process. An address label was affixed during assignment prep, so a housing unit that later responded to the mailout questionnaire would have been pulled from the AA binder.

In addition, not all NRFU cases with data were included in the analysis. "Add" cases, in which an enumerator found a housing unit not otherwise known to be recorded previously, were removed from all analysis. These would not have been assigned a form during assignment preparation and are outside the universe for this study as they had no chance to be completed using an experimental form. Also, it was necessary to limit the analysis to data that were tabulated accurately. Variables DOC_ID (numeric code associated with form type, and other characteristics) and OP_CODE (field operation numeric code) contained numeric strings related to the form type. Cases with OP_CODE or DOC_ID that did not match the listed form type could not be classified as experimental or control questionnaires with complete certainty and were, therefore, excluded from analysis.

Additionally, the measurable differences were reduced in two ways. First, though many NRFU housing units were successfully enumerated in three or fewer contact attempts, the primary driver for comparison between the three form types were cases where four, five, or six contact attempts were made. Finally, the item nonresponse and form completeness analyses were

limited to occupied NRFU households since vacant and delete units require very little data. For the experimental questionnaires, sample variances were computed using simple random sample estimation.

Table 1. Panel Design for NRFU Number of Contacts Experiment

Panel	Treatments	Form Type	Effective Sample Size
1	Control: 2010 Census enumerator form (which allows 6 contacts)	D-1(E)	45,411,474
2	5 Contact Attempts: 2010 Census enumerator form revised to allow only 5 contacts	D-1(E) X1	507,404
3	4 Contact Attempts: 2010 Census enumerator form revised to allow only 4 contacts	D-1(E) X2	502,194

3.3.2 Form and Contact Criteria

For various reasons, there was duplication when the files were created, both from multiple questionnaires and scans of the same questionnaires. In order to keep the NRFU contact strategy experiment consistent with other NRFU-related reports, the same criteria were utilized in selecting final NRFU questionnaires for each housing unit. The variables used to determine final form were VERSION and FORM_SEQ. VERSION pertains to duplication of questionnaires for single housing units. Each time a new form for a housing unit was checked in to the LCO, office clerks were required to manually increment the version on the questionnaire; this did not always happen. Multiple questionnaires for the same housing unit could have the same version number. Additionally, if the same form was data captured more than once, it would have the same version number as previous scans. FORM_SEQ was assigned during Census Bureau headquarters data processing and is independent of housing unit. Questionnaires were selected first by taking the highest VERSION number and then the highest FORM_SEQ number. This ensured that the last form completed and scanned in, which is likely to be the most complete, was used for all analysis purposes.

When enumerators made a contact attempt there were a number of fields that they were instructed to complete. These fields included checkboxes for contact type (personal visit or telephone); month, day, and time of the interview; and the outcome of the attempt. The criteria for defining a contact attempt were based on a combination of having useful data and an obvious intent from the enumerator. A record was counted as a valid contact attempt if one of the following was met:

- A contact outcome was recorded by the enumerator; or
- A contact date (month and day) was recorded; or
- A contact mode (personal or telephone) was recorded (except on the first contact).

Though the record of contact section of the enumeration form was not always clearly recorded, this was the only way to interpret what was done by the enumerator. If full completion of all fields was required to determine that a contact attempt was made, a number of cases might be lost due to enumerators forgetting to mark a field when the record could still contain useful data.

It was also necessary to set criteria for defining an interview. This study used a combination of values from the record of contact section and the final housing unit population count from the Interview Summary. Table 2 explicitly shows all criteria for defining a contact. Because the record of contact section is the primary source of data for analysis, any enumerator-provided outcome of "CI," indicating that an interview was conducted, was defined as an indicator of a successful interview. Those cases without a "CI" were then checked for a valid population count or code (Vacant, Delete, etc.). A small percentage of completed NRFU questionnaires had an entry in the population count box that did not fit within the criteria of acceptable responses. These were not defined as interviews unless a "CI" was in the Record of Contact section. Cases were not required to fit both criteria.

Table 2. Case Definition Criteria

Record of Contact Section	Interview Summary Pop Count	Defined Interview
"CI"	Any Outcome	Yes
All Other Outcomes	00 – 49 or 98	Yes
All Other Outcomes	50 – 97 or 99	No

3.3.3 Cost-Benefit Analysis

To analyze the possible cost savings that could be achieved by reducing contact attempts, we estimated the cost per attempt for the 2010 NRFU operation. Cost data were not available at more than a generic per case level making calculation of different cost estimates for telephone and personal visits impossible. The overall estimates were applied to the actual NRFU contact profile (i.e., number of contacts required for completion). This same strategy was applied to both of the contact treatments to come up with the savings associated with both levels of contact reduction. The cost-benefit component was balanced against data quality analysis to determine the tradeoffs between cost reduction and potential data quality reduction.

3.3.4 Enumerator Debriefing Questionnaire

In addition to the quantitative data analysis, there was an additional qualitative component added to this study. General questions about job title, regional office, and prior census experience were asked. The debriefing included a section of questions on enumeration technique and the experimental questionnaires as well. These responses gave an idea of how well instructions were followed and if the reduced contact spaces on the form made any actual difference to those in the field.

Questions regarding NRFU contact strategy were as follows:

- On average, how many contact attempts did you usually need to make to ensure that you obtained an interview?
- For how many interviews did you make more contact attempts than the questionnaire allowed for?
- Where did you record the additional contacts?

- During training, did you understand that you might come across some questionnaires that allowed for <u>fewer</u> than six contact attempts?
- During training, how clear were the instructions on how to work with questionnaires that allowed for <u>fewer</u> than six contact attempts?
- How many experimental questionnaires did you receive in your assignment that allowed for <u>four (4) contact attempts</u>?
- How many experimental questionnaires did you receive in your assignment that allowed for <u>five (5) contact attempts</u>?
- If a questionnaire allowed for <u>fewer</u> than six contact attempts, did you change your normal work routine/strategy in any way?
- Please explain what strategies you used for a questionnaire that allowed for <u>fewer</u> than six contact attempts?

The enumerator debriefing questionnaires were distributed as a systematic random sample across all regions, and administered to select field operational supervisor areas in all LCOs. Enumerators and crew leader assistants responded to this debriefing questionnaire toward the end of NRFU field operation.

4. Limitations

4.1 Sample Implementation

Placement of the experimental questionnaires was performed in the field during the largest field staff mobilization of the decade. Given the complexity of this organization, there is no guarantee that the intended sampling method was followed exactly at every LCO. Reports and discussion with field staff illuminated occurrences of inconsistent form placement, multiple experimental questionnaires in the same AA binder, labeled questionnaires removed before going into the field, among other problems. The predominant effect of this was an increase in randomization in an otherwise systematic sample. In cases where entire binders contained experimental questionnaires, clustering may have occurred. There is no anticipated negative effect from these deviations. For more complete descriptions see Section 3.3.1.

4.2 Actual Number of Enumeration Attempts

Enumerators were trained to make up to the number of contacts specified on the form, but this did not mean that they followed these instructions for the recorded contact attempts after becoming accustomed to six attempts. There is evidence to show that some enumerators made undocumented attempts (such as an enumerator continuing to make further attempts which are recorded on an info-com or not recorded due to lack of space on the form). This study assumes that the number of contact attempts recorded in the record of contact section was the actual number of attempts made. Thus, by definition, the standard six-contact form could have no more than six attempts, the five-contact form could have no more than five attempts, and the four-contact form could have no more than four attempts. It is possible and likely that some enumerators made undocumented attempts that could not be accounted for in the cost analysis. If some enumerators made more attempts than recorded, estimated cost savings reported would be higher than would actually be realized on implementation.

4.3 Data Capture of Contact Outcomes

This study relies completely on the ability of the enumerators to have accurately recorded all data in a manner in which the data capture software was able to record successfully. Any case with ambiguous responses such as an outcome of "CT" or "OI" was treated as an undeterminable response and not recoded to either "CI" or "OT," for completed interview and other, respectively. It is likely that some of cases with a successfully conducted interview have been considered a "No Interview" for this analysis due to the strict criteria of this study.

4.4 Cost Estimation

The NRFU estimated cost per case is an average calculated across all cases (see Section 5.3). This does not take into consideration any differences in cost for telephone calls compared with personal visits, initial compared with subsequent attempts, regional variability, etc. Detailed cost data by contact were not available for the 2010 NRFU operation.

4.5 Form Selection

Selection was based on use of the final version of the final form submitted for each NRFU case. This could lead to discrepancies in the data for experimental cases. Cases that were reworked for any reason would have been completed on a six-contact form, though the case initially was assigned an experimental form. This may not only lead to reassignment of some cases that should have been experimental, but could have artificially increased data quality on the retained experimental questionnaires. Though analysis of the first data captured questionnaires yielded no differences, it is possible initial questionnaires were never transmitted to Census Bureau Headquarters.

5. Results

Analysis of the NRFU contact strategy interview outcomes is found in Section 5.1. Quality of data that were collected is addressed in Section 5.2. Cost-benefits analysis and estimated cost savings from implementation of either experimental strategy is found in Section 5.3. Qualitative data from the enumerator debriefing survey are summarized in Section 5.4.

As explained in Section 3.3.2 attempts and contacts had to be defined by specific data based criteria. This resulted in segmented analysis of different universes depending upon what was of interest. Sample sizes for each segment of the universe used in the analysis are shown in Table 3.

Table 3. Sample Sizes by Defined Interviews and Contact Attempts.

	D-1 (E)	D-1 (E)(X1)	D-1 (E)(X2)
Total Cases	45,411,474	507,404	502,194
Cases with a Defined Contact Attempt	45,220,696	506,078	500,816
Cases with a Defined Interview and Contact Attempt	44,857,302	501,730	496,669
Cases with a Defined Interview and Occupied Status	27,337,269	310,612	305,967

Source: 2010 Decennial Response File and Auxiliary files

5.1. Interview and Outcome Distributions

Interview completion is the most important measure of success for the experimental treatments. If a reduction in contact attempts resulted in a reduction of completed interviews, this would harm the effectiveness of the NRFU operation. Analysis included all cases with a defined contact attempt.

Table 4 shows the total number of contact attempts made for all cases with a defined interview (as described in Section 3.3.2). This is separated by form with four, five, or six contact attempts in the record of contact section. All cases without a defined interview are grouped in the last row for each form. These cases have anywhere between one and six attempts. Cases with no attempts documented have been removed from analysis. Cases where attempts were made and no defined interview was recorded are listed as "No Interview" (see Section 4.3).

As shown in Table 4, approximately one percent of all NRFU cases did not have a defined interview by the final contact attempt. The final cumulative percentage of completed cases was within 0.1 percent for all contact strategies (four-, five-, and six- contacts). Of note is the similarity of distributions between the treatments. For instance, the fourth contact attempt had the same cumulative completion rate (91.1 percent) for both the six- and five-contact strategies. The cumulative total of interviews after the third contact attempt were also relatively similar across the three treatments, within 1.5 percentage points of each other (although the cumulative rate is significantly higher for the four attempt form at $\alpha=0.10$). As predicted, additional effort made by the enumerators to complete cases on the final attempt occurs regardless of how many previous attempts have been made.

Table 4. Cumulative Total and Percentage Point Increase for Defined Interviews by Form Type

	Contact Attempts	Interviews Completed at Each Contact	Cumulative Total	Cumulative Percent	Percentage Point Increase
	1	18,605,185	18,605,185	41.1	
Six	2	11,259,665	29,864,850	66.0	24.9
Attempt	3	7,353,238	37,218,088	82.3	16.3
Treatment	4	3,964,490	41,182,578	91.1	8.8
	5	1,629,254	42,811,832	94.7	3.6
	6	2,045,470	44,857,302	99.2	4.5
	No Interview	363,394	45,220,696		0.8
	1	197,363	197,363	39.0 (0.07)	
Five	2	130,347	327,710	64.8 (0.07)	25.8 (0.07)
Attempt	3	86,401	414,111	81.8 (0.05)	17.1 (0.06)
Treatment	4	46,685	460,796	91.1 (0.04)	9.2 (0.05)
	5	40,934	501,730	99.1 (0.01)	8.1 (0.04)
	No Interview	4,348	506,078		0.9
	1	199,216	199,216	39.8 (0.07)	
Four	2	133,501	332,717	66.4 (0.07)	26.7 (0.07)
Attempt	3	83,428	416,145	83.1 (0.05)	16.7 (0.06)
Treatment	4	80,524	496,669	99.2 (0.01)	16.1 (0.05)
	No Interview	4,147	500,816		0.8

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance.

On average, cases assigned a production six-contact enumerator questionnaire and cases assigned an experimental five-contact questionnaire took 2.2 contact attempts to complete. Cases assigned an experimental four-contact questionnaire took only 2.1 contact attempts on average to complete. For comparison purposes, Table 4 was also subset by each of the three housing unit status types (occupied, vacant, delete). These results are found in the Appendix (occupied housing units in Table A1, vacant housing units in Table A2, and deletes in Table A3) and are similar to those found in Table 4. We also found that the results did not vary when subset by LCO type (Urban/Metropolitan, Urban/Hard to Count, Suburban/Rural, Rural/Remote).

Table 5 shows the distribution of all contact outcomes, by contact attempt number, for each experimental treatment. Unlike Table 4, which shows the cumulative total of defined interviews by the total number of contact attempts, this table shows all possible outcomes at each attempt number for defined attempts. Potential outcomes from the record of contact section were conducted interview (CI), left notice of visit (NV), refusal (RE), no contact (NC), and other (OT). The undetermined category contains all other letter combinations and missing contained cases where no outcome was recorded in the presence of other information. Note that in some cases an enumerator may have recorded a contact as a "CI" but, for unknown reasons, there were subsequent contact attempts for that housing unit. This incidence was relatively low (0.87 percent overall). This table also includes cases without an outcome of a defined interview, those that remained unresolved by the end of the NRFU operation.

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Table 5. Distribution of Outcomes at Each Contact by Form Type

	Contact Number	Number of Contact Attempts	Conducted Interview	Left Notice of Visit	Refusal	No Contact	Other	Undetermined	Missing
						Contact Outcome in Percents			
Six Attempt Treatment	1	45,220,696	39.8	47.1	1.3	4.9	6.5	0.2	0.2
	2	26,543,824	41.8	34.3	1.6	15.4	6.3	0.2	0.5
	3	15,244,351	47.4	26.4	2.0	17.1	6.3	0.1	0.5
	4	7,804,378	49.8	22.7	2.0	17.3	7.2	0.2	0.9
	5	3,792,340	41.6	26.1	2.5	21.2	7.6	0.2	0.8
	6	2,134,725	83.3	4.2	1.8	6.3	3.3	0.2	0.9
Five Attempt Treatment	1	506,078	37.7 (0.07)	48.5 (0.07)	1.4 (0.02)	5.0 (0.03)	6.9 (0.04)	0.2 (0.01)	0.2 (0.01)
	2	308,049	41.6 (0.09)	34.4 (0.09)	1.8 (0.02)	14.8 (0.06)	6.8 (0.05)	0.2 (0.01)	0.5 (0.01)
	3	177,215	48.0 (0.12)	25.7 (0.10)	2.4 (0.04)	16.6 (0.09)	6.7 (0.06)	0.1 (0.01)	0.5 (0.02)
	4	89,672	50.9 (0.17)	21.5 (0.14)	2.4 (0.05)	16.6 (0.12)	7.5 (0.09)	0.2 (0.01)	1.0 (0.03)
	5	42,366	83.4 (0.18)	4.5 (0.10)	1.8 (0.06)	5.7 (0.11)	3.5 (0.09)	0.2 (0.02)	0.9 (0.05)
Four Attempt Treatment	1	500,816	38.6 (0.07)	48.4 (0.07)	1.3 (0.02)	4.8 (0.03)	6.5 (0.03)	0.2 (0.01)	0.2 (0.01)
	2	301,056	43.7 (0.09)	33.0 (0.09)	1.7 (0.02)	14.6 (0.06)	6.3 (0.04)	0.2 (0.01)	0.4 (0.01)
	3	167,111	48.9 (0.12)	25.8 (0.11)	2.2 (0.04)	16.0 (0.09)	6.4 (0.06)	0.2 (0.01)	0.5 (0.02)
	4	82,697	86.3 (0.12)	4.0 (0.07)	1.5 (0.04)	4.4 (0.07)	2.9 (0.06)	0.2 (0.02)	0.7 (0.03)

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact
treatment is the standard census form and has no variance.

If enumerators were resolving cases in a consistent way, there would not be any major
differences in the distribution of contact outcomes at each contact number between the three
different contact strategies. In fact, the distributions of outcomes at initial contact were similar
among all strategies. For instance, 47.1 percent of the initial visits for the standard six-contact
form had an outcome of "left notice of visit," compared to 48.5 percent and 48.4 percent in the
five- and four- attempt treatments. Distributions for the final attempt (fourth, fifth, or sixth
respectively) were also similar. Although intermediate distributions varied dependent upon
strategy, they were still generally similar to each other in outcome (for instance, 15 to 17 percent
of the second and third contacts for each strategy resulted in no contact with the housing unit).
Tables A4 and A5 in the appendix show contact outcome at each attempt for personal visits and
telephone calls.

The reduction by two attempts does not appear to cause any damage to successful case completion. Results of outcome by attempt showed that, regardless of the contact strategy, the majority of final attempts results in a conducted interview (83.3 percent for the six-contact form, 83.4 percent for the five-contact form, and 86.3 percent for the four-contact form). This suggests that some enumerators may have altered their strategy or increased effort to complete the cases by the final attempt.

Next, we examined the rate of proxy and household member interviews between the three NRFU contact strategies. Table 6 shows the distribution of contacts by respondent type for each of the treatment groups for cases with a defined interview. There was not a large difference in the average number of proxy[3] respondents for the treatments (51.8 percent for the six-contact strategy, 49.7 percent for the five-contact strategy, and 50.2 percent for the four-contact strategy). The percentage of cases that have a missing or undetermined respondent is comparable.

The percentage of household member respondents was significantly higher on both the reduced contact treatments (47.5 percent of six-contact attempts, 49.5 percent of five contacts, and 49.1 percent of four contacts). This is a positive finding for the two experimental treatments because one of the concerns was that fewer contact attempts would lead to enumerators seeking a proxy sooner. The concern stems from evidence that the use of proxy respondents leads to higher item nonresponse (Chesnut 2005).

Lower proxy rates from the experimental questionnaires could be related to the form data selection process in which the final NRFU form for each household was used for analysis purposes. It is possible proxy cases were more likely to be reworked (needed additional attempts to enumerate). Cases that were reworked or corrected for any reason would have been completed on a six-contact form though the case initially was assigned an experimental form. If this was the case, it may have altered the overall household proxy rates by "moving" some of the experimental proxy cases to the control group.

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[3] For the purposes of this analysis, "proxy" respondents include household in-movers after Census Day (April 1) and neighbors or landlords, for example.

Table 6. Distribution of Respondent Type for Defined Interviews by Form Type

	Contact Number	Household Respondent (Percent)	Proxy Respondent (Percent)	Missing (Percent)
	1	52.1	46.8	1.1
Six	2	49.4	50.1	0.5
Attempt	3	44.9	54.5	0.5
Treatment	4	35.1	64.5	0.4
	5	40.1	59.4	0.5
	6	34.2	65.2	0.6
	Total	**47.5**	**51.8**	**0.7**
	1	54.8 (0.11)	44.0 (0.11)	1.2 (0.02)
Five	2	51.2 (0.14)	48.2 (0.14)	0.6 (0.02)
Attempt	3	46.7 (0.17)	52.7 (0.17)	0.6 (0.03)
Treatment	4	37.9 (0.22)	61.6 (0.23)	0.5 (0.03)
	5	38.0 (0.24)	61.3 (0.24)	0.7 (0.04)
	Total	**49.5 (0.07)**	**49.7 (0.07)**	**0.8 (0.01)**
	1	54.7 (0.11)	44.4 (0.11)	1.0 (0.02)
Four	2	50.2 (0.14)	49.3 (0.14)	0.5 (0.02)
Attempt	3	45.7 (0.17)	53.8 (0.17)	0.5 (0.02)
Treatment	4	36.9 (0.17)	62.6 (0.17)	0.4 (0.02)
	Total	**49.1 (0.07)**	**50.2 (0.07)**	**0.7 (0.01)**

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact
treatment is the standard census form and has no variance.

The units that were vacant or deleted required a proxy respondent since there was no household living in the unit on Census Day. For comparison purposes, householder and proxy frequencies similar to those found in Table 6 were recalculated so only occupied housing units were included in Table 7. This resulted in a large reduction in the frequencies of proxy respondents at each attempt. There was a significantly greater proportion of household respondents for both reduced contact strategies (significant at $\alpha=0.10$). Overall, household member respondents made up 76.2 percent of six-contact cases, 78.2 percent of five-contact cases, and 77.9 percent of four-contact cases.

Table 7. Distribution of Respondent Type for Defined Interviews in Occupied Housing Units by Form Type

	Contact Number	Household Respondent (Percent)	Proxy Respondent (Percent)	Missing (Percent)
	1	89.2	10.4	0.4
Six	2	84.4	15.2	0.4
Attempt	3	67.7	32.0	0.4
Treatment	4	50.3	49.4	0.3
	5	53.0	46.6	0.4
	6	43.0	56.5	0.5
	Total	**76.2**	**23.4**	**0.4**
	1	91.7 (0.08)	7.9 (0.08)	0.4 (0.02)
Five	2	86.4 (0.12)	13.2 (0.012)	0.4 (0.02)
Attempt	3	69.8 (0.19)	29.8 (0.19)	0.4 (0.03)
Treatment	4	53.9 (0.28)	45.7 (0.28)	0.4 (0.04)
	5	48.5 (0.28)	51.0 (0.28)	0.5 (0.04)
	Total	**78.2 (0.07)**	**21.4 (0.07)**	**0.4 (0.01)**
	1	91.4 (0.08)	8.3 (0.08)	0.3 (0.02)
Four	2	85.1 (0.13)	14.6 (0.13)	0.3 (0.02)
Attempt	3	68.8 (0.20)	30.9 (0.20)	0.3 (0.02)
Treatment	4	49.9 (0.21)	49.7 (0.21)	0.4 (0.03)
	Total	**77.9 (0.08)**	**21.8 (0.07)**	**0.3 (0.01)**

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Only occupied units with completed interviews were included.

Table 8 shows the distribution of contact mode (telephone or personal visit) at each contact attempt for cases with a defined interview. The enumerator trainer manual instructed trainers to encourage making three personal visits over telephone attempts, which would suggest a higher proportion of personal visits for the five-contact and four-contact questionnaires due to fewer total attempts. Despite this, the distributions of contact types did not vary considerably between the three NRFU contact strategies. Overall, 82.0 percent of the six-contact questionnaires were completed by personal visit, 9.5 percent by telephone interview, and 8.5 percent had a missing or undetermined (i.e., both boxes checked) contact mode. This distribution was relatively consistent with the four-contact strategy, although the five-contact strategy had a slightly lower percentage of personal visits compared to the four-contact strategy (significant at $\alpha=0.10$).

Table 8.   Distribution of Contact Type for Defined Interviews by Form Type

	Contact Number	Personal Visit	Telephone	Undetermined /Missing
Six Attempt Treatment	1	94.6	0.2	5.2
	2	73.9	16.1	10.0
	3	75.3	14.5	10.1
	4	69.9	18.6	11.5
	5	70.0	18.6	11.5
	6	68.7	15.0	16.3
	Total	**82.0**	**9.5**	**8.5**
Five Attempt Treatment	1	94.4 (0.05)	0.1 (0.01)	5.5 (0.05)
	2	72.6 (0.12)	16.1 (0.10)	11.3 (0.09)
	3	74.2 (0.15)	14.9 (0.12)	10.9 (0.11)
	4	69.5 (0.21)	20.0 (0.19)	10.5 (0.14)
	5	66.2 (0.23)	16.6 (0.18)	17.1 (0.19)
	Total	**80.7 (0.06)**	**10.0 (0.04)**	**9.3 (0.04)**
Four Attempt Treatment	1	94.9 (0.05)	0.0 (0.00)	5.0 (0.05)
	2	74.2 (0.12)	16.3 (0.10)	9.5 (0.08)
	3	75.3 (0.15)	15.9 (0.13)	8.9 (0.10)
	4	67.9 (0.16)	16.7 (0.13)	15.4 (0.13)
	Total	**81.7 (0.05)**	**9.8 (0.04)**	**8.5 (0.04)**

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance.

For comparison purposes, personal visit and telephone call frequencies similar to those found in Table 8 were recalculated so only occupied housing units have been included in Table 9. There was no great shift in distribution when vacant and delete units were removed.

Table 9. Distribution of Contact Type for Defined Interviews in Occupied Housing Units by Form Type

	Contact Number	Personal Visit	Telephone	Undetermined /Missing
Six Attempt Treatment	1	98.7	0.2	1.1
	2	78.1	12.6	9.3
	3	78.3	12.7	8.9
	4	71.8	17.4	10.8
	5	72.0	17.3	10.7
	6	70.3	14.4	15.3
	Total	**84.8**	**8.6**	**6.6**
Five Attempt Treatment	1	98.9 (0.03)	0.1 (0.01)	1.0 (0.03)
	2	77.3 (0.15)	12.4 (0.12)	10.3 (0.11)
	3	77.3 (0.18)	13.1 (0.14)	9.6 (0.12)
	4	71.4 (0.26)	18.9 (0.22)	9.8 (0.17)
	5	68.1 (0.26)	15.8 (0.21)	16.1 (0.21)
	Total	**83.8 (0.07)**	**9.0 (0.05)**	**7.3 (0.05)**
Four Attempt Treatment	1	99.1 (0.03)	0.0 (0.00)	0.9 (0.03)
	2	78.7 (0.15)	12.7 (0.12)	8.6 (0.10)
	3	78.2 (0.18)	14.0 (0.15)	7.8 (0.12)
	4	69.5 (0.19)	15.7 (0.15)	14.7 (0.15)
	Total	**84.7 (0.07)**	**8.7 (0.05)**	**6.7 (0.05)**

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Only occupied units with completed interviews were included.

5.2. Item Nonresponse and Completeness

Though case completion is of great concern for NRFU, the quantity and detail of the data being collected were also very important. Data quality can mean many different things, however this study looked at very specific measures to analyze the quality of the data obtained for each of the three strategies. These included overall form completeness and item nonresponse.

There should not have been any change in form completeness by response type if the experimental treatments had no effect on the data quality. Table 10 shows the average form completeness based on contact type for each of the three contact strategies. The results demonstrate that average form completeness for both personal visit and telephone contacts are the same for both experimental questionnaires and have slightly more telephone interviews than the standard six-contact form.   In general, personal visit interviews elicited slightly better form completeness (e.g., 92.0 percent for the six-contact questionnaires) than telephone interviews (e.g., 90.8 percent for the six-contact questionnaires) for each form treatment (statistically significant at $\alpha=0.10$). Overall, 91.3 percent of the census data on the six-attempt questionnaires were complete, 91.8 percent on the five-attempt form, and 91.8 percent on four-attempt questionnaires.

Table 10. Average Form Completeness by Mode of Contact for Defined Interviews by Form Type.

	Contact Number	Personal Visit	Telephone Call	Undetermined	Overall
	1	96.4	92.9	74.8	96.1
Six	2	94.5	94.6	91.3	94.2
Attempt	3	87.9	92.3	82.5	88.0
Treatment	4	81.7	86.7	78.4	82.2
	5	82.9	87.4	77.3	83.1
	6	79.4	84.6	73.1	79.2
	Total	**92.0**	**90.8**	**82.6**	**91.3**
	1	97.1 (0.05)	95.2 (2.48)	73.6 (1.30)	96.9 (0.05)
Five	2	95.1 (0.09)	95.0 (0.23)	92.2 (0.30)	94.8 (0.08)
Attempt	3	88.5 (0.15)	92.8 (0.30)	83.2 (0.51)	88.5 (0.13)
Treatment	4	82.9 (0.25)	87.5 (0.42)	78.5 (0.73)	83.3 (0.21)
	5	81.1 (0.27)	86.0 (0.49)	75.6 (0.60)	81.0 (0.22)
	Total	**92.6 (0.05)**	**91.2 (0.17)**	**83.4 (0.25)**	**91.8 (0.05)**
	1	96.9 (0.05)	88.7 (6.91)	73.4 (1.37)	96.7 (0.05)
Four	2	94.6 (0.09)	94.7 (0.23)	90.7 (0.36)	94.3 (0.08)
Attempt	3	88.3 (0.16)	91.8 (0.34)	81.7 (0.60)	88.3 (0.14)
Treatment	4	81.8 (0.19)	86.6 (0.36)	76.5 (0.46)	81.8 (0.16)
	Total	**92.6 (0.05)**	**91.1 (0.17)**	**82.0 (0.27)**	**91.8 (0.05)**

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Only occupied units with completed interviews were included.

Table 11 shows the average form completeness based on respondent type for each of the treatments. Average form completeness for household members and proxies is comparable across all treatments. In general, form completeness was higher for household-member interviews (97.1 percent for six-contact questionnaires) than for proxy cases (72.5 percent for six-contact questionnaires), and almost identical across the three contact strategies (significant at α=0.10). Proxy respondents are often correlated with poorer data quality than that of household members (Chesnut 2005) since they do not typically have full knowledge of or familiarity with all residents compared to an actual household member.

Table 11. Average Form Completeness by Respondent Type for Defined Interviews by Form Type

	Contact Number	Household Member	Proxy Respondent	Undetermined	Overall
	1	97.7	82.4	87.2	96.1
Six	2	97.4	77.0	86.5	94.2
Attempt	3	96.6	69.9	79.9	88.0
Treatment	4	95.8	68.5	77.6	82.2
	5	95.4	69.1	77.3	83.1
	6	94.0	67.9	71.1	79.2
	Total	**97.1**	**72.5**	**83.4**	**91.3**
	1	97.9 (0.04)	85.3 (0.37)	90.0 (1.32)	96.9 (0.05)
Five	2	97.4 (0.06)	77.9 (0.42)	83.5 (2.16)	94.8 (0.08)
Attempt	3	96.6 (0.09)	69.7 (0.35)	79.7 (2.65)	88.5 (0.13)
Treatment	4	95.7 (0.15)	68.8 (0.38)	80.5 (3.45)	83.3 (0.21)
	5	94.2 (0.19)	68.5 (0.37)	70.7 (3.62)	81.0 (0.22)
	Total	**97.2 (0.03)**	**72.6 (0.17)**	**83.5 (1.02)**	**91.8 (0.05)**
	1	97.8 (0.04)	85.1 (0.36)	90.1 (1.52)	96.7 (0.05)
Four	2	97.3 (0.06)	77.2 (0.40)	84.9 (2.31)	94.3 (0.08)
Attempt	3	96.5 (0.10)	70.1 (0.35)	75.4 (3.27)	88.3 (0.14)
Treatment	4	95.0 (0.13)	68.6 (0.27)	72.9 (3.09)	81.8 (0.16)
	Total	**97.1 (0.03)**	**72.8 (0.17)**	**82.8 (1.19)**	**91.8 (0.05)**

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Only occupied units with completed interviews were included.

Table 12 shows the item nonresponse for each of the data items on the enumerator questionnaire. The table separates respondent types because proxy reports typically have a higher item nonresponse, independent of other factors (Chesnut 2005). Similar to what we found with the overall form completeness analysis (see Table 7), item nonresponse rates for household respondents did not differ much between the three contact strategies. There was some variability in item nonresponse between strategies for proxy respondent cases. For example, nonresponse to the tenure question was 33.9 percent on the six-contact form, 36.1 percent on the five-contact form, and 35.2 percent on the four-contact form (statistically significant at α=0.10). Also, nonresponse to the age question was 54.9 percent for the six-contact form and 54.8 percent for the five- and four-contact questionnaires (not statistically significant at α=0.10). However, on the whole no one form type performed better across all items.

Individual measures such as population count, Hispanic origin, race, and the overcount question had reduced nonresponse for experimental strategies, while tenure, name and age saw an increase in nonresponse. We do not believe any of these small, but significant, differences were attributable to the questionnaire type and were likely caused by random error. Further, Table A6 in the appendix shows that item nonresponse rates, when separated by mode of contact, are similar across treatments.

Table 12. Item Nonresponse at Each Contact for Respondent Type by Form Type

	Contact Number	Household Member Report								Proxy report							
		Population Count	Tenure	Name	Sex	Age	Hispanic Origin	Race	Overcount	Population Count	Tenure	Name	Sex	Age	Hispanic Origin	Race	Overcount
	1	0.2	3.2	1.2	1.4	4.7	2.0	2.2	1.6	2.6	22.2	11.3	5.0	33.7	13.0	12.3	14.0
Six	2	0.2	3.7	1.4	1.5	5.3	2.2	2.5	1.8	2.5	29.5	18.0	6.3	47.3	18.2	17.1	22.2
Attempt	3	0.2	4.7	2.0	1.8	6.7	2.8	3.1	2.5	2.9	38.6	27.1	8.0	60.5	26.0	24.4	33.1
Treatment	4	0.3	5.6	2.6	2.2	8.3	3.4	3.7	3.2	2.9	38.0	28.9	8.7	63.9	29.7	28.0	37.8
	5	0.4	6.0	3.0	2.4	9.3	3.8	4.1	3.7	3.0	36.9	30.4	8.4	64.1	27.7	26.1	36.9
	6	0.6	7.6	4.0	3.0	11.9	5.0	5.2	5.1	3.6	36.7	32.7	9.0	66.0	28.9	27.3	38.5
	Average	0.2	3.9	1.6	1.6	5.7	2.4	2.6	2.0	2.9	33.9	24.0	7.4	54.9	23.5	22.1	29.6
	1	0.1 (0.01)	3.0 (0.05)	1.1 (0.03)	1.3 (0.03)	4.6 (0.06)	1.9 (0.04)	2.1 (0.04)	1.4 (0.04)	2.1 (0.15)	19.8 (0.42)	7.7 (0.28)	4.3 (0.21)	27.9 (0.47)	9.8 (0.31)	9.6 (0.31)	10.5 (0.32)
Five	2	0.2 (0.02)	3.7 (0.07)	1.4 (0.05)	1.5 (0.05)	5.0 (0.09)	2.2 (0.06)	2.4 (0.06)	1.7 (0.05)	2.3 (0.15)	30.0 (0.46)	16.1 (0.37)	5.9 (0.24)	45.1 (0.50)	17.2 (0.38)	15.6 (0.36)	20.7 (0.41)
Attempt	3	0.2 (0.02)	4.8 (0.11)	2.0 (0.07)	1.8 (0.07)	6.6 (0.13)	2.6 (0.08)	3.0 (0.09)	2.4 (0.08)	2.9 (0.13)	41.5 (0.38)	27.2 (0.34)	7.7 (0.21)	60.9 (0.38)	24.9 (0.33)	23.1 (0.32)	32.3 (0.36)
Treatment	4	0.3 (0.04)	6.2 (0.18)	2.7 (0.12)	2.1 (0.11)	8.2 (0.21)	3.6 (0.14)	3.8 (0.15)	3.2 (0.13)	2.8 (0.14)	40.3 (0.41)	28.6 (0.37)	7.7 (0.22)	63.9 (0.40)	26.9 (0.37)	26.0 (0.36)	35.6 (0.40)
	5	0.4 (0.05)	7.7 (0.22)	3.5 (0.15)	2.9 (0.14)	11.5 (0.26)	4.9 (0.17)	5.1 (0.18)	4.7 (0.17)	3.2 (0.14)	39.5 (0.39)	32.1 (0.37)	8.4 (0.22)	65.5 (0.38)	26.8 (0.35)	25.1 (0.34)	36.2 (0.38)
	Average	0.2 (0.01)	4.0 (0.04)	1.6 (0.03)	1.6 (0.03)	5.6 (0.05)	2.3 (0.03)	2.6 (0.03)	1.9 (0.03)	2.7 (0.06)	36.1 (0.19)	23.7 (0.16)	7.0 (0.10)	54.8 (0.19)	22.1 (0.16)	20.8 (0.16)	28.5 (0.18)
	1	0.1 (0.01)	3.0 (0.05)	1.2 (0.03)	1.4 (0.04)	4.8 (0.07)	1.9 (0.04)	2.1 (0.04)	1.5 (0.04)	2.0 (0.14)	19.6 (0.40)	9.1 (0.29)	3.9 (0.20)	30.1 (0.47)	9.5 (0.30)	9.2 (0.29)	11.0 (0.32)
Four	2	0.2 (0.02)	3.9 (0.08)	1.5 (0.05)	1.6 (0.05)	5.3 (0.09)	2.3 (0.06)	2.5 (0.06)	1.9 (0.05)	2.4 (0.14)	30.2 (0.43)	18.4 (0.37)	6.0 (0.22)	47.7 (0.47)	17.1 (0.35)	15.9 (0.34)	21.5 (0.39)
Attempt	3	0.2 (0.02)	4.7 (0.11)	2.0 (0.07)	1.7 (0.07)	6.7 (0.13)	2.9 (0.09)	3.1 (0.09)	2.5 (0.08)	2.6 (0.12)	40.4 (0.38)	27.8 (0.35)	7.6 (0.20)	60.5 (0.38)	24.7 (0.33)	23.0 (0.33)	32.2 (0.36)
Treatment	4	0.4 (0.04)	6.7 (0.15)	3.1 (0.10)	2.6 (0.09)	9.7 (0.17)	4.1 (0.12)	4.3 (0.12)	4.0 (0.11)	3.2 (0.10)	39.3 (0.29)	32.0 (0.27)	8.5 (0.16)	64.7 (0.28)	27.3 (0.26)	25.1 (0.25)	36.6 (0.28)
	Average	0.2 (0.01)	4.0 (0.04)	1.6 (0.03)	1.6 (0.03)	5.7 (0.05)	2.4 (0.03)	2.6 (0.03)	2.0 (0.03)	2.7 (0.06)	35.2 (0.19)	24.7 (0.17)	7.1 (0.10)	54.8 (0.19)	21.8 (0.16)	20.3 (0.16)	28.6 (0.18)

Source: 2010 Decennial Response File and Auxiliary files. Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Only occupied Units with defined interviews were included.

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5.3 Cost-Benefit Analysis

As shown in Section 5.1, the cumulative percentage of NRFU interviews completed was approximately the same regardless of the maximum number of contacts made or mode in which the case was completed. The final count of unique housing units enumerated in the 2010 Census NRFU operation was 47,197,405 at an average field operation cost of $28.00 per case, after enumerator training was excluded (Jackson et. al. 2011). This study had a case average of 2.23 attempts to make an interview (based on defined interviews). The average cost per case divided by the average number of attempts per case came out to about $12.56 spent per contact attempt.

Without precise data, average cost was calculated for any attempt regardless of mode of contact. This then, is a *high end estimate* as it assumes an equal distribution of cost across attempts. It is likely that there is a base cost per case as well as high variability in cost across attempts (i.e., initial attempts may cost more than subsequent attempts, final attempts may cost more than earlier attempts, etc.). Any deviation in the average cost from that of the true cost would exaggerate cost reduction estimates as more attempts are reduced. In lieu of more comprehensive data on NRFU costs per contact attempt, we provide a rough order of magnitude benchmark for potential cost savings in this section.

In order to analyze cost-benefits for a reduced contact strategy, we extrapolated the NRFU workload that would have been completed on each attempt, had a uniform strategy been employed. Percentages were calculated to include all cases, including those in which contact attempts were recorded but lacked a defined interview, which would have added to cost in NRFU and are not the same as those in previous analyses. Cases with a defined interview but no defined contact attempt data were excluded from analysis.

Table 13. Estimated Total NRFU Costs for Each Contact Strategy

	Six-Contact Strategy (Control)			Five-Contact Strategy			Four-Contact Strategy		
	Percent Cases	Estimated Cases	Estimated Cost	Percent Sample Cases	Estimated Cases	Estimated Cost	Percent Sample Cases	Estimated Cases	Estimated Cost
1	41.3	19,493,284	$244,835,647	39.1	18,468,465	$231,963,920	39.9	18,825,584	$236,449,335
2	25.0	11,793,402	$296,250,258	25.9	12,201,702	$306,506,754	26.7	12,623,112	$317,092,573
3	16.5	7,765,192	$292,592,435	17.3	8,164,343	$307,632,444	16.9	7,955,260	$299,754,197
4	8.9	4,187,415	$210,375,730	9.3	4,411,802	$221,648,932	16.5	7,793,449	$391,542,878
5	3.7	1,730,073	$108,648,584	8.4	3,951,093	$248,128,640			
6	4.7	2,228,039	$167,905,019						
	Total	**47,197,405**	**$1,320,670,673**	Total	**47,197,405**	**$1,315,880,692**	Total	**47,197,405**	**$1,244,838,983**
	Census Adjusted Cost	$1,322,493,400		Savings	$4,726,981		Savings	$75,768,690	

Source: 2010 Decennial Response File and Auxiliary files and 2010 Decennial Cost Data
Note: Calculations are based on rounded numbers. Census Adjusted Cost consists of total NRFU field work costs which include production hours, production and training units and miscellaneous expenses for enumerators, crew leaders, and field operation supervisors.

The method used to calculate cost savings involved calculation of the cost for each case based on the number of maximum contact attempts. The total number of cases was multiplied by the percentage of sample cases completed at each attempt to calculate an estimated number of cases

that would be completed in each number of attempts. The average cost per attempt (approximately $12.56) was then multiplied by the number of cases and the number of attempts those cases would require. For example, using the four-contact strategy, an estimated 12,623,112 housing units would need two attempts to complete the case. The estimated total NRFU cost for these housing units is $317,092,573 ($2 \times 12.56 \times 12,623,112$). These total estimated costs were summed to gain an overall cost for the NRFU operation assuming the given strategy had used one treatment exclusively. Rounded numbers were used for all calculations. The full results are shown in Table 13.

Because the vast majority of the enumeration used a six-contact form, it was not surprising that the six-contact strategy was within 0.01 percent of the actual NRFU field operation costs. To control for calculation error, strategies were only compared against each other. For example, estimated cost savings using a four-contact strategy is the estimate for a four contact strategy subtracted from the estimate for a six-contact strategy. All cost savings were calculated by comparison to the six-contact control.

- Savings associated with the use of a five-contact strategy instead of the six-contact strategy were approximately 0.4 percent of the six-contact estimated cost (4.7 million dollars).

- Savings associated with using a four-contact strategy instead of a six-contact strategy were approximately 5.74 percent of the six-contact estimated cost (75.8 million dollars).

The larger reduction in attempts could elicit increased effort very early in enumeration, which is supported by Table 4. A slightly larger number of cases were completed within the first three attempts with a four-contact strategy (83.1 percent) when compared to the five- or six-contact strategies (81.8 percent and 82.3 percent respectively). It is possible that the reduction to a four-contact strategy could encourage enumerators to complete cases more quickly and result in more cases being enumerated in two or three attempts.   Summed across the entire NRFU workload of over 47 million cases, a one or two percentage point difference adds up to large cost savings.

Alternatively, the larger increase in estimated cost savings from five to four contact attempts could result from the lack of cost distribution data by contact attempt. As mentioned in the limitations (Section 4), it is likely that the average cost per case includes a base price per case. So a reduction in one attempt, though calculated as saving 12 dollars might only reduce cost 10 dollars or 5 dollars. Among other reasons, first attempts require time to find the unit and must be made in person. Also travel cost to a neighborhood, which would initially be spread amongst numerous cases, would be the same if only a single case remained in the neighborhood. This would drive up the cost per case of later attempts.

5.4 Debriefing Questionnaire Results

The NRFU debriefing questionnaire was a qualitative survey taken by a sample of enumerators and other field workers participating in enumeration procedures. Results are not statistically representative of the population of enumerators, but gave researchers an idea of enumerator perceptions and how field operations were handled. The majority of respondents to the NRFU

debriefing questionnaire were enumerators (78.5 percent) while the remaining were made up of crew leaders (20.5 percent) or others (1 percent). The regional offices responded fairly evenly with the exception of Denver, with only three completed questionnaires. The majority of enumeration workers had not worked on a previous Census operation (75.1 percent); however of those who had, more had worked previous 2010 operations (12.7 percent) than a previous census (10.1 percent). Since the questions refer to their actions in an enumeration capacity, we refer to them as enumerators for all subsequent descriptions.

The reported average number of contact attempts needed to complete a case was between three and four attempts (64.6 percent). This differs from the data which found the average to be around 2.2 contact attempts per case. Only about 2.6 percent of the enumerators reported that the average was more than six attempts to complete a case, while about half that many report that all cases took more than six attempts. Most enumerators (69.7 percent) reported having at least a few cases that took more than six contact attempts, though a large proportion (30.3 percent) reported never having made more than six contact attempts. About half of contact attempts made in excess of the maximum were reportedly never recorded. Of those that were, the majority were recorded in the margins, notes, or comments section of the enumerator questionnaire, which are not tallied or data captured.

The majority of people understood that they might see experimental questionnaires (88.9 percent). Of those, most felt they were trained in how to handle them (90.3 percent). Most say they did not change their strategy on the experimental questionnaires (83.4 percent); however this is consistent with results, as no more than 12 percent would have reached the final contact attempt. Of those who reported changing their strategy on the experimental questionnaires, the greatest number claim to have either sought a proxy sooner or varied their timing of attempts (56.5 percent). Both of these strategies would result in cost savings for the enumeration operation. A large number also sought the advice of neighbors (24.3 percent) on when to make attempts.

Actual responses within the debriefing illuminate how individual enumerators responded to the experimental questionnaires. Some enumerators reported making cost-saving changes to their strategies, for example "Targeted evening hours when respondent is more likely to be home." or "Looked for a proxy earlier than I otherwise might have." Other enumerators reported having disregarded the reduced contacts, for example "I was more concerned with getting a 'CI' than number of visits." or "I still tried to contact six times, used sticky notes and personal notes to indicate day and time of visit.'' Enumerators also reported behavior such as "Park outside their houses longer." or "I interviewed a neighbor after initial attempt failed to try to get information on them."

6. Related Assessments, Evaluations and/or Experiments

The 2010 Census Nonresponse Followup Operations (NRO) assessment.

7. Lessons Learned, Conclusions, and Recommendations

7.1 Conclusions

Previous research indicated that 70 percent or more of NRFU housing units would be enumerated in three contacts or fewer (Tancreto and Bentley 2004). In the 2010 Census, over 80 percent of housing units were enumerated in three or fewer attempts. Overall, data show that experimentally reducing the maximum number of contact attempts neither reduces the number of successfully completed cases, nor inflates the use of proxy respondents.

The expected "final push" to complete cases occurred on the last attempt regardless of the maximum number of contact attempts on the questionnaire. Whether this is due to extra effort made on the last contact or merely exaggerates the existing tendency for enumerators to make additional, unrecorded attempts is unknown given the methodology employed. Enumerator debriefing results suggest both explanations. Regardless, there is no increase in proxy respondents.

There was no reduction in form completeness or item nonresponse rates as might have been expected when reducing the maximum number of contact attempts an enumerator had to make before seeking a proxy respondent. Form completeness and item nonresponse were both fairly consistent between all strategies. This supports reducing the maximum number of contact attempts in order to realize savings in enumeration cost.

Cost savings estimates ranged from 5 million to over 75 million dollars if the standard six-contact attempts procedure were reduced to a five- or four-contact procedure, respectively. This most likely over estimates actual cost-savings, since debriefing results suggest more than half of enumerators still made more contacts than indicated in the record of contact data. Because of this, we must be cautious when interpreting results from this research. However, the cost analysis does give an idea of the magnitude of cost savings and that cost savings are a real possibility.

Though enumerators made more contact attempts than were recorded, there is evidence that a number of enumerators reduced the number of contacts and sought a proxy sooner. This could result in cost saving with high estimates near a 5 percent reduction in the total NRFU budget. More importantly, we found no evidence that reducing the maximum number of attempts would increase item nonresponse or reduce overall form completeness. In conclusion, a reduction in the number of contact attempts has the potential to maintain the same level of data quality and save costs in the NRFU operation, provided these experimental results hold when implemented at the area level, as opposed to the case level.

7.2 Recommendations

We recommend an area-level study be conducted before full scale implementation of a reduction in the maximum number of NRFU contact attempts.

We see no reduction in data completeness when a reduced contact strategy is employed and no increase in proxy respondents. Implementation of a reduction in the number of contact attempts for all enumeration procedures should not have any detrimental effects on case completion or data quality, based on the results of this experiment. There should also be some cost savings realized if a reduced contact strategy were employed.

However, this study was unable to control for a number of factors that could have a significant impact on overall cost savings.   Though we found no reduction in data quality, an area-level design in a mid-decade test would eliminate concerns over poor data quality clustering of census data. Area-level implementation would also allow for homogeneity of organizational, training, and caseload management, to ensure consistency between enumerators and across field operations.

It is important that site selection be made based on comparability in all features. Not only would this allow direct comparison of case completion and data quality for the NRFU operation performed under each strategy, but accurate cost savings comparisons could be made. This would also provide data on other factors not taken into consideration in this study.

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Appendix

Table A1. Cumulative Total and Percentage Point Increase for Defined Interviews by Form Type for Occupied Housing Units

	Contact Attempts	Interviews Completed at Each Contact	Cumulative Total	Cumulative Percent	Percentage Point Increase
	1	10,630,776	10,630,776	38.4	
Six	2	6,433,324	17,064,100	61.7	23.3
Attempt	3	4,774,904	21,839,004	79.0	17.3
Treatment	4	2,699,764	24,538,768	88.7	9.8
	5	1,206,060	25,744,828	93.1	4.4
	6	1,592,441	27,337,269	98.8	5.8
	No Interview	321,952	27,659,221		*1.2*
	1	115,208	115,208	36.6 (0.09)	
Five	2	75,447	190,655	60.6 (0.09)	24.0 (0.08)
Attempt	3	56,472	247,127	78.6 (0.07)	18.0 (0.07)
Treatment	4	32,106	279,233	88.8 (0.06)	10.2 (0.05)
	5	31,379	310,612	98.8 (0.02)	10.0 (0.05)
	No Interview	3,805	314,417		*1.2*
	1	116,525	116,525	37.6 (0.09)	
Four	2	77,001	193,526	62.5 (0.09)	24.9 (0.08)
Attempt	3	54,202	247,728	80.0 (0.07)	17.5 (0.07)
Treatment	4	58,239	305,967	98.8 (0.02)	18.8 (0.07)
	No Interview	3,717	309,684		*1.2*

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance.

Table A2. Cumulative Total and Percentage Point Increase for Defined Interviews by Form Type for Vacant Housing Units

	Contact Attempts	Interviews Completed at Each Contact	Cumulative Total	Cumulative Percent	Percentage Point Increase
	1	5,558,879	5,558,879	40.8	
Six	2	3,944,965	9,503,844	69.7	29.0
Attempt	3	2,233,225	11,737,069	86.1	16.4
Treatment	4	1,115,657	12,852,726	94.3	8.2
	5	371,857	13,224,583	97.1	2.7
	6	396,704	13,621,287	100.0	2.9
	No Interview	4,683	13,625,970		*0.0*
	1	56,441	56,441	38.3 (0.13)	
Five	2	44,267	100,708	68.3 (0.12)	30.0 (0.12)
Attempt	3	25,644	126,352	85.7 (0.09)	17.4 (0.10)
Treatment	4	12,731	139,083	94.3 (0.06)	8.6 (0.07)
	5	8,269	147,352	100.0 (0.00)	5.6 (0.06)
	No Interview	69	147,421		*0.0*
	1	57,255	57,255	38.7 (0.13)	
Four	2	45,933	103,188	69.8 (0.12)	31.1 (0.12)
Attempt	3	25,216	128,404	86.9 (0.09)	17.1 (0.10)
Treatment	4	19,307	147,711	100.0 (0.00)	13.1 (0.09)
	No Interview	60	147,771		*0.0*

Source: 2010 Decennial Response File and Auxiliary files

Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance.

Table A3. Cumulative Total and Percentage Point Increase for Defined Interviews by Form Type for Deleted Housing Units

	Contact Attempts	Interviews Completed at Each Contact	Cumulative Total	Cumulative Percent	Percentage Point Increase
	1	2,308,864	2,308,864	62.1	
Six	2	837,743	3,146,607	84.6	22.5
Attempt	3	325,801	3,472,408	93.3	8.8
Treatment	4	139,775	3,612,183	97.1	3.8
	5	48,149	3,660,332	98.4	1.3
	6	52,287	3,712,619	99.8	1.4
	No Interview	7,440	3,720,059		0.2
	1	24,546	24,546	58.9 (0.24)	
Five	2	10,108	34,654	83.1 (0.18)	24.2 (0.21)
Attempt	3	4,043	38,697	92.8 (0.13)	9.7 (0.14)
Treatment	4	1,715	40,412	96.9 (0.08)	4.1 (0.10)
	5	1,205	41,617	99.8 (0.02)	2.9 (0.08)
	No Interview	89	41,706		*0.2*
	1	24,346	24,346	59.3 (0.24)	
Four	2	10,038	34,384	83.8 (0.18)	24.5 (0.21)
Attempt	3	3,785	38,169	93.0 (0.13)	9.2 (0.14)
Treatment	4	2,786	40,955	99.8 (0.02)	6.8 (0.12)
	No Interview	94	41,049		0.2

Source: 2010 Decennial Response File and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance.

Table A4. Distribution of Outcomes at Each Contact by Form Type (Personal Visits)

	Contact Number	Number of Contact Attempts	Contact Outcome in Percents						
			Conducted Interview	Left Notice of Visit	Refusal	No Contact	Other	Undetermined	Missing
Six Attempt Treatment	1	45,173,080	39.8	47.2	1.3	4.9	6.5	0.2	0.2
	2	22,299,424	37.7	38.7	1.6	15.9	5.5	0.1	0.4
	3	12,537,070	45.3	29.9	2.1	17.1	5.2	0.1	0.4
	4	5,997,888	46.9	27.3	2.0	17.0	5.7	0.1	0.9
	5	2,964,233	38.8	30.8	2.5	21.0	6.0	0.2	0.8
	6	1,627,758	82.9	4.8	1.8	6.3	3.1	0.2	0.9
Five Attempt Treatment	1	505,780	37.6 (0.07)	48.6 (0.07)	1.4 (0.02)	5.0 (0.03)	6.9 (0.04)	0.2 (0.01)	0.2 (0.01)
	2	256,228	37.4 (0.10)	39.0 (0.10)	1.8 (0.03)	15.2 (0.07)	6.0 (0.05)	0.2 (0.01)	0.4 (0.01)
	3	143,486	45.9 (0.13)	29.3 (0.12)	2.4 (0.04)	16.4 (0.10)	5.5 (0.06)	0.1 (0.01)	0.4 (0.02)
	4	68,030	48.3 (0.19)	26.0 (0.17)	2.5 (0.06)	16.2 (0.14)	5.9 (0.08)	0.2 (0.02)	1.0 (0.04)
	5	31,579	82.6 (0.21)	5.5 (0.13)	1.8 (0.07)	5.8 (0.13)	3.3 (0.10)	0.2 (0.03)	0.9 (0.05)
Four Attempt Treatment	1	500,654	38.6 (0.07)	48.4 (0.07)	1.3 (0.02)	4.8 (0.03)	6.5 (0.03)	0.2 (0.01)	0.2 (0.01)
	2	251,971	39.9 (0.10)	37.2 (0.10)	1.7 (0.03)	15.1 (0.07)	5.6 (0.05)	0.1 (0.01)	0.4 (0.01)
	3	138,301	46.2 (0.13)	29.4 (0.12)	2.3 (0.04)	16.2 (0.10)	5.3 (0.06)	0.2 (0.01)	0.5 (0.02)
	4	62,678	85.3 (0.14)	4.8 (0.09)	1.6 (0.05)	4.6 (0.08)	2.8 (0.07)	0.2 (0.02)	0.6 (0.03)

Source: 2010 Decennial Response File (DRF) and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Contact Number based off slot in which response was written and not order of defined attempts.

Table A5. Distribution of Outcomes at Each Contact by Form Type (Telephone Interviews)

| | Contact Number | Number of Contact Attempts | Contact Outcome in Percents | | | | | | |
			Conducted Interview	Left Notice of Visit	Refusal	No Contact	Other	Undetermined	Missing
Six Attempt Treatment	1	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
	2	2,730,588	67.8	3.2	1.4	13.5	13.6	0.1	0.4
	3	1,786,830	60.8	3.3	1.7	18.7	15.0	0.1	0.4
	4	1,275,569	58.7	3.2	1.8	20.5	14.9	0.1	0.8
	5	580,782	52.6	3.5	2.2	24.3	16.6	0.1	0.7
	6	338,049	88.0	0.5	1.5	5.4	3.9	0.1	0.6
Five Attempt Treatment	1	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
	2	32,138	66.4 (0.26)	3.0 (0.10)	1.8 (0.07)	14.4 (0.20)	13.9 (0.19)	0.1 (0.02)	0.3 (0.03)
	3	22,175	59.1 (0.33)	3.0 (0.11)	2.0 (0.09)	19.7 (0.27)	15.7 (0.24)	0.1 (0.02)	0.3 (0.04)
	4	16,006	59.1 (0.39)	3.0 (0.13)	2.1 (0.11)	19.6 (0.31)	15.3 (0.28)	0.1 (0.02)	0.8 (0.07)
	5	7,569	87.9 (0.37)	0.5 (0.08)	1.5 (0.14)	5.1 (0.25)	4.0 (0.23)	0.1 (0.04)	0.9 (0.11)
Four Attempt Treatment	1	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
	2	32,410	68.5 (0.26)	3.0 (0.09)	1.5 (0.07)	13.3 (0.19)	13.2 (0.19)	0.1 (0.02)	0.4 (0.04)
	3	21,163	63.6 (0.33)	3.5 (0.13)	1.7 (0.09)	16.6 (0.26)	14.1 (0.24)	0.1 (0.02)	0.5 (0.05)
	4	14,579	91.1 (0.24)	0.5 (0.06)	1.1 (0.09)	3.4 (0.15)	3.2 (0.15)	0.2 (0.04)	0.5 (0.06)

Source: 2010 Decennial Response File (DRF) and Auxiliary files
Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance. Contact Number based off slot in which response was written and not order of defined attempts.

Table A6. Item Nonresponse by Mode at Each Contact by Maximum Attempt Treatment

	Contact Number	Personal Visit								Telephone Interview							
		Population Count	Tenure	Name	Sex	Age	Hispanic Origin	Race	Overcount	Population Count	Tenure	Name	Sex	Age	Hispanic Origin	Race	Overcount
Six Attempt Treatment	1	0.4	4.8	1.8	1.6	6.6	2.6	2.8	2.3	2.0	9.6	2.5	3.2	7.9	6.8	6.8	6.7
	2	0.5	7.2	3.1	1.9	9.4	3.5	3.7	3.6	0.6	6.7	2.7	2.2	9.0	4.5	4.4	4.3
	3	1.0	15.7	7.7	3.0	18.5	7.6	7.6	9.0	0.6	8.6	4.2	2.7	13.4	6.2	6.1	6.5
	4	1.6	22.5	13.0	4.5	29.2	13.0	12.6	16.1	1.2	13.4	7.4	3.9	22.7	11.2	10.9	12.2
	5	1.5	20.9	13.3	4.4	28.8	11.9	11.6	15.4	1.1	12.4	7.9	4.0	23.5	10.8	10.6	12.4
	6	2.2	23.9	17.7	5.4	36.2	15.1	14.6	19.7	1.4	14.2	10.3	4.8	29.9	13.8	13.5	16.0
	Average	0.7	10.1	4.7	2.3	12.2	5.0	5.1	0.7	0.8	9.8	5.1	3.0	15.8	7.6	7.4	8.1
Five Attempt Treatment	1	0.2 (0.01)	4.0 (0.06)	1.4 (0.03)	1.4 (0.03)	5.7 (0.07)	2.2 (0.04)	2.4 (0.05)	1.8 (0.04)	1.4 (1.37)	5.4 (2.63)	0.7 (0.97)	2.7 (1.88)	6.8 (2.93)	5.5 (2.65)	2.1 (1.67)	11.4 (3.69)
	2	0.4 (0.03)	6.8 (0.10)	2.7 (0.07)	1.7 (0.05)	8.3 (0.11)	3.2 (0.07)	3.3 (0.07)	3.1 (0.07)	0.4 (0.07)	6.8 (0.26)	2.6 (0.16)	2.2 (0.15)	8.6 (0.29)	4.2 (0.21)	4.2 (0.21)	4.5 (0.21)
	3	1.0 (0.05)	15.9 (0.18)	7.4 (0.13)	2.8 (0.08)	17.7 (0.18)	6.9 (0.12)	6.8 (0.12)	8.3 (0.13)	0.7 (0.10)	8.5 (0.32)	3.7 (0.22)	2.6 (0.19)	12.2 (0.38)	5.9 (0.27)	6.0 (0.28)	6.8 (0.29)
	4	1.4 (0.08)	22.9 (0.28)	12.1 (0.22)	3.9 (0.13)	27.2 (0.29)	11.1 (0.21)	11.1 (0.21)	14.2 (0.23)	0.9 (0.12)	13.7 (0.44)	6.8 (0.32)	3.2 (0.23)	21.0 (0.52)	9.8 (0.38)	9.5 (0.38)	1.2 (0.14)
	5	1.8 (0.09)	24.3 (0.29)	15.7 (0.25)	4.8 (0.15)	33.0 (0.32)	13.1 (0.23)	12.5 (0.23)	16.9 (0.26)	1.0 (0.14)	14.0 (0.49)	8.9 (0.40)	4.1 (0.28)	26.9 (0.63)	11.8 (0.46)	11.5 (0.45)	13.3 (0.48)
	Average	0.6 (0.02)	9.9 (0.06)	4.3 (0.04)	2.1 (0.03)	11.5 (0.06)	4.5 (0.04)	4.6 (0.04)	5.0 (0.04)	0.7 (0.05)	10.0 (0.18)	4.8 (0.13)	2.8 (0.10)	15.1 (0.21)	7.0 (0.15)	7.0 (0.15)	7.2 (0.16)
Four Attempt Treatment	1	0.3 (0.02)	4.1 (0.06)	1.6 (0.04)	1.5 (0.04)	6.1 (0.07)	2.3 (0.04)	2.4 (0.05)	1.9 (0.04)	0.0 (0.0)	9.5 (6.40)	8.6 (6.12)	2.9 (3.66)	14.3 (7.64)	8.6 (6.12)	2.9 (3.66)	11.4 (6.94)
	2	0.4 (0.03)	7.4 (0.11)	3.2 (0.07)	1.9 (0.06)	9.2 (0.12)	3.4 (0.07)	3.5 (0.07)	3.5 (0.07)	0.4 (0.06)	6.6 (0.25)	2.7 (0.16)	2.1 (0.15)	9.4 (0.30)	4.5 (0.21)	4.6 (0.21)	4.5 (0.21)
	3	0.9 (0.05)	15.9 (0.18)	7.7 (0.13)	2.8 (0.08)	18.2 (0.19)	7.3 (0.13)	7.1 (0.12)	8.7 (0.14)	0.7 (0.10)	9.5 (0.34)	4.4 (0.24)	2.7 (0.19)	14.4 (0.40)	6.9 (0.29)	6.3 (0.28)	6.8 (0.29)
	4	1.7 (0.06)	23.4 (0.21)	14.8 (0.18)	4.7 (0.11)	30.6 (0.23)	12.5 (0.16)	11.9 (0.16)	16.1 (0.18)	1.2 (0.11)	13.0 (0.35)	8.3 (0.29)	3.9 (0.20)	24.7 (0.45)	10.9 (0.33)	10.7 (0.32)	1.2 (0.11)
	Average	0.6 (0.02)	9.8 (0.06)	4.5 (0.04)	2.2 (0.03)	11.7 (0.06)	4.6 (0.04)	4.5 (0.04)	5.1 (0.04)	0.8 (0.05)	9.6 (0.18)	5.0 (0.13)	2.9 (0.10)	15.7 (0.22)	7.2 (0.16)	7.0 (0.16)	7.8 (0.16)

Source: 2010 Decennial Response File (DRF) and Auxiliary files. Note: Standard errors are provided in parentheses for experimental treatments. The six-contact treatment is the standard census form and has no variance.