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MEMORANDUM FOR	ACS Research and Evaluation Advisory Group
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Subject:	Using 2010 Census Data to Evaluate Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies

The attached report was presented at the 2012 Joint Statistical Meetings and appears in the conference proceedings. It summarizes the results of the project, "Using 2010 Census Data to Evaluate Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies", ACS Research and Evaluation project ID #01160.

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Using 2010 Census Data to Evaluate Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies

FINAL REPORT

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Using 2010 Census Data to Evaluate Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies[1]

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Abstract
The Census Bureau has developed a new imputation-based methodology to improve the American Community Survey (ACS) estimates of the group quarters (GQ) population for small areas. The motivation for this work was that there are small geographies which either do not have GQ sample or have GQ sample that is not representative of the area, which could lead to distorted estimates of characteristics and/or total population. The new method imputes whole person records to GQ facilities which appear on the sampling frame but were not selected into sample. Previous evaluations have established the method's feasibility and allowed for its refinement. This evaluation aimed to establish that the new methodology improved the usability of estimates for census tracts. We applied the new methodology to the 2006-2010 ACS 5-year data and compared the imputation-based results with design-based results, using the 2010 Census as a benchmark. We found the imputation-based methods had a better distribution of GQ population by major type of GQ across tracts and a better distribution of demographic totals across tracts, as measured by the mean squared error.

Key Words: sample design, small area estimation

1. Introduction

The Census Bureau has implemented an imputation program to enhance ACS estimates of the GQ population for small areas. The study documented in this paper is the final piece in a series of evaluations to assess the new program. Previous evaluations have shown that the Group Quarters Small Area Estimation (GQSAE) was generally not detrimental to county-level and state-level estimates. Asiala, Beaghen, and Navarro (2011) showed the method sound for state-level estimates of characteristics published for the GQ population. Smith (2011) found that the new method produced estimates of total GQ population of counties by major GQ type more consistent with the 2010 Census than the design-based estimates, while finding no detriment in national-level age and sex estimates. Further, Jones (2012) determined the new estimates of race to be only slightly different for the nation and state, and Ramirez (2012) found only slight differences between the two methods for national and state estimates of Hispanic origin. In contrast to these favorable results, Rapino (2012) noted some deleterious effects of the new methodology in estimates of geography‑dependent characteristics for place-level estimates. This study aims to evaluate change in tract-level estimates, with comparisons

[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 issues are those of the authors and not necessarily those of the U.S. Census Bureau.

to the 2010 Census serving as a benchmark. For more details on previous evaluations of the GQSAE methodology see Asiala, Beaghen, Navarro, and Weidman (2012).

The Census Bureau undertook a research program aimed at improving the American Community Survey (ACS) estimates of characteristics of the group quarters (GQ) population for substate geographies such as counties and tracts. The resulting new estimation methodology for GQ population is being implemented starting with the ACS estimates produced in 2012, that is, the 2007-2011 5-year, the 2009-2011 3-year, and 2011 1-year estimates. The development of this methodology was spurred both by limitations in the usability of the ACS data pointed out by ACS data users, and by long-term concerns from within the Census Bureau about the design of the ACS GQ sample and its weighting. Ultimately, the GQ sample is too small to support tract-level estimates. The ACS sample design and weighting were designed to produce state-level estimates of characteristics of the GQ population, whereas estimates of the GQ population contribute to substate estimates of the characteristics of the total resident population. ACS estimates of characteristics of the GQ population are published for states and larger geographies, but not for substate geographies. However, ACS data products which include GQ population are released for substate areas as small as block groups.

We focused our resources on developing a new estimation methodology because we do not have other good alternatives at this time. No changes in the GQ sample design could be made quickly enough to remedy the problem for the ACS estimates produced in 2012. Further, the sample for GQ persons is fixed by budget constraints, and any changes to the sampling plan that increase the number of GQs requiring visits by interviewers would increase the cost of the survey. Also, while publishing estimates for only the household population for substate areas was an option, it was not appealing, as data users expect estimates for the total resident population, such as had been provided by the Census 2000 sample (long form) data. The approach we developed involved imputing GQ person records into facilities that are on the ACS sampling frame but not selected in sample.

In the research described in this paper we compared both the design- and imputation-based 2006-2010 ACS 5-year results to the 2010 Census. The aim was to confirm and assess improvements for tract-level estimates, with comparisons to the 2010 Census serving as a benchmark. The first sections of this document are introductory, starting with a description of the problem and the goals of the new methodology, and moving on to a description of the imputation methodology. While this introductory overview has appeared in other documents (Asiala, Beaghen, and Navarro, 2011), it is repeated here as necessary background. In Section 2 we describe some aspects of the ACS GQ sampling and estimation processes. In Section 3 we show gaps in representation of the ACS GQ sample across tracts and counties. Section 4 describes the general approach of the new imputation-based methodology. The rest of the paper describes, as follows, the methodology in Section 5, the results in Section 6, and the limitations of the methodologies in Section 7.

2. ACS Sampling and Estimation for the Group Quarters Population

For a better understanding of the issues in this paper, some description of the ACS GQ sample design and estimation is needed. Of salience is that the sampling and estimation methodologies for the GQ population are designed to produce optimal state-level estimates, as it is only for states or larger geographies that estimates of the characteristics of the GQ population are produced. Only the estimates of the total GQ population are published for geographies smaller than the state. While the sample stratification includes type of GQ and geography, the sampling rates are such that many counties and tracts do not have sample for particular major types of GQ which nevertheless exist within them. Further, the GQ population estimates are controlled at the state level, whereas the ACS estimates of the total resident population are controlled at the level of county-based weighting areas.

The GQ sampling selects groups of GQ residents, not the GQ facilities themselves, in contrast to the HU address sampling. The GQ frame is divided into two sampling strata within each state, a small GQ stratum and a large GQ stratum, each with different sampling methods. The small stratum consists of GQs with expected populations of 15 or fewer and GQs closed on April 1, 2000. Small stratum GQs are sampled systematically within each state, sorted by small versus closed on census day, new GQ facility versus previously existing, GQ type, and geographical order (county, tract, block, street name, and GQ identifier). The sampling rate varies by state, being higher for states with the smallest GQ populations, but was about 1-in-40 (Marquette, 2011) for many states in the 2008, 2009 and 2010 ACS samples (the GQ sampling rates by state were changed for the 2011 ACS GQ sample). If there are 15 or fewer people found in a small stratum GQ, then everyone in the GQ is in sample. If there are 16 or more people found in a small stratum GQ, then ten people are systematically selected from the GQ. The large stratum includes GQs with expected populations of 16 or more. The primary sampling unit for large stratum GQ facilities is a group of ten people, not the facility itself. For each large stratum GQ selected to be in sample, one or more systematic samples of groups of ten people are taken to achieve the state sampling rate. All large GQ facilities in a state are sorted by GQ type and geographical order in the large GQ frame. On the 2007 GQ sampling frame, there were approximately 105,000 small stratum GQ facilities, 77,000 large stratum GQ facilities, and 3,000 facilities with an unknown population which were sampled like the small stratum GQ facilities (U.S. Census Bureau, 2009).

3. Representation of ACS Group Quarters Sample Across Tracts

The distribution of ACS sample GQ facilities across counties and tracts illustrates the limitations of the sample design with respect to producing small area estimates. Table 1 and Table 2 show the representation of the ACS sample across tracts in the years 2006-2010. In Table 1 we see that 20,105 of 44,157 tracts with GQ facilities did not have at least one GQ facility in the ACS sample from 2006-2010. The number of tracts and counties with GQs was determined from the ACS sampling frame, which is based on the 2000 decennial census. For perspective, note that in the Census 2000 sample (long form) there was better coverage of GQ facilities. The Census 2000 long form was distributed to a sample of 1-in-6 persons residing in GQs, and further, the Census 2000 visited all GQ facilities and thus every one potentially had persons in the long form sample.

Table 1: ACS GQ Sample in Tracts in 2006-2010

	Frequency
Tracts with GQs	44,157
Tracts with ACS GQ sample	24,052
Tracts without ACS GQ sample	20,105

Table 2 shows the representation of ACS sample in tracts broken down by the seven major types of GQ facilities. The categorization by seven major types shown in the tables is used in assigning the weights and is a convenient categorization here. Major GQ type is relevant because people in different types of GQ facilities differ from each other in consistent, predictable ways. In Table 2 we see that for a given major GQ type, many tracts with that major GQ type on the frame do not have sample for that major GQ type. For example, of the 4,993 tracts with an adult correctional facility, 1,908 did not have any facilities in the ACS sample from 2006 to 2010.

Table 2: ACS GQ Sample in Tracts by Major Type of GQ in 2006-2010

Major Type of Group Quarters	Tracts with ACS Sample	Tracts without ACS Sample	Total Tracts with Type of GQ
(1) Adult correctional facilities	3,085	1,908	4,993
(2) Juvenile facilities	1,343	1,582	2,925
(3) Nursing/skilled nursing facilities	10,859	5,775	16,634
(4) Other health care facilities	1,075	2,533	3,608
(5) College/university student housing	2,538	827	3,365
(6) Military group quarters	304	276	580
(7) Other noninstitutional facilities	11,805	23,611	35,416

Further evidence of the limitations of the ACS GQ sample design are the large year-to-year fluctuations of county estimates of total GQ population and of the poverty rates of the total resident population, which are documented in Beaghen and Stern (2009).

4. Overview of the Group Quarters Small Area Imputation Methodology

The objective of the new methodology is to improve the estimates of the GQ population for counties and tracts, thereby also improving estimates of the total resident population for counties and tracts. The limitations in the sample design can be viewed both in terms of high variances of estimates of the GQ population for substate geographies, as well as in a lack of representation of ACS sample in counties and tracts which are known to have GQ facilities. Though we approach the problem from the point of view of trying to have GQ person records, sampled or imputed, in the smallest geographies, a successful methodology should shrink the variances of small area estimates. The description of the methodology given in this section is only an overview, for more details see Asiala, Beaghen, and Navarro (2011).

4.1 The Basic Approach

The approach to the problem is to populate selected GQ facilities without ACS sample with person records copied from in-sample GQ facilities, with appropriate weighting adjustments. This imputation is a whole person imputation and not an item-level imputation. The whole set of person characteristics of the donor is copied to the recipient record (with the exception of geography-dependent variables; see Asiala, Beaghen, and Navarro, 2011). The recipient record maintains the recipient GQ type characteristics and current residence geography. Imputing to not-in-sample facilities has the important advantage for data processing that the imputed person records function as pseudo-sample and are transparent to the data processing and production of estimates.

4.2 The Frame

The listing of GQ facilities to which we potentially impute is the ACS GQ sampling frame. In addition to the listing of GQs, an important feature of the frame is population counts, which are needed in determining how many GQ person records to impute to a given GQ and in the weighting.

4.3 Identify Group Quarters Facilities that Require Imputation

The GQSAE imputes persons to a subset of not-in-sample GQ facilities on the frame. The GQ selection procedure gives priority to obtaining representation for each major GQ type group in each county. Hence we refer to it as "county first". Then facilities are selected to establish representation for each major type group at the tract level. Imputing to all would have required imputing a prohibitively large number of records. The selection of not-in-sample GQs for imputation is prioritized as follows.

- The primary objective is to establish representation of county by major type of GQ in the tabulations for each combination that exists on the frame.
- A secondary objective is to establish representation of tract by major type of GQ for each combination that exists on the frame, as is reasonably feasible.

These priorities lead to a scheme where all large stratum GQs are imputed to, but only a sample of small stratum GQs are imputed to so that the second objective is met. Note that the second objective is relevant only to the 5-year estimates, for which we produce tract-level estimates. However, we use the same methodology for 1-, 3-, and 5-year estimates.

4.4 Determining How Many GQ Persons to Impute

How many imputed person records each not-in-sample GQ facility receives is a function of its population, which is either modeled or observed. For this determination we make a distinction between small and large stratum GQ facilities. A detailed outline of the procedure follows.

1. For each year and each large GQ not in sample, impute the number of records equal to 2.5% of the expected GQ population. This is roughly similar to the overall sampling rate of the GQ population.
2. For each year and for each combination of county and major GQ type on the year's frame that is neither in the year's sample nor in the year's imputes (from Step 1), randomly select a small GQ facility from the small GQ facilities in the county of the same major GQ type.
3. For each GQ selected in Step 2, impute the number of records equal to 20% of the expected GQ population or 1, whichever is larger.
4. Identify all combinations of tract and major GQ type that exist on any year's sampling frame but are not in any year's sample, nor in any year's imputed records.
5. For each combination identified in Step 4 and for each year that the combination exists on the sampling frame, select a small GQ facility with equal probability from the small GQ facilities in the tract of the same major GQ type.
6. For each GQ selected in Step 5, impute the number of records equal to 20% of the expected GQ population or 1, whichever is larger.

4.5 Select Donors: The Expanding Search Method

The donor selection method is referred to as the expanding search approach (Erdman and Nagaraja, 2010). Note that for each year, donors are selected only from that same year. The donor selection procedure chooses from within specific type when the donor to imputation ratio within the specific type is large enough for this to be feasible, and gives preference to donors from facilities that are geographically close. Once GQ facilities have been selected for imputation, the donor pool for each facility is set to be the first combination of geography and GQ type in the following list in which there is at least one donor per five imputed records needed. Donors are recruited first in the lower ranking step starting with step 1. If a suitable donor is not found in a given step, then proceed to the next step.

1. County and specific type
2. County and major type
3. State and specific type
4. State and major type
5. Division and specific type (a census division is a grouping of states and the District of Columbia; the nine divisions are subdivisions of the four census regions)
6. Division and major type
7. Region and specific type (the four census regions are groupings of states and the District of Columbia)
8. Region and major type
9. Specific type
10. Major type

4.6 Weighting

The new imputation methodology implies a new weighting scheme which makes a clean break from the old weighting design that was used for ACS estimates released prior to 2012. For details see Asiala, Beaghen, and Navarro (2011). We only point out a key feature here. The weighting procedure is applied to the augmented data, that is, the data set containing both the sampled and imputed records, making no distinction between sampled and imputed GQ person records.

5. Research Methodology

This research aimed to answer the question of whether the GQSAE tract-level estimates were closer to the HDF than the design-based ones. We describe the more detailed research questions in Section 5.1, and in Section 5.2 we describe the research methodology.

5.1 Research Questions

a) Did the GQSAE improve the distribution of estimates of the total GQ population and of the total resident population for tracts? (These two totals are related, as the total resident population equals the household population plus the GQ population).
b) Did the GQSAE improve the distribution of demographic characteristics of the total resident population for tracts?[2] In particular, did it improve the distribution of demographic characteristics such sex and the age groups 18-25 and 65+, which are related to certain types of GQ facilities, such as college dormitories, military facilities, and nursing homes?
c) Did the GQSAE improve the distributions of estimates in tracts with particular major types of GQ facilities?

[2] Total population and demographics are controlled for most counties for both the design-based and imputation-based estimates. While the two sets of estimates can differ because of the collapsing of the cells to which controls are applied, any such differences will usually be small. For this reason we did not investigate the demographic estimates of the total resident population of counties.

5.2 Methodology and Metrics

The question this study answered was which set of 2006-2010 ACS tract-level estimates was closest to the 2010 Census, the design-based (the official published) estimates, or the GQSAE estimates (an evaluation). We compared on the total GQ population and on the demographic estimates of the total resident population, because these are the only estimates published by the ACS for tracts (demographic estimates of the GQ population are published only for states). On the other hand, demographics of the total resident population are published for small geographies. Ultimately, the motivation of the GQSAE methodology was to improve tract-level estimates of the demographics of the total resident population as much as to improve estimates of total GQ population.

The key presumption we made was that if the imputation-based estimates are closer to the 2010 Census than the design-based ones, it is evidence they are better. This interpretation was potentially problematic as we compared five-year estimates with a point-in-time count. There were several potentially ambiguous scenarios where a GQ facility which existed in an earlier data year and was in the ACS sample ceased to exist as GQ in later years. Asiala and Beaghen (2012) discuss these situations in detail.

For all comparisons we calculated two sets of differences: the difference between the 2010 Census estimates and the ACS estimates using the design-based methodology (used for ACS estimates produced before the 2011 estimates); and the difference between the 2010 Census estimates and the ACS estimates using the new GQSAE imputation (these 2006-2010 GQSAE results had been produced in an earlier evaluation). We calculated these differences for 2006-2010 ACS 5-year estimates of total population and demographics.

For the comparisons we used two metrics, the root mean squared difference, and the mean absolute difference. The root mean squared difference is analogous to the mean squared error (MSE), a commonly used and understood measure of fit for statistical modeling. The root mean squared difference is optimal for normally distributed data and similarly well-behaved data, but it is known to be sensitive to outliers and suboptimal for heavy-tailed distributions. For heavy-tailed distributions or data with outliers the mean absolute difference is a commonly used alternative. We calculated these two sets of comparison statistics for tracts as detailed below.

For the total GQ population of tracts

- Over all tracts.
- Separately for tracts broken down by 2010 Census size of GQ population size as follows: 1-99, 100-499, 500-999, 1,000+, and no GQ residents.
- For tracts broken down by the existence in them of GQs of the seven major GQ types, according to the 2010 Census.

For the total resident population of tracts

- For breakdowns of the total resident population by demographic group: age, sex, and race/ethnicity. The age groups were 0-17, 18-25, 26-64 and 65+. We formed the age groups 18-25 and 65+ because these were age groups that might be sensitive to GQ, such as college/university student housing or nursing/skilled nursing facilities. Race and ethnicity were grouped three ways: Hispanic, non-Hispanic black, and other non-Hispanic, as these captured the two larger racial/ethnic minority groups. Because of the limited population sizes of tracts we did not examine cross-tabulations of age, sex, or race/ethnicity groups.

- For the demographic breakdowns described above, broken down by groups of tracts which contain the seven major types of GQ.

6. Results

To better explain the results we first discuss how many tracts had GQ population. There were 73,435 tracts in the 2010 Census, which we refer to as the hundred percent detail file (HDF). Of these, 45,855 had GQ population. The 2006-2010 ACS (design-based) estimates had only 19,827 tracts with observed GQ population. The 2006-2010 ACS had a smaller number because many tracts with GQ residents were not in sample. There were 52,385 tracts with GQ residents in the 2006-2010 GQSAE. The 19,827 tracts in the 2006-2010 design-based estimates were a subset of these 52,385. Table 4 shows the tract counts.

We also see there were 8,341 tracts with GQ population in the GQSAE which did not have GQ population in the HDF. A major reason why the GQSAE had these additional tracts was that the sampling frames for the years 2006-2009 had GQ facilities that no longer existed in 2010. In fact, some of these facilities on the 2006-2009 ACS sampling frames would not even have existed as GQ facilities in the in the 2006-2009 time period, as they could have been closed down. However, since they were not in the ACS sample in these years they would not have been identified as such. Such potentially out-of-date listings on the ACS sampling frame are a limitation of the GQSAE methodology.

For the calculations we include in the tables the base of tracts over which any calculations were made. For many of the analyses the base was all tracts with GQ population according to either the 2006-2010 GQSAE evaluation ACS estimates or the 2010 HDF, which amounted to 54,196 tracts.

Table 4: Counts of Tracts

Tracts with GQ Population	
In GQSAE	52,385
In Design-based	19,827
In HDF	45,855
In GQSAE but not HDF	8,341
In Design-based but not HDF	1,025
In HDF but not GQSAE	1,811
In HDF or in GQSAE	54,196
All Tracts on HDF, with or without GQ population	73,435

In Table 5 we show the comparisons of the GQSAE and the design-based estimates to the total GQ population in the HDF. We see the GQSAE GQ populations were noticeably closer to the HDF than the design-based estimates were, with mean absolute differences of 53.6 persons per tract for the GQSAE versus 85.7 for the design-based. (For simplicity of discussion, we will refer only to the mean absolute difference, as the results for the RMS differences were consistent with them).

In the next lines in Table 5 we see the comparisons broken down by the HDF GQ population in the tracts. This breakdown highlights where the GQSAE was closer to the

HDF, namely, in tracts where there were GQ residents according to the HDF, with a mean absolute difference of 57.1 persons per tract versus 97.2 for the design-based estimates. In tracts where there were no GQ residents in the HDF, the design-based estimates were closer to the HDF than the GQSAE, with a mean absolute difference from the HDF of 22.4 persons per tract, compared to 34.5 for the GQSAE estimates. The design based estimates had an advantage for these tracts because some of the GQ facilities listed on the frame no longer existed as GQ facilities. Interviewers would identify these as such, and the design-based estimates would reflect their zero population. However, the GQSAE methodology imputed persons to these facilities when they were not in sample, as they were not identified as not being GQ facilities. In contrast, among those tracts with GQ population according to the HDF, the breakdown by size of the HDF GQ population shows consistent advantages for the GQSAE.

Table 5: Differences between Design-based and HDF Estimates and between GQSAE and HDF Estimates in the Total GQ Population of Tracts

	Root Mean Square Difference Persons per Tract		Mean Absolute Difference Persons per Tract		Number of Tracts
	GQSAE	Design-based	GQSAE	Design-based	
Tracts with GQ residents in the HDF or GQSAE	232.8	271.7	53.6	85.7	54,196
Tracts with no GQ residents in the HDF, and residents in the GQSAE	257.3	152.4	34.5	22.4	8,341
Tracts with GQ residents in the HDF	228.0	288.2	57.1	97.2	45,855
Tracts with 1-99 GQ residents in the HDF	69.4	96.4	20.6	39.2	32,069
Tracts with 100-499 GQ residents in the HDF	133.0	224.0	65.8	141.0	10,680
Tracts with 500-999 GQ residents in the HDF	297.9	452.9	208.5	330.5	1,329
Tracts with 1000+ GQ residents in the HDF	1,040.1	1,233.1	552.1	707.6	1,777

In Table 6 we examine the percentile absolute differences between the GQSAE and the HDF and the design-based and the HDF counts of GQ population. At 12 persons, the median (50th percentile) absolute difference for the GQSAE was smaller than that of the design-based, which was 22 persons. Most absolute differences were modest compared to those of the 99th percentile, which were 985 persons and 726 persons for the design-based estimates and GQSAE estimates. The greater relative advantage for the GQSAE at the higher percentiles implies the benefits of the GQSAE methodology are not evenly distributed across tracts, but rather are concentrated in a minority of tracts. We make the following additional observations from Table 6.

1. For both the GQSAE and design-based estimates the median absolute differences were small in magnitude compared to 90th or higher percentiles; for example, for the design-based estimates it was 22 persons versus 189 persons.
2. The advantage for the GQSAE was relatively pronounced at the 75th percentile, with an absolute difference from the HDF of 39 persons; the design-based estimates had an absolute difference of 79 persons from the HDF.

3. In contrast, there was little advantage at the 25th percentile for the GQSAE over the design-based estimates, with absolute differences of 4 and 5 persons respectively.

Of interest was the impact of the GQSAE methodology in tracts with particular types of GQ facilities. Thus we classified tracts into seven groups depending on whether or not population existed in that major type of GQ in the HDF. Note that tracts with population in more than one major type of GQ on the HDF were counted in the groups for each of those major types. The results are displayed in Table 7.

Table 6: Distribution of Absolute Differences between Design-based and HDF and between GQSAE and HDF Estimates of Total GQ Population of Tracts

Percentile	Design-based Absolute Difference from the HDF in Persons	GQSAE Absolute Difference from the HDF in Persons
100th (maximum)	19,329	19,327
99th	985	726
95th	335	193
90th	189	103
75th (third quartile)	79	39
50th (median)	22	12
25th (first quartile)	5	4
10th	0	1
5th	0	1
1st	0	0
0th (minimum)	0	0

Table 7: Tract-level Differences in GQ Population in Tracts where a Given Major Type of GQ Existed in the HDF

Major Type of Group Quarters	GQSAE RMS Difference Persons per Tract	Design-based RMS Difference Persons per Tract	GQSAE Mean Absolute Difference Persons per Tract	Design-based Mean Absolute Difference Persons per Tract	Number of Tracts with a GQ of this Major Type in HDF or GQSAE
(1) Adult correctional facilities	506.8	567.1	187.8	246.0	4,672
(2) Juvenile facilities	222.7	284.6	68.4	115.6	5,870
(3) Nursing/skilled nursing facilities	210.6	266.7	54.6	113.2	15,577
(4) Other health care facilities	433.4	538.8	96.7	162.2	1,521
(5) College/university student housing	373.2	546.6	183.7	307.1	3,515
(6) Military group quarters	1,190.2	1,386.2	357.2	539.7	401
(7) Other noninstitutional facilities	199.0	253.8	46.6	82.5	35,517

We observe in Table 7 that the GQSAE estimates were closer to the HDF than the design-based estimates for all seven groups of tracts when we categorized the tracts by presence of population in a major type of GQ. For example, in tracts with nursing/skilled nursing facilities, major type 3, the mean absolute difference between the GQSAE estimate and the HDF was 54.6 persons per tract, while the difference between the design-based and the HDF was 113.2 persons per tract. We note further that the size of the differences between the HDF and either the GQSAE or design-based estimates were a function of the size of the GQs themselves. Military GQs, the largest GQs, had the largest mean absolute differences, with 357.2 and 539.7 persons per tract for the GQSAE and design-based estimates. Other noninstitutional facilities, the smallest GQs, had the smallest mean absolute differences with 46.6 and 82.5 persons per tract for the GQSAE and design-based estimates respectively.

In Table 8 we examined the tract-level estimates of demographics of the total resident population (the decennial census did not collect characteristics outside of basic demographics). We broke the population into four age groups and three race/ethnicity groups in addition to sex. We formed a smaller number of groups to have more reliable estimates of differences. The age groups we formed isolated ages associated with certain types of GQ facilities, such as 18-25 and 65+, which would be typical of residents of college/university student housing and nursing/skilled nursing facilities. The race/ethnicity breakdowns isolated only the two largest minority groups of potential interest, Hispanic and non Hispanic black.

Some remarks on the analysis of demographic totals of the total resident population of tracts seen in Table 8 follow.

1. For each demographic group we studied we included in the analysis all tracts with that demographic group. We present the number of tracts involved in the calculation as these counts vary. For example, virtually all tracts have at least one male, though there are hundreds of tracts with no non-Hispanic blacks.
2. We showed only estimates for male because female and male are additive, and we saw similar values for females.
3. The RMS and mean absolute difference results were consistent.

Table 8: Differences between Design-based and HDF and between GQSAE and HDF Estimates of Demographic Totals of the Total Resident Population of Tracts

Tracts by GQ Population on the HDF	Root Mean Square Difference Persons per Tract		Mean Absolute Difference Persons per Tract		Number of Tracts
	GQSAE	Design-based	GQSAE	Design-based	
Total resident population	669.1	675.0	323.1	333.3	73,435
Number of Males	381.6	386.7	195.6	202.7	73,425
Number Ages 0-17	218.8	219.7	134.7	135.8	73,305
Number Ages 18-25	197.4	210.7	106.5	112.9	73,337
Number Ages 26-64	354.3	359.9	180.4	184.7	73,426
Number Ages 65+	121.6	130.9	73.7	80.7	73,259
Number Hispanic	541.3	537.5	181.4	182.1	73,305
Number Non-Hispanic Black Only	193.5	197.0	109.7	111.3	72,349
Number Other Non-Hispanic	325.6	339.0	215.7	224.9	73,182

While the GQSAE estimates of demographic totals were consistently closer to the HDF, their advantage over the design-based estimates was less dramatic than what was seen with the total GQ population in Table 5 and in Table 7. The largest advantages for the GQSAE were for the age groups 18-25 and 65+, and for males, though none of these differences were great. For example, the mean absolute difference between the GQSAE estimate and the HDF count of the number of 18 to 25 year olds was 106.5 persons per tract, compared to 112.9 for difference between the design-based estimates and the HDF.

Improvements in the GQ population may be diluted when looking at the demographics of the much larger total resident population. Hence, to better understand where GQSAE methodology was most efficacious, we looked to the classification of tracts by the presence of the seven major types of GQ in the tract according to the HDF. Viewed this way in Table 9, we see more distinctive advantages for the GQSAE estimates of demographics tracts with particular major types of GQs. We see these advantages especially for estimates of age groups, where we would have predicted advantages, though expected advantages for certain tract/demographic combinations were more modest.

Table 9 shows the proportions of age groups for tracts classified by whether any residents of the particular major type existed in the HDF. Table 10 shows the same for the proportion male. Some observations follow.

1. In Table 9 we see that for military GQs the GQSAE differed from the HDF estimate of proportion 18-25 years old by 5.8% (mean absolute difference) for the GQSAE and 7.9% for the design-based.
2. For the 18-25 years age group we saw that tracts with college/university student housing were noticeably impacted, with 3.4% versus 4.5% mean absolute differences for the GQSAE and the design-based.
3. Tracts with nursing homes showed only a modest impact for the 65+ age group, a tract/demographic combination where we might have expected to see a larger one. The mean absolute difference from the HDF estimate of 1.8% for GQSAE estimates, versus 2.2% for the design-based.
4. In Table 10, for military GQs, we see mean absolute differences for males of 4.6% for the GQSAE versus 6.9% for the design-based estimates. We see little differences for males for the other six major types of GQ.
5. In both Tables 9 and 10 we saw that the GQSAE estimates were closer to the HDF counts for tracts with military GQs. This may have been because of the sheer size of the military GQs and the degree to which they differed systematically from the general population; they are predominantly younger adults, male, with a disproportionate number of race/ethnic minorities.

Asiala and Beaghen (2012) present a table analogous to Tables 9 and 10 for the race/ethnicity groups. Only for tracts with military GQs was the GQSAE closer to the 2010 Census for race/ethnic groups.

Table 9: Proportions of Age Groups: Differences between Design-based and HDF and between GQSAE and HDF

Age Group	Major Type of Group Quarters Exists in the Tract	GQSAE RMS Differ-ence	Design-based RMS Differ-ence	GQSAE Mean Absolute Differ-ence	Design-based Mean Absolute Differ-ence
<18	(1) Adult correctional facilities	3.3%	3.5%	2.4%	2.5%
<18	(2) Juvenile facilities	3.3%	3.5%	2.3%	2.4%
<18	(3) Nursing/Skilled nursing facilities	2.8%	2.9%	2.1%	2.2%
<18	(4) Other health care facilities	3.4%	3.7%	2.3%	2.5%
<18	(5) College/university student housing	3.6%	3.3%	2.2%	2.3%
<18	(6) Military group quarters	5.5%	7.0%	3.8%	4.5%
<18	(7) Other noninstitutional facilities	3.2%	3.2%	2.3%	2.3%
18-25	(1) Adult correctional facilities	3.2%	3.5%	2.2%	2.4%
18-25	(2) Juvenile facilities	3.0%	3.3%	2.1%	2.3%
18-25	(3) Nursing/Skilled nursing facilities	2.7%	2.9%	1.9%	2.0%
18-25	(4) Other health care facilities	3.5%	3.7%	2.3%	2.5%
18-25	(5) College/university student housing	5.0%	7.0%	3.4%	4.5%
18-25	(6) Military group quarters	9.3%	14.7%	5.8%	7.9%
18-25	(7) Other noninstitutional facilities	3.1%	3.4%	2.2%	2.3%
26-64	(1) Adult correctional facilities	4.9%	5.2%	2.8%	3.0%
26-64	(2) Juvenile facilities	3.6%	3.9%	2.5%	2.7%
26-64	(3) Nursing/Skilled nursing facilities	3.2%	3.4%	2.3%	2.5%
26-64	(4) Other health care facilities	4.0%	4.8%	2.7%	3.0%
26-64	(5) College/university student housing	4.1%	5.1%	2.8%	3.4%
26-64	(6) Military group quarters	7.2%	10.1%	4.6%	5.6%
26-64	(7) Other noninstitutional facilities	4.0%	4.4%	2.6%	2.7%
65+	(1) Adult correctional facilities	2.5%	2.6%	1.7%	1.9%
65+	(2) Juvenile facilities	2.3%	2.8%	1.7%	1.8%
65+	(3) Nursing/Skilled nursing facilities	2.5%	3.1%	1.8%	2.2%
65+	(4) Other health care facilities	2.8%	4.1%	1.9%	2.1%
65+	(5) College/university student housing	2.3%	3.1%	1.6%	1.8%
65+	(6) Military group quarters	2.7%	5.9%	1.5%	1.9%
65+	(7) Other noninstitutional facilities	2.5%	2.8%	1.7%	1.8%

Table 10: Proportion Male: Differences between Design-based and HDF and between GQSAE and HDF

Major Type of Group Quarters Exists in the Tract	GQSAE RMS Difference	Design-based RMS Difference	GQSAE Mean Absolute Difference	Design-based Mean Absolute Difference
(1) Adult correctional facilities	5.3%	5.7%	2.8%	3.0%
(2) Juvenile facilities	3.2%	3.3%	2.3%	2.4%
(3) Nursing/Skilled nursing facilities	3.0%	3.1%	2.2%	2.2%
(4) Other health care facilities	4.2%	5.0%	2.6%	2.8%
(5) College/university student housing	4.0%	4.7%	2.9%	3.1%
(6) Military group quarters	7.7%	15.6%	4.6%	6.9%
(7) Other noninstitutional facilities	3.7%	4.1%	2.4%	2.5%

Section 7. Limitations

An important limitation of this research was that it used a point-in-time count, the 2010 Census, as a benchmark for comparing two sets of 5-year, period estimates. While we may expect the 2010 ACS 1-year estimate would be close to the 2010 Census, we have no expectation that the ACS estimates for data years 2006 through 2009 would be. Since we made comparisons to the 2010 Census, changes over five years may have lead to misleading measures of correctness for comparisons to the ACS 5-year estimates. For example, consider a GQ facility which existed in 2006 but not in 2010; it would be correctly reflected in the ACS 5-year estimates, both the design-based and the GQSAE, yet it would have appeared as wrong or inaccurate in the comparison to the 2010 Census benchmark. Asiala and Beaghen (2012) argue that while this limitation weakened the clarity of the comparisons, it did not undermine the basic conclusions, as the GQSAE and design-based estimates were about equally affected.

Section 8. Conclusions

In this study we found the estimates based on GQSAE methodology generally to be as close to or closer to the 2010 Census counts as the design-based estimates. We interpret this as evidence that the GQSAE, improved, on the whole, the 5-year ACS tract-level estimates. We saw sizeable improvements in the estimates of the total GQ population of tracts, across both tracts with varying total GQ population sizes and tracts containing various types of GQ facilities. However, much of the improvement was concentrated in a minority of the tracts.

We saw more modest improvements in the estimates of demographic groups of the total resident population, and only for age groups 18-25 and 65+, and for sex. We would have expected improvements in the estimates of the GQ population to be diluted in measures of the total resident population. Not surprisingly, these improvements were concentrated in tracts with specific major GQ type by demographic group combinations: namely, 18-25 in tracts with college dormitories and military facilities, 65+ in tracts with nursing homes, and males in tracts with military facilities. Overall, having military facilities represented in tracts where they should be seemed to have had the greatest impact. There was little overall improvement in the tract-level estimates of race or ethnic minority groups.

The only tracts where we saw the GQSAE performed worse than the design-based were those with no GQ population on the HDF. The GQSAE imputed persons into some of tracts with no GQ population because the ACS sampling frame could be out-of-date. Nevertheless, on the whole, the GQSAE estimates were closer to the HDF, as there were many more tracts with GQ facilities but with no sample in the design-based method. This study and the others preceding it show that despite the limitation of the ACS sampling frame being potentially out-of-date, the GQSAE 5-year tract-level estimates are generally as good as or better than the design-based estimates.

References

Asiala, M., Beaghen, M., and Navarro, A. (2011). “Using Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies”. *2011 Joint Statistical Meetings: Proceedings of the Survey Research Methods Section.* American Statistical Association.

Asiala, M., and Beaghen, M. (2012). “Using 2010 Census Data to Evaluate Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies”. Internal U.S. Census Bureau document to appear in 2012.

Asiala, M., Beaghen, M., Navarro, A., and Weidman, L. (2012). “Evaluations of Imputation Methods to Improve the American Community Survey Estimates of the Group Quarters Population for Small Geographies”. *Proceedings from the 2012 Federal Committee on Statistical Methodology Research Conference.*

Beaghen, M., and Stern, S. (2009). “Usability of the American Community Survey Estimates of the Group Quarters Population for Substate Geographies”. *2009 Joint Statistical Meetings: Proceedings of the Survey Research Methods Section.* American Statistical Association.

Erdman, C. and Nagaraja, C. (2010). "Imputation Procedures for the American Community Survey Group Quarters Small Area Estimation". Research Report (Statistics #2010-09), Statistical Research Division, U.S. Census Bureau, Washington, DC.

Jones, N. 2012. “Evaluation of 2010 ACS GQ Synthetic Race Data”. Internal Census Bureau report.

Marquette, E. (2011). “2011 Group Quarters Initial Sampling Results for the American and Puerto Rico Community Surveys”. Census Bureau Memorandum: DSSD 2011 American Community Survey Memorandum Series #ACS11–S–18.

Ramirez, R. 2012. “Evaluation of 2010 ACS GQ Synthetic Data”. Internal Census Bureau report.

Rapino, M. 2012. “Synthetic GQ Data Review”. Internal Census Bureau report.

Smith, A. 2011. “Review of 2010 ACS GQ Data”. Internal Census Bureau report.

U.S. Census Bureau (2009). “Design and Methodology: American Community Survey”. Issued April 2009. http://www.census.gov/acs/www/methodology/methodology_main/