Comparing AHS Public Housing and Housing Choice Voucher Households with Bayesian Propensity Scores

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Abstract
HUD currently has no program data to compare housing quality of public housing units to that of HCVP units. The American Housing Survey (AHS) are the only data available to compare subjective housing and neighborhood quality assessments in HUD's largest rental assistance programs.

Quality comparisons based on AHS data are problematic because the AHS over-represents Public Housing, and under-represents vouchers. In 2011, the Census Bureau will begin verifying whether AHS households reporting assistance actually receive HUD assistance. However they will not check programs. Furthermore, the information will not be available in the public use file.

HUD administrative data, however, are and excellent source of prior information for the expected proportion of households in public housing. In this study I explore Bayesian methods for using prior information on variables such income and rents to estimate propensity scores for program participation. I then use the Bayesian propensity scores to improve the reliability of AHS-based quality comparisons. Results indicate that after adjusting for program participation propensities, there is little difference in AHS household and neighborhood quality ratings between public housing and voucher households.

I) Introduction

Today, HUD provides assistance to about 1 million households in public housing projects, and about 2.1 million through the Housing Choice Voucher program (HCVP).

There are numerous arguments for providing assistance in privately owned buildings instead of public housing. The primary motivation for increasing private sector housing choices has been expanding social and economic opportunities for low-income households receiving housing assistance. Another argument is that private owners might have better incentives for operational efficiency, thus lowering program costs.

An argument against private sector choices is that private landlords may have more incentive to control costs through reducing housing quality.[1] To insure all HCV units meet a minimum quality threshold, HUD requires compliance with Housing Quality Standards regulations.

Public Housing Agencies (PHAs) must pre-inspect units before tenants occupy a unit and PHAs enter into assistance contracts. Annual re-inspections are also required for all units. Samples of units must be selected for quality control inspections. And PHAs must insure housing quality problems are promptly rectified by landlords and tenants.

Currently, HUD has no program data to compare housing quality of public housing units to that of HCVP units. Geocoding of HUD administrative records allows comparison of census measures of neighborhood quality such as median income, poverty rates, and minority concentration. However, Buron and Pantrabansh (2007) report that census measures do not correlate well with HCVP households' subjective opinions of their neighborhoods.
The American Housing Survey (AHS) are the only data available to compare subjective housing and neighborhood quality assessments in HUD's largest rental assistance programs.

Quality comparisons based on AHS data are problematic because the AHS over-represents Public Housing, and under-represents vouchers. The 2009 sum of weights were approximately 1.65 million for either program. Apparently, many AHS households using vouchers respond that they live in public housing (HUD 2008, Shroder 2002, Casey 1992, Rucinski and Athey 1995).

In 2011, the Census Bureau will begin verifying whether AHS households reporting assistance actually receive HUD assistance. However they will not check programs. Furthermore, the information will not be available in the public use file.

HUD administrative data, however, are and excellent source of prior information for the expected proportion of households in public housing. In this study I explore Bayesian methods for using prior information on variables such income and rents to estimate propensity scores for program participation. I then use the Bayesian propensity scores to improve the reliability of AHS-based quality comparisons. Results indicate that after adjusting for program participation propensities, there is little difference in AHS household and neighborhood quality ratings between public housing and voucher households.

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[1] Unfortunately, data are not available to directly compare housing quality in public housing and HCV units.

The remainder of the article is organized as follows. Relevant literature is reviewed in the next section. Next, the data employed are discussed and summarized. Household characteristics of families in both programs are compared in the next section. AHS data quality is then discussed, followed by AHS-based home and neighborhood quality comparisons. Results are summarized in the final section.

II) Literature Review

Comparing Public Housing and Vouchers Numerous studies have compared outcomes between public housing and vouchers. Some programs, such as the Gautreaux program in Chicago, have compared outcomes for families using vouchers to move out of public housing. The Moving To Opportunity (MTO) program compares outcomes for public housing residents in five cities randomly assigned to three groups. The first group, referred to as the MTO treatment group, are households that received a voucher that could only be used to move to low poverty neighborhoods. Along with the voucher, families in this group received special counseling and assistance in locating rental units. The second group, referred to as the Section 8 comparison group, received regular vouchers with no geographic restrictions and whatever assistance PHAs normally provide in locating housing. The final group, referred to as the in-place control group, received no voucher but continued to receive public housing assistance.

MTO is considered an improvement over previous programs such as Gautreaux where families that used vouchers to move out of public housing were self-selected. The most appropriate MTO groups for general comparison of public housing and vouchers are the in-place and Section 8 groups.

Other studies, more relevant to this study, have made cross-sectional comparisons. Newman and Schnare (1997) is one widely cited example. They compare neighborhood quality using census tract measures such as the poverty rate and minority concentration. They find that compared to public housing residents, voucher households are less likely to be located in extremely high poverty neighborhoods. The find little evidence, however, that vouchers "encourage moves into middle- and upper-income areas to any significant degree" (Newman and Schnare 1997: 728).

HUD's Picture of Subsidized Households reports census tract measures of poverty rates, minority concentration, and percentage of households that are owner-occupied.[1]

While HUD program data on rental assistance programs are available annually, census tract data are only available from the decennial census or the American Community Survey averaged over five years (2005-2009). Furthermore, Buron and Pantrabansh (2007) report that census measures do not correlate well with HCVP households' subjective opinions of their neighborhoods. Mast (2010), however, reports that Buron and Pantrabansh's findings may be driven by use of household data. When household opinions are aggregated at the tract level, Mast (2010) reports fairly strong correlation with census variables.

The American Housing Survey (AHS) are the only data available to compare subjective housing and neighborhood quality assessments in HUD's largest rental assistance programs. The survey

asks respondents if they live in PHA owned housing or if their rent is subsidized by a voucher. Numerous studies have measured housing and neighborhood quality with AHS data (Mast 2010, Hipp 2007, Chapman and Lombard 2006, Goodman 2005, Thibodeau 1995, Dilulio 1994). Yet no previous studies have use AHS data to compare housing or neighborhood quality in HUD rental assistance programs. This is perhaps due to reporting error regarding assistance status.

Reporting Assistance Numerous studies have examined reporting of housing assistance and type of assistance (HUD 2008, Shroder 2002, Casey 1992, Rucinski and Athey 1995).

According to Shroder (2002),

"researchers should expect difficulties in using and interpreting survey data when they are interested in identifying households receiving housing assistance and the type of assistance received. The fact and type of housing assistance are widely misreported" (Shroder 2002: 411-412).

In general, public housing residents tend to report assistance much more accurately than voucher households. Casey (1992) compared known HUD-assisted addresses to addresses of AHS respondents. 91% of public housing residents correctly identified their type of assistance. 33% of voucher households incorrectly identified themselves as public housing residents.

In 2011, the Census Bureau will begin verifying whether AHS households reporting assistance actually receive HUD assistance. However they will not verify which program funds HUD-assisted households. Furthermore, the information will not be available in the public use file.

This study attempts to extend this literature by using Bayesian methods to more accurately predict type of assistance for AHS households reporting assistance. While not as accurate a method as address matching (HUD 2008, Rucinski and Athey 1995, Casey 1992), the propensity score method I employ is a useful alternative for researchers using public use AHS data.

I do not calculate propensity scores for receipt of assistance. The method I employ could be adopted to predict both receipt of assistance and type of assistance, however.

III) Data Sources

I analyze data from two main sources: HUD's PIC data system, the AHS.

PIC Data The PIC system has quarterly entries for each family receiving HUD rental assistance starting in 1995. Data are available on income, rent, and a large number of other household and PHA characteristics. I use PIC data for HUD's two largest rental assistance programs: the Housing Choice Voucher Program (including Project Based vouchers and excluding Homeownership vouchers), and public housing (PH).

I drop some outlier observations with suspect data. I exclude HCVP households if: 1) adjusted annual income is negative or above $42,000; 2) total household income is negative, above $44,000, or less than adjusted income; or 3) household rent burden [(household rent + utility

allowance)/adjusted monthly income] is less than 28% or more than 100% of adjusted monthly income.

I exclude PH households if: 1) adjusted annual income is negative or above $62,000; 2) total household income is negative, above $64,000, or less than adjusted income; or 3) rent burden is less than 10% or more than 100% of adjusted monthly income. The upper income cutoffs for both programs are approximately the 99^{th} percentiles; lower rent burden cutoffs are below the 1st percentiles. Households with missing incomes are dropped. Rent burden is not defined for households with $0 adjusted income; these cases are not dropped.

The PIC data system is transaction based. The most common transactions are 1) admissions; 2) annual re-exams; 3) interim re-exams due to changes in eligibility factors such as income or family size; 4) moves; and 5) exits from the program. The system captures the most recent transaction at the end of each quarter. If multiple transactions for a household occur during a quarter, only the most recent is available. If there is no transaction during a quarter, the family's entry is a duplicate of the entry for the previous quarter.

Rent contracts are effective for one year, and most households have only one transaction per year. Therefore most changes are annual (not quarterly). For this study, I employ a longitudinal file that captures the most recent PIC transaction at the end 2009. The data provide a consistent snapshot for each family on December 31^{st}, 2009. In total, I analyze PIC data on 1,967,865 HCVP households and 1,032,239 PH households.

AHS Data While PIC data provide a large amount of information, they do not include housing quality data. To compare HCVP and PH housing quality, I use AHS data. The AHS includes both national and metro surveys; I employ national AHS data, primarily for 2009.

I limit my AHS sample to households that self-report receiving voucher rental assistance or living in public housing. The AHS voucher question asks "Did a public housing authority, or some similar agency, give you a CERTIFICATE or VOUCHER to help pay the rent for this housing unit?" (HUD 2006, p. 529). The public housing questing asks "Is the building owned by a public housing authority?" (HUD 2006, p. 404). Neither question asks if the subsidy program is HUD funded, so it's possible that a respondent could have participated in a local or state funded program.

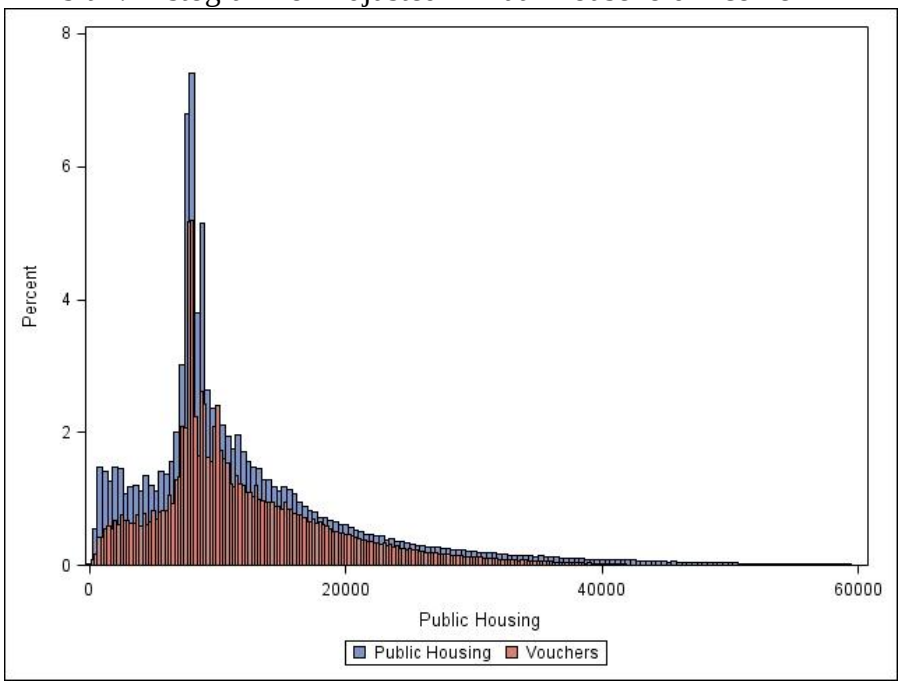
In addition, the sum of weights for 2009 AHS voucher respondents is about 1.64 million, while the count of occupied HCVP units was around 2.1 million. The 2009 AHS sum of weights for public housing is greater than the actual number of households in HUD public housing. One possible explanation for the discrepancy is that some households receiving vouchers respond that they live in public housing. These discrepancies will be studied in more detail below.

IV) Household Characteristics

In this section, I compare incomes and rents of HCVP and PH households using 2009 PIC data. Differences in income and rents will be used in the next section to estimate program participation probabilities.

Because income limits are higher for PH, incomes can be larger in public housing compared to the HCVP program. Exhibit 1 depicts distributions for adjusted annual income in both programs. While the distributions are similar, the PH distribution has a much longer upper tail. Exhibit 2 reports means and percentiles (10^{th}, 25^{th}, Median, 75^{th}, 90^{th}) for adjusted and total annual household income. For both programs, adjusted income is about 92% of total income at the mean.

Exhibit 1: Histogram for Adjusted Annual Household Income



N=for 1,032,239 for Public Housing and for the 1,967,865 Housing Choice Voucher Program. Source: 2009 PIC data.

Exhibit 2: Summary Statistics for Household Adjusted and Total Annual Income

Household Adjusted Annual Income

Program	10th Pctl	25th Pctl	Median	Mean	75th Pctl	90th Pctl
HCV	4524	7688	10040	12057.747	15506	22068
PH	3420	7332	9233	12192.113	15060	23870

Household Total Annual Income

Program	10th Pctl	25th Pctl	Median	Mean	75th Pctl	90th Pctl
HCV	5424	8256	10901	13131.833	16812	23669
PH	4225	8088	10192	13212.673	16456	25341

N=for 1,032,239 for Public Housing and for the 1,967,865 Housing Choice Voucher Program. Source: 2009 PIC data.

Median income is slightly higher in the voucher program. Adjusted (total) median income is $10,040 ($10,901) in the HCVP, compared to $9,233 ($10,192) in PH. Mean income, however, is slightly higher in PH. Adjusted (total) mean income is $12,058 ($13,132) in the HCVP, compared to $12,192 ($13,213) in PH. 10% of voucher households have adjusted incomes below

$4,524, and only 10% have adjusted incomes above $22,068. For public housing, 10th percentile adjusted income is $3,420, and the 90th percentile is $23,870.

Compared to income differences, rent burden differences between programs are much greater. While gross rent as a percent of adjusted income is not supposed to fall below 30% in the HCVP, the flat rent option makes burdens well below 30% possible in public housing. Exhibit 3 reports percentages of households by program in 5 rent burden categories: missing, 10-19%, 20-27%, 28-31%, 32-40%, and 41% and above. The missing category is for households with $0 adjusted income for which rent burden is undefined. 10.776% of voucher households have undefined burden, as do 11.642% of PH households.

Exhibit 3: Rent Burden Frequency Distributions

Rent burden category	% of HCV households	% of PH households
Missing	10.776%	11.642%
10% -19%	0.000%	6.280%
20% - 27%	0.000%	6.137%
28% - 31%	58.196%	72.717%
32% - 40%	20.493%	0.906%
41% & Above	10.535%	2.319%

N=for 1,032,239 for Public Housing and for the 1,967,865 Housing Choice Voucher Program.
Rent burden=(rent + utility allowance)/adjusted income. Source: 2009 PIC data.

6.280% of PH households have burdens less than 20%, and 6.137% have burdens between 20 and 27%. Because of the 30% minimum, no voucher families fall in these categories. 58.196% of PH families have burdens between 28 and 31%, as do 72.717% of HCVP families. 20.493% of HCVP households have burdens between 32 and 40%, and 10.535% have burdens greater than 40%. In sharp contrast, less than 4% of PH households have burdens above 31%.

V) AHS Data Quality

Measuring Housing and Neighborhood Quality Because rent burdens tend to be lower in PH compared to the HCVP, one might question whether PH households are better off than HCVP households with similar incomes. The voucher program is designed to foster choices outside areas with high concentrations of poverty, however. And HCVP households with higher burdens might be compensated with higher housing quality or better neighborhoods.

Unfortunately, HUD has no administrative data to compare housing quality in the two programs. Geocoding of PIC households allows comparison of census tract measures of neighborhood quality. Exhibit 8 reports household means for tract measures of minority concentration, median income, the poverty rate, and a binary indicator for tracts with poverty rates of at least 40%. Tract measures are from the 2000 census.

Exhibit 8: Census Measures of Neighborhood Quality

	Public housing		HCVP	
Variable	Mean	Std	Mean	Std

		Deviation		Deviation
Percent Minority	57.492	35.469	47.791	33.356
Median income	25135.280	12411.738	35160.165	13707.941
Poverty rate	30.303	16.632	18.984	12.283
Poverty rate >=40%	0.226	0.418	0.067	0.250

N= 1,031,855 for public housing and 1,961,593 for HCVP. Source: PIC 2009 and U.S. Census Bureau 2000 Census.

Compared to public housing households, HCVP households tend to live in census tracts with lower percentages of minorities. The average tract minority percentage is 57.5% for public housing households, versus 47.8% for voucher families. Voucher households also tend to live in higher median income tracts with lower poverty rates. The average tract poverty rate is 30.3% for public housing residents, versus 19.0% for voucher households. 22.6% of public housing residents live in tracts with poverty rates at or above 40%. The corresponding percentage for voucher households is 6.7%.

The results in Exhibit 8 are consistent with Newman and Schnare's (1997) findings that compared to other housing assistance programs, vouchers tend to lower "the probability that families live in the most economically and socially distressed areas" (Newman and Schnare 1997: 728). However, Buron and Pantrabansh (2007) report that census measures do not correlate well with HCVP huseholds' subjective opinions of their neighborhoods. Subjective measures of both household and neighborhood quality are available from the AHS.

Counting Households To measure subjective housing and neighborhood quality, I use data from the national AHS which is weighted to be nationally representative. As noted above in section IV, AHS weighted household frequencies over-represent PH households, and under-represent the HCVP program. Exhibit 9 reports responses, weighted household frequencies, and proportion of households in PH from the 2005, 2007, and 2009 national AHS. Of course, AHS over-representation of public housing in any given year could be due to random sampling variance. Yet the over-representation occurs each year.

Exhibit 9: AHS Counts of Voucher and Public Housing Households

Year	Responses	Weighted HCVP households	Weighted public housing households	Weighted proportion in public housing
2005	1125	898894.827	1850511.568	0.673
2007	1119	1266161.033	1900532.929	0.600
2009	1422	1642866.569	1656487.705	0.502

Source: AHS data for 2005, 2007, and 2009.

For comparison with AHS estimates, Exhibit 10 reports HUD counts and ratios for the same years, along with 95% confidence intervals. Uneven PIC reporting in the HCVP Moving to Work demonstration program could result in under-counting of vouchers. To more accurately estimate the proportion of households in PH, HCVP data in Exhibit 5 are based on HUD financial data on counts of occupied units by PHA[2].

Exhibit 10: HUD Counts of Voucher and Public Housing Households

Year	HCVP households	Public housing households	Proportion in public housing	Lower 95% CI	Upper 95% CI
2005	1994827	1072730	0.350	0.325	0.379
2007	1993524	1090901	0.354	0.330	0.384
2009	2105004	1053481	0.334	0.312	0.359

Sources: *HUD Voucher Management System data; **PIC data. Confidence intervals are bootstrap estimates with 1000 samples. Bootstrap sample size is 1125 for 2005, 1119 for 2007, and 1422 for 2009.

The confidence intervals in Exhibit 10 are non-parametric estimates based on a simulation with 1000 random samples with replacement. I simulated data for each year, with total households and proportions in PH according to HUD official counts reported in Exhibit 5. I then took 1000 repeated random samples with replacement, generating a new estimate of the proportion in public housing for each sample. The sample size for the repeated samples in a given year is the number of AHS respondents reporting PH or HCVP assistance that year. This process, referred to as bootstrapping, provides a method for computing confidence intervals directly from the distribution of sample means, or in our case, sample proportions (Lohr 2007, p. 307). I computed 95% confidence intervals based on the 2.5^{th} and 97.5^{th} percentiles.

The confidence intervals measure the probability that a random sample of assisteded households, of the same sample size as the AHS, will have a PH proportion equal to the AHS estimate. None of the confidence intervals contain the AHS estimate. Not reported, the same is true for wider 99% confidence intervals. It is highly unlikely that the AHS systematic over-counting of public housing is the result of random sampling variability.

Numerous studies (see Shroder 2002 for a review) find that assisted households often misreport their type of assistance. For instance, Casey (1992) compared known HUD-assisted addresses to addresses of AHS respondents. 91% of public housing residents correctly identified their type of assistance. 33% of voucher households incorrectly identified themselves as public housing residents.

The over-representation of public housing raises serious questions regarding our ability to compare public housing and HCVP households with AHS data. HUD administrative data, however, are and excellent source of prior information for the expected proportion of households in public housing. I will now explore Bayesian methods for using this prior information to improve the reliability of AHS-based comparisons.

Bayesian Analysis As discussed in section V, incomes and rent burdens vary across programs; we can use this information to help predict whether a given AHS assisted household participates in the HCVP or PH program. I start by constructing 21 categories based on income and rent burden reported in Exhibit 11. The 1^{st} category is for households with $0 income for which rent burden cannot be computed. The remaining categories are based on 4 rent burden ranges and 5 income ranges. The upper limits for the rent burden categories are roughly the 25^{th}, 50^{th}, 75^{th}, and 100^{th} percentiles for the 2009 PIC combined programs. The upper income limits are

approximately the 20th, 40th, 60th, 80th, and 100th percentiles. While HUD program regulations are based on adjusted income, it is not possible to construct a comparable income measure with AHS data. As such, the income and rent burden categories in Exhibit 11 are based on total income.

Exhibit 11: PIC Income and Rent Burden Categories

Category	Household annual income	Rent burden	Total HCVP and public housing households	Public housing households	Proportion of total households in public housing (μ)
1	0	Missing	308030	114132	0.371
2	1 - 7032	0% - 26.6%	175484	61001	0.348
3	1 - 7032	26.7% - 28.5%	61027	26803	0.439
4	1 - 7032	28.6% - 30.0%	39045	15244	0.390
5	1 - 7032	30.1% - 100%	120104	29208	0.243
6	7033 - 9012	0% - 26.6%	97219	40964	0.421
7	7033 - 9012	26.7% - 28.5%	247419	118144	0.478
8	7033 - 9012	28.6% - 30.0%	112024	50605	0.452
9	7033 - 9012	30.1% - 100%	115176	3182	0.028
10	9013 - 12168	0% - 26.6%	103352	45700	0.442
11	9013 - 12168	26.7% - 28.5%	81902	31381	0.383
12	9013 - 12168	28.6% - 30.0%	275946	108090	0.392
13	9013 - 12168	30.1% - 100%	112499	2874	0.026
14	12169 - 18108	0% - 26.6%	125960	66252	0.526
15	12169 - 18108	26.7% - 28.5%	170175	61040	0.359
16	12169 - 18108	28.6% - 30.0%	158164	55490	0.351
17	12169 - 18108	30.1% - 100%	118947	1592	0.013
18	18109 and above	0% - 26.6%	170607	126591	0.742
19	18109 and above	26.7% - 28.5%	116009	34545	0.298
20	18109 and above	28.6% - 30.0%	167034	38043	0.228
21	18109 and above	30.1% - 100%	117325	974	0.008
Total			2993448	1031855	0.345

Rent burden=(rent + utility allowance)/total household monthly income. N=2,993,448. Source: PIC 2009 data.

Also reported in Exhibit 11 is the number of PIC HCVP and PH households in each category, the number of PH households, and the proportion of households in each category living in PH (μ). For example, in 2009 there were 112,024 PIC households in category 8 with incomes from $7,033 to $9,012 and burdens between 28.6 and 30.0%. Of these, 50,605 or 45.2% resided in public housing. The last row presents data for all households. In total, 34.5% of PIC HCVP and PH households resided in PH.

I will use the proportion μ for each of the 21 categories as the prior probability that an AHS household in the same category resides in PH. While PIC under-reporting of voucher households in Moving to Work PHAs may slightly bias the percentages, they are almost certainly closer to actual values than AHS estimates.

Exhibit 12 reports 2009 AHS responses in each category, total weighted households, weighted households in public housing, and the weighted proportion in public housing (p). The standard error of the proportion (s) is also reported. In total, 50.4% of AHS weighted HCVP and PH households report living in PH; this is much larger than the PIC estimate of 34.5%. I assume the AHS proportion in each category follows a Normal distribution with mean p and standard deviation estimated by s.

Exhibit 12: AHS Income and Rent Burden Categories

Category	Total household annual income	Rent burden	Responses (n)	Weighted households	Weighted public housing households	Weighted proportion in public housing (p)	Std error of the proportion (s)
1	0	Missing	269	637350.388	320594.637	0.503	0.033
2	1 - 7032	0% - 26.64%	18	49467.811	23496.325	0.475	0.123
3	1 - 7032	26.65% - 28.54%	5	15713.676	5003.032	0.318	0.201
4	1 - 7032	28.55% - 29.98%	3	5884.999	4599.286	0.782	0.214
5	1 - 7032	29.99% - 100%	65	151803.567	84971.343	0.560	0.065
6	7033 - 9012	0% - 26.64%	26	58474.976	33161.209	0.567	0.105
7	7033 - 9012	26.65% - 28.54%	20	48048.620	31624.642	0.658	0.115
8	7033 - 9012	28.55% - 29.98%	14	35084.124	23754.470	0.677	0.124
9	7033 - 9012	29.99% - 100%	114	263543.008	122977.892	0.467	0.050
10	9013 - 12168	0% - 26.64%	57	122602.651	74871.213	0.611	0.069
11	9013 - 12168	26.65% - 28.54%	28	62535.122	29335.519	0.469	0.101
12	9013 - 12168	28.55% - 29.98%	16	40257.142	27122.221	0.674	0.121
13	9013 - 12168	29.99% - 100%	81	191740.481	72521.760	0.378	0.057
14	12169 - 18108	0% - 26.64%	67	153255.898	67949.053	0.443	0.064
15	12169 - 18108	26.65% - 28.54%	17	30007.312	14741.893	0.491	0.131
16	12169 - 18108	28.55% - 29.98%	17	42215.125	23839.046	0.565	0.128
17	12169 - 18108	29.99% - 100%	103	231933.140	102997.225	0.444	0.053
18	18109 and above	0% - 26.64%	157	377578.581	228974.067	0.606	0.042
19	18109 and above	26.65% - 28.54%	14	34938.048	21183.670	0.606	0.143
20	18109 and above	28.55% - 29.98%	16	36929.959	13052.627	0.353	0.121
21	18109 and above	29.99% - 100%	89	206297.510	82736.247	0.401	0.055
Total			1196	2795662.139	1409507.379	0.504	

Rent burden=(rent + utility allowance)/total household monthly income. Source: AHS 2009 data.

I drop 226 AHS responses: 202 responses with burdens above 100%, and 24 responses with household incomes above $64,000. My remaining sample consists of 1196 responses. 269 cases

have missing burdens due missing rent data or $0 income; these were relegated to the 1st category in Exhibit 11 for missing data.

The Bayesian Posterior distribution for each category is Normal with mean p* and standard deviation s*; exhibit 13 reports p* and s*. s* equals the square root of 1/[— + —], where n is the AHS number of responses and σ is the prior standard deviation. I set σ equal to 1/ . p* equals [— + —] s^{*2}, where μ is the PIC mean proportion reported in Exhibit 11. ; For comparison n, μ, p, σ, and s are also reported in Exhibit 13.

Exhibit 13: Bayesian Posterior Statistics

Category	AHS responses (n)	Prior proportion (μ)	AHS proportion (p)	Bayesian Posterior proportion (p*)	Prior standard deviation (σ)	AHS standard deviation (s)	Bayesian Posterior standard deviation (s*)
1	269	0.371	0.503	0.397	0.001	0.033	0.001
2	18	0.348	0.475	0.373	0.014	0.123	0.013
3	5	0.439	0.318	0.415	0.045	0.201	0.040
4	3	0.390	0.782	0.469	0.062	0.214	0.055
5	65	0.243	0.560	0.307	0.004	0.065	0.004
6	26	0.421	0.567	0.451	0.010	0.105	0.009
7	20	0.478	0.658	0.514	0.013	0.115	0.012
8	14	0.452	0.677	0.497	0.017	0.124	0.015
9	114	0.028	0.467	0.115	0.002	0.050	0.002
10	57	0.442	0.611	0.476	0.005	0.069	0.004
11	28	0.383	0.469	0.400	0.010	0.101	0.009
12	16	0.392	0.674	0.448	0.015	0.121	0.013
13	81	0.026	0.378	0.096	0.003	0.057	0.003
14	67	0.526	0.443	0.509	0.004	0.064	0.004
15	17	0.359	0.491	0.385	0.016	0.131	0.014
16	17	0.351	0.565	0.394	0.016	0.128	0.014
17	103	0.013	0.444	0.100	0.003	0.053	0.002
18	157	0.742	0.606	0.715	0.002	0.042	0.001
19	14	0.298	0.606	0.359	0.019	0.143	0.017
20	16	0.228	0.353	0.253	0.015	0.121	0.014
21	89	0.008	0.401	0.087	0.003	0.055	0.003

Source: PIC 2009 and AHS 2009 data.

We can define an alternative equation for p* as a weighted average of the prior mean and AHS sample mean (Laskey 2009). Let r be the precision (inverse variance) of the AHS data; and λ be the prior precision: $r = 1/s^2$, and $\lambda = 1/\sigma^2 = 4n/s^2 = 4nr$. λ* is the posterior precision: $\lambda^* = \lambda + nr = 5nr$. The posterior mean $p^* = (\lambda\mu + nrp)/\lambda^*$. The prior mean μ receives weight $\lambda/\lambda^* = 4/5$, and the AHS mean p receives weight $nr/\lambda^* = 1/5$.

I chose 4nr for the prior precision so that the prior mean would have 4 times the influence as the AHS mean on the posterior mean. I gave the PIC-based prior much greater weight because I believe it to be a much more reliable data source than the AHS.

For instance, consider category 6; this is the category with the median number of AHS responses equal to 26. The prior mean μ=.421, and the AHS mean p=.567. The posterior mean p*=.451 is a weighted average of .421 and .567, with .421 receiving weight 4/5 and .567 receiving weight 1/5.

We can use the Bayesian Posterior proportion p* as a propensity score for an AHS respondent residing in PH, conditional on their income and rent burden. Using propensity score weighting, the probability of an AHS household residing in PH is .352, which is much closer to the PIC estimate of .345 than the unadjusted AHS estimate of .504.

Note that the normal-normal conjugate model I employed only adjusts the likelihood of residing in public housing; incomes and rent burdens are not adjusted. Additional variables could be adjusted with a multinomial-Dirichlet conjugate model.

VI) AHS Housing and Neighborhood Quality Measures

In this section, I compare AHS housing and neighborhood quality responses of HCVP and PH respondents. I measure housing quality with responses to a question asking households to rate their home on a scale of 1 to 10. I measure neighborhood quality with a neighborhood rating on a scale of 1 to 10, and a question asking if crime was a serious neighborhood problem in the last year. I compare both unadjusted estimates and estimates adjusted by the propensity scores computed in the previous section.

Exhibits 14 and 15 report weighted 2009 AHS home and neighborhood ratings, respectively, along with ratings adjusted by propensity scores. The adjusted public housing ratings were computed by multiplying the survey weight by the propensity score for residing in PH. The adjusted voucher ratings were computed by multiplying the survey weight by one minus the propensity score.

Exhibit 14: Home Ratings

Home rating	% of public housing households	% of HCVP households	Adjusted % of public housing households	Adjusted % of HCVP households
1	1.513	1.814	1.627	1.684
2	1.142	0.829	1.478	0.717
3	1.180	1.931	1.921	1.361
4	1.699	1.713	1.745	1.685
5	9.014	8.569	8.615	8.884
6	7.074	6.925	6.759	7.129
7	17.041	16.128	15.473	17.183
8	23.933	23.402	24.712	23.098

9	8.941	10.454	10.926	9.038
10	28.466	28.235	26.745	29.221

N=1196. Source: 2009 AHS and PIC data. Adjusted data are adjusted by propensity scores for program participation.

Exhibit 15: Neighborhood Ratings

Neighborhood rating	% of public housing households	% of HCVP households	Adjusted % of public housing households	Adjusted % of HCVP households
1	2.525	4.140	3.763	3.103
2	2.358	2.642	2.861	2.305
3	2.248	2.343	2.439	2.219
4	3.433	2.575	2.849	3.086
5	13.244	13.166	12.576	13.545
6	9.094	8.292	9.655	8.171
7	10.653	13.967	13.215	11.828
8	19.287	20.337	19.820	19.810
9	11.240	8.068	9.342	9.816
10	25.917	24.471	23.481	26.117

N=1196. Source: 2009 AHS and PIC data. Adjusted data are adjusted by propensity scores for program participation.

Exhibit 16 reports sample means for binary home, neighborhood, and low crime indicators. For home and neighborhood ratings, three binary indicators are constructed for ratings of at least 7, 8, and 9. H7-H9 are the binary home indicators, and N7-N9 are the binary neighborhood indicators. The crime indicator equals 1 for households that responded "yes" when asked if crime was a major problem; "no" and "don't know" responses are set to 0. Non-responses for all indicators are set to missing.

Exhibit 16: Binary Indicators of Home and Neighborhood Quality

	Public housing		HCVP		Adjusted public housing		Adjusted HCVP	
Variable	Mean	Std error	Mean	Std error	Mean	Std error	Mean	Std error
H7	0.782	0.019	0.784	0.019	0.779	0.016	0.785	0.014
H8	0.615	0.021	0.608	0.022	0.617	0.018	0.608	0.016
H9	0.387	0.021	0.374	0.021	0.377	0.017	0.383	0.016
N7	0.668	0.021	0.671	0.021	0.659	0.018	0.676	0.015
N8	0.520	0.022	0.559	0.022	0.518	0.018	0.551	0.016
N9	0.325	0.020	0.372	0.022	0.328	0.017	0.359	0.016
Crime	0.257	0.019	0.293	0.020	0.282	0.016	0.271	0.014

N=1196. Source: 2009 AHS data. Adjusted data are adjusted by propensity scores for program participation.

There is little difference in home ratings across programs, either for the adjusted or unadjusted ratings. There are more pronounced differences in neighborhood ratings. For the proportions

adjusted by propensity scores, 55.1% of HCVP families rated their neighborhoods 8 or greater on a scale of 1-10; the corresponding percentage for PH households is 51.8%. 35.9% of adjusted HCVP households rated their neighborhoods 9 or greater, compared to 32.8% of adjusted PH households.

The unadjusted crime indicator is considerably lower for public housing (.257) compared to HCVP (.293). There is little difference in adjusted crime indicators between programs; 27.1% of voucher respondents report major crime problems, as did 28.2% of PH households.

Exhibit 17 reports Rao-Scott Chi-square test statistics and probability values for each binary indicator. The null hypothesis is that the sample proportions are equal for both HCVP and public housing. Only one unadjusted test statistic is significant at the .05 level -- the unadjusted crime indicator is significantly lower for public housing respondents compared to HCVP households. None of the test statistics are statistically significant for data adjusted by propensity scores. One whole, there is little evidence that any of the indicators vary significantly across programs.

Exhibit 17: Rao-Scott Chi-Square Test Statistics

	Unadjusted data		Adjusted data	
Variable	Chi-square test statistic	Probability value	Chi-square test statistic	Probability value
H7	0.004	0.952	0.108	0.742
H8	0.054	0.817	0.159	0.690
H9	0.184	0.668	0.064	0.801
N7	0.007	0.931	0.542	0.462
N8	1.638	0.201	1.863	0.172
N9	2.477	0.116	1.850	0.174
Crime	6.563	0.038	0.235	0.628

N=1196. Source: 2009 AHS and PIC data. Adjusted data are adjusted by propensity scores for program participation.

VII) Conclusion

HUD currently has no program data to compare housing quality of public housing units to that of HCVP units. Geocoding of HUD administrative records allows comparison of census measures of neighborhood quality such as median income, poverty rates, and minority concentration. Buron and Pantrabansh (2007), however, report that census measures do not correlate well with HCVP households' subjective opinions of their neighborhoods.

The American Housing Survey (AHS) are the only data available to compare subjective housing and neighborhood quality assessments in HUD's largest rental assistance programs.

Quality comparisons based on AHS data are problematic because the AHS over-represents Public Housing, and under-represents vouchers. While there are about twice as many vouchers as public housing units, the 2009 AHS sum of weights were approximately 1.65 million for either program. Apparently, many AHS households using vouchers respond that they live in public housing.

In 2011, the Census Bureau will begin verifying whether AHS households reporting assistance actually receive HUD assistance. However they will not check programs. Furthermore, the information will not be available in the public use file.

HUD administrative data, however, are and excellent source of prior information for the expected proportion of households in public housing. In this study I explore Bayesian methods for using prior information on variables such income and rents to estimate propensity scores for program participation. I then use the Bayesian propensity scores to improve the reliability of AHS-based quality comparisons.

Results indicate that after adjusting for program participation propensities, there is little difference in AHS household and neighborhood quality ratings between public housing and voucher households.

References

Buron, Larry and Satyendra Patrabansh. 2008 "Are Census Variables Highly Correlated With Housing Choice Voucher Holders' Perception of the Quality of Their Neighborhoods?," *Cityscape A Journal of Policy Development and Research* Vol 10(1), pp. 157-184. http://www.huduser.org/periodicals/cityscpe/vol10num1/ch6.html accessed January 2011.

Casey, C.H., 1992. "Characteristics of HUD-assisted renters and their units in 1989" US Department of Housing and Urban Development, Office of Policy Development and Research, March 1992.

Chapman, David W and; Lombard, John R. 2006. Determinants of Neighborhood Satisfaction in Fee-Based Gated and Nongated Communities. *Urban Affairs Review*. 41(6), July, pp. 769-99. http://www.sagepub.com/journalsProdDesc.nav?prodId=Journal200784 accessed August 2010.

DiIulio, John J., Jr. 1994. "The Question of Black Crime." *Public Interest* (117), Fall, p. 3.

Goodman, Jack. 2005. Constant Quality Rent Indexes for Affordable Housing. Working paper W05-4, Joint Center for Housing Studies, Harvard University, June. http://www.jchs.harvard.edu/publications/rental/w05-4.pdf accessed November 2010.

Hipp, John. 2007. Resident Perceptions of Crime: How Similar are They to Official Crime Rates? Center for Economic Studies, U.S. Census Bureau, Working Papers. http://ideas.repec.org/p/cen/wpaper/07-10.html accessed January 2011.

Laskey, Kathryn 2009.*Unit 3: Statistical Models with a Single Parameter* http://volgenau.gmu.edu/~klaskey/SYST664/Bayes_Unit3.pdf accessed August, 2010.

Lohr, 1999. *Sampling: Design and Analysis*. Duxberry Press, New York.

Mast, Brent D. "Measuring Neighborhood Quality with Survey Data: A Bayesian Approach" *Cityscape A Journal of Policy Development and Research* Vol 12(3), pp. 123-142. http://www.huduser.org/portal/periodicals/cityscpe/vol12num3/ch7.pdf accessed January 2011.

Newman, Sandra, and Ann Schnare 1997. "And a Suitable Living Environment: The Failure of Housing Programs to Deliver on Neighborhood Quality" *Housing Debate* 8(4): 703-741.

Rucinski, D., Athey, L., 1995. "Identifying Recipients of Housing Assistance Through Survey Questions", National Opinion Research Center.

Shroder, Mark 2002 "Does Housing Assistance Perversely Affect Self-Sufficiency? A Review Essay" *Journal of Housing Economics* 11, 381-417.

Thibodeau, Thomas. 1995. House Price Indices from the 1984-1992 MSA American Housing Surveys. *Journal of Housing Research* 6(3):439-481.

US Department of Housing and Urban Development 2008, "Characteristics of HUD-assisted renters and their units in 2003" Office of Policy Development and Research, May 2008.

[1] http://www.huduser.org/portal/datasets/assthsg.html

[2] Exhibit 5 data on HCVP occupied units are from HUD's Voucher Management System. The system does not report separately on Homeownership vouchers. For Exhibit 5, I subtracted PIC Homeownership voucher counts from VMS counts of total vouchers. Homeownership vouchers are a tiny fraction of total vouchers, totaling 8,496 in 2009 according to PIC.