Estimating Local Area Population Using the Housing Unit Method & ACS Data

Joe Francis
Professor Emeritus
Cornell University

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Introduction

A key assumption of this presentation is that there is a persistent desire for current information about population size and trends in local areas (unincorporated subcounty areas, small places, urban neighborhoods).

To meet this desire, over the years, various procedures for estimating population size and change have been advanced:

1. Administrative records method
2. Ratio-correlation method
3. Housing unit method

Of these, the housing unit method has been one of the most commonly used approach for local areas and may remain so given the unavailability, incompleteness and unreliability of administrative records at many local areas.

Introduction

Traditionally, the widespread use of the housing unit method derived from some key properties:

1. Conceptually simple
2. Historically absent any major (or no) errors in the data
3. One of the most accurate and cost effective ways to produce small area population estimates
4. Easily expressed mathematically as:

Population = occupied housing units * household size + population in group quarters

However, the preference for this method has become hampered of late by the extent of errors in the data that have arisen due to smaller sample size of the ACS compared to the decennial Census.

Housing Unit Method

Plus, non-sampling sources of inaccuracy that may impede this method include data collection and estimation problems, especially

1. uncertainty in the number of housing units,
2. uncertainty in household size, and
3. lack of information about the group quarters population at subcounty levels.

Moreover, procedures for estimating the sampling errors (MOEs) of these estimates result in yet more uncertainty in determining

1. the true value of population size and/or
2. whether significant change in population size has occurred over time.

This paper will attempt to address these kinds of issues for small, local areas.

Presentation Goals

Stated more directly, this presentation is primarily about estimating local, small area population using

1. A modified version of the housing unit method
2. and American Community Survey Data, specifically the ACS 2012-16 datasets

The fundamental question pursued is: Can the ACS data render a reasonable estimate of population size for small, local areas?

This presentation is also concerned with the issue of how accurately the key variables of the housing unit method (e.g. average household size) will be when aggregated from lower levels of geography (e.g. block-groups) to higher levels (tracts) or “non-standard” geographies (neighborhoods).

Third, the replicate variance method will be compared with the old approximation method for computing MOEs.

Geographic Area

For purposes of this paper, again, the term local, small area population means unincorporated subcounty areas, small places, and geography areas within urban places.

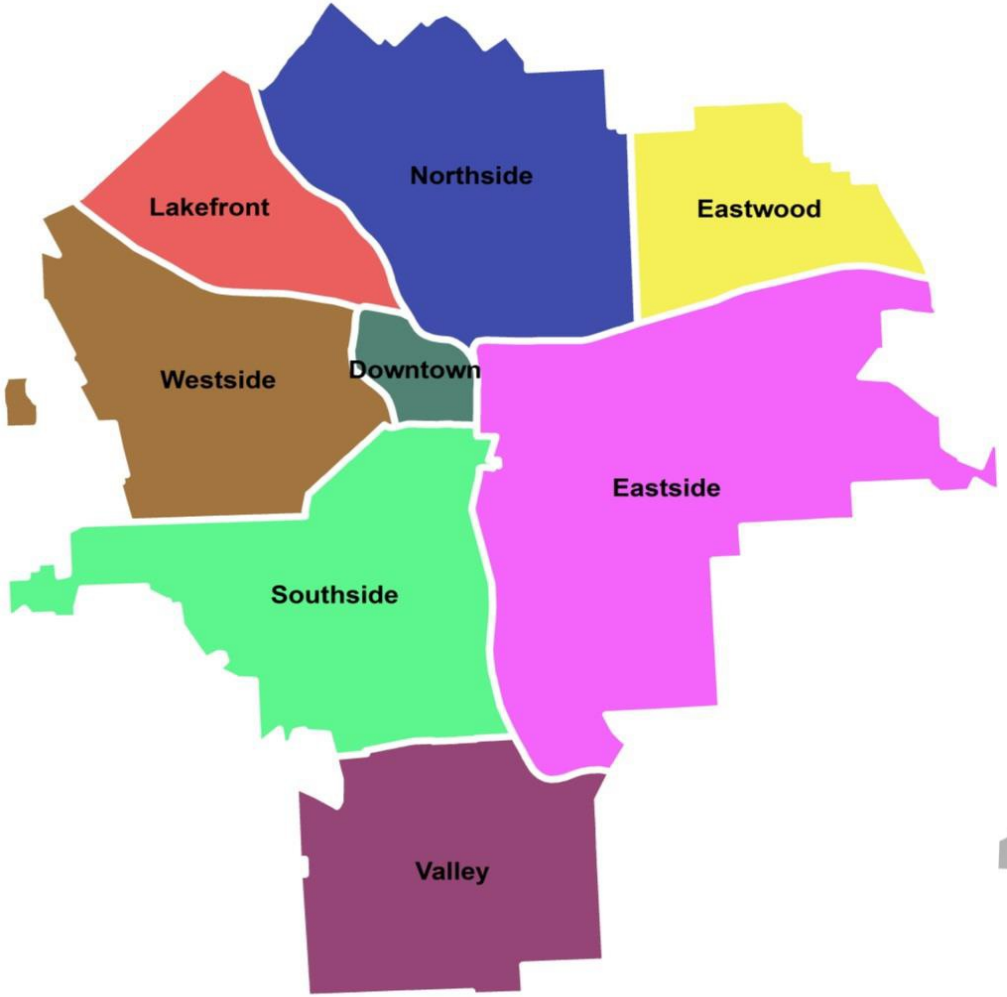
For this analysis ACS 2012-16 block-group level of geography information was used to compile results at the tract and non-standard “geographies” like neighborhoods.

The specific area under analysis is Syracuse, NY neighborhoods.

As the following slide shows, the Syracuse neighborhood association has defined 8 such neighborhood areas into which the divide the city.

Urban Neighborhoods

City of Syracuse and “Tomorrow’s Neighborhoods Today” (TNT)



Geographic Area

Syracuse provides a great case study as all the census tracts involved are totally enclosed within the city boundaries as can be seen on the following slide.

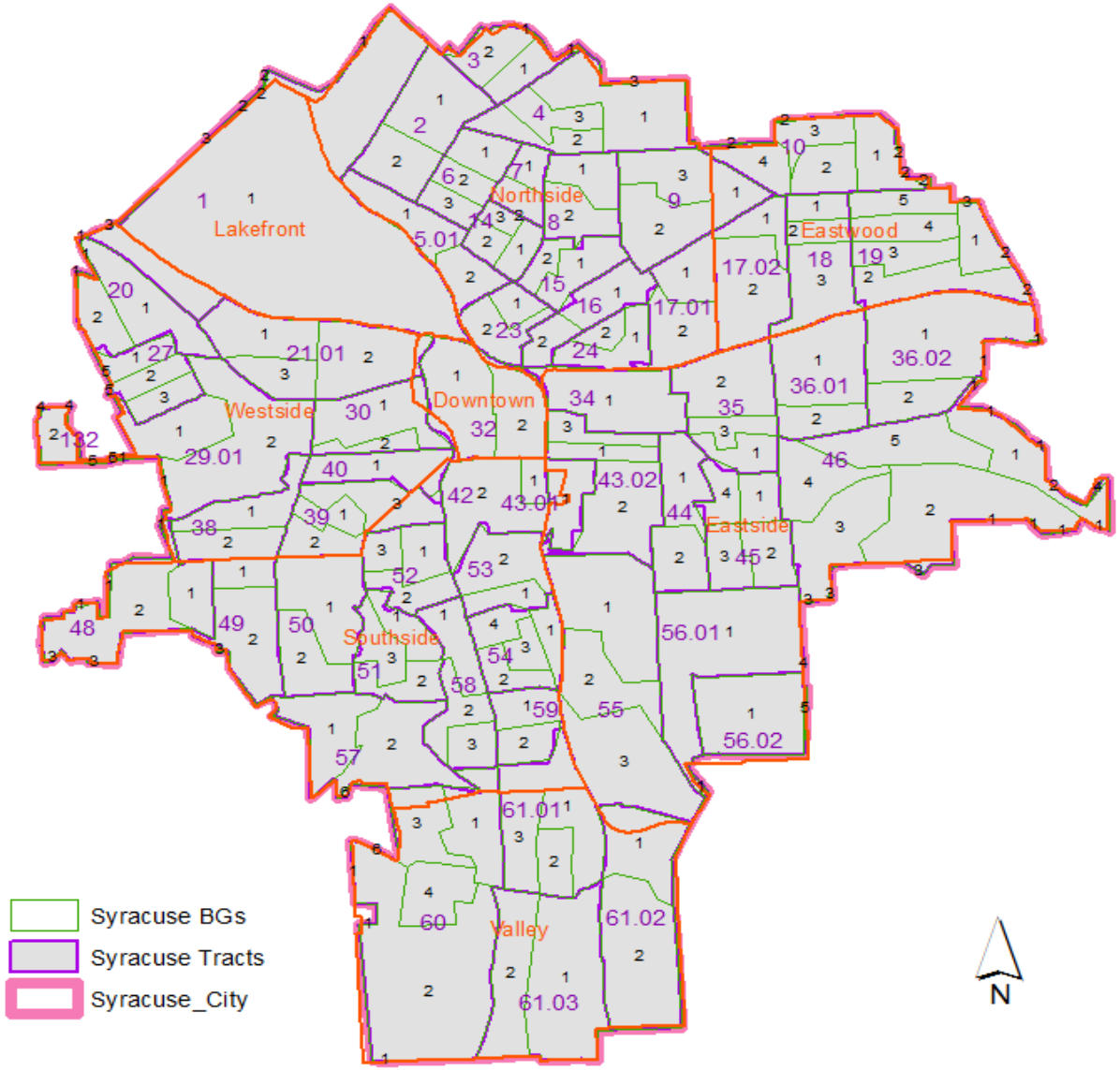
Likewise for block-groups that reside within those tracts.

These geographic properties eliminate the need to make any spatial adjustment of population or housing unit counts due to boundary spill overs.

You will also notice, on the next slide, that the neighborhood boundaries respectfully conform to block group geographies with a few exceptions.

This generally eliminated the need to make spatial adjustments to population and housing units that are located in a block group split by a neighborhood boundary.

Syracuse BGs, Tracts and Neighborhoods



Constraints

There are various constraints to utilization of the housing unit method for small areas like these:

1. No readily available information on group quarters population
2. Availability of only two plausible measures of household size in the ACS:
   a. Average Household Size
   b. Persons per room

Due to the absence of information on group quarters at the geographic level of urban neighborhoods, this paper will use a modified version focused only on household population:

Household Population = Occupied housing units * household size

Moreover, household size will be measured using the ACS variable—**average household size**.

The Modified Housing Unit Method

You might well ask: how big an error arises from absence of population residing in "non-occupied housing units" when the estimate desired is the total population in local area?

Table 1, below, attempts to address that question for Syracuse neighborhoods.

Table 1

Syracuse Neighborhood	ACS 2012-16 POP	ACS 2012-16 OccHUpop	Δ (Pop-OccHUP	%Δ (Pop-OccHUp	LCL ACS 2012-16 OccHUpop	UCL ACS 2012-16 OccHUpop	Significance
Lakefront	674	674	0	0.0	589	759	NS
Northside	44116	42957	1159	2.7	41913	44001	0.10↑
Downtown	4754	3695	1059	28.7	3405.9	3984.1	0.10↑
Eastwood	6792	6752	40	0.6	6344.9	7159.1	NS
Eastside	36610	25983	10627	40.9	25138.8	26827.2	0.10↑
Westside	16549	16366	183	1.1	15956.5	16775.5	NS
Southside	24394	23295	1099	4.7	22555.5	24034.5	0.10↑
Valley	10461	10427	34	0.3	9940.5	10913.5	NS

The Modified Housing Unit Method

Clearly for several of the local areas of interest (Syracuse neighborhoods), the modified housing unit method proposed here will fall “significantly short” due to the large numbers of people living in group quarters (nursing homes, dormitories, etc.)

Most notable is the downtown neighborhood that includes a large dormitory population connected with Syracuse University and the Eastside neighborhood that includes a large number of nursing homes.

Additional effort would be required to garner information on these living arrangements if a researcher wanted to predict total population in these neighborhoods.

That additional work was not undertaken for purposes of this paper/presentation which was purposefully restricted to examining how well ACS data would perform by itself.

The Modified Housing Unit Method

So, ignoring group quarters and other non-occupied housing unit living arrangements, here is the procedure followed.

First, the two components on the right hand side of the above equation were multiplied to produce a predicted household population value.

Then, that predicted household population value was compared with the ACS 2012-16's independent estimate for occupied housing population, acting here as the "observed value."

1. At the block-group level of geography
2. At the census tract level of geography
3. At the neighborhood level of geography

Table 2, next slide, shows some of the results, beginning with block groups and aggregating those to their census tract.

Modified Housing Unit Method Results

Table 2: comparison of predicted household population to occupied housing units population reported in ACS2012-16 for Syracuse block groups.

	Table 25010		Table 25002			Table 25008			
Geography	ACS2012-16 AveHHSize	AveHHSizeMOE	ACS2012-16 OccHU	AggMOE	RepMOE	PredPopOccHU	ObservPopOccHU	ObsPopOccHUMOE	Abs(Diff1)
Block Group 1, Census Tract 1, Onc	1.45	0.14	466	65		676	674	85	1.7
# of BG	Sum of BG Estimates								
Census Tract 1	1.45	0.14	466	65			674		
Block Group 1, Census Tract 2, Onc	2.22	0.36	652	110		1447	1445		2.44
Block Group 2, Census Tract 2, Onc	2.36	0.44	623	123		1470	1473		2.72
# of BG	2.29	0.569	1275	165	129	2920	2918		1.75
Census Tract 2	2.29	0.24	1275		129		2918	400	
AveHHSize Ratio Derived	2.29	0.32							
Block Group 1, Census Tract 3, Onc	2.39	0.26	360	49		860	859		1.4
Block Group 2, Census Tract 3, Onc	2.65	0.47	288	56		763	763		0.2
# of BG	2.52	0.537	648	74.4	51	1633	1622		10.96
Census Tract 3	2.50	0.23	648		51		1622	166	
AveHHSize Ratio Derived	2.50	0.26							
Block Group 1, Census Tract 4, Onc	1.90	0.25	679	87		1290	1288		2.1
Block Group 2, Census Tract 4, Onc	2.95	0.59	450	91		1328	1326		1.5
Block Group 3, Census Tract 4, Onc	2.24	0.34	430	84		963	965		1.8
# of BG	2.36		1559	151.35	99	3684	3579		105.4366667
Census Tract 4	2.30	0.20	1559		99		3579	382	
AveHHSize Ratio Derived	2.30	0.07							
Block Group 1, Census Tract 5.01, (	2.29	0.44	487	74		1115	1113		2.23
Block Group 2, Census Tract 5.01, (	2.52	0.42	427	84		1076	1077		0.96
# of BG	2.41		914	111.9	97	2198	2190		8.17
Census Tract 5.01	2.40	0.29					2190	303	
AveHHSize Ratio Derived	2.40	0.33							
Block Group 1, Census Tract 6, Onc	2.27	0.38	593	95		1346	1346		0.11
Block Group 2, Census Tract 6, Onc	4.12	0.85	330	76		1360	1360		0.4
Block Group 3, Census Tract 6, Onc	2.44	0.38	416	101		1015	1015		0.04
# of BG	~~2.94~~		1339	158.1	117	3941	3721		220.1233333
Census Tract 6	2.78	0.28					3721	392	
AveHHSize Ratio Derived	2.78	0.29							

Modified Housing Unit Method Results

Looking at the last column in Table 2 we see that, except for a couple block-groups, the predicted occupied housing unit population differed from the observed by no more than 3 persons. Indeed, most predictions differed by less than 2 persons.

So, **within** a census tract, the modified housing unit method, works quite well for a given block-group. Not so for aggregations to the census tract (see last column).

Because my interest is in how the method perform for combinations of block groups like tracts or neighborhoods, something needed rethinking.

Table 3, on next slide, shows that if one simply sums the block-group predicted occupied housing unit population for the tract, that aggregated value is much closer to the observed occupied household for the tract.

Modified Housing Unit Method Results

Table 3

	Table 25010		Table 25002				Table 25008				
Geography	ACS2012-16 AveHHSize	AveHHSizeMOE	ACS2012-16 OccHU	AggMOE	RepMOE	PredPopOccHU	ObservPopOccHU	ObsPopOccHUMOE	Abs(Diff1)	PredPopOccHU	Abs(Diff2)
Block Group 1, Census Tract 1, On	1.45	0.14	466	65		676	674	85	1.7	675.7	1.7
# of BG Sum of BG Estimates											
Census Tract 1	1.45	0.14	466	65			674				
Block Group 1, Census Tract 2, On	2.22	0.36	652	110		1447	1445		2.44	1447.44	2.44
Block Group 2, Census Tract 2, On	2.36	0.44	623	123		1470	1473		2.72	1470.28	2.72
# of BG Sum of BG Estimates	2.29	0.569	1275	165	129	2920	2918		1.75	2917.72	0.28
Census Tract 2	2.29	0.24	1275		129		2918	400			
AveHHSize Ratio Derived	2.29	0.32									
Block Group 1, Census Tract 3, On	2.39	0.26	360	49		860	859		1.4	860.4	1.4
Block Group 2, Census Tract 3, On	2.65	0.47	288	56		763	763		0.2	763.2	0.2
# of BG Sum of BG Estimates	2.52	0.537	648	74.4	51	1633	1622		10.96	1623.6	1.6
Census Tract 3	2.50	0.23	648		51		1622	166			
AveHHSize Ratio Derived	2.50	0.26									
Block Group 1, Census Tract 4, On	1.90	0.25	679	87		1290	1288		2.1	1290.1	2.1
Block Group 2, Census Tract 4, On	2.95	0.59	450	91		1328	1326		1.5	1327.5	1.5
Block Group 3, Census Tract 4, On	2.24	0.34	430	84		963	965		1.8	963.2	1.8
# of BG Sum of BG Estimates	2.36		1559	151.35	99	3684	3579		105.4366667	3580.8	1.8
Census Tract 4	2.30	0.20	1559		99		3579	382			
AveHHSize Ratio Derived	2.30	0.07									

Modified Housing Unit Method Results

Clearly, the extent of these discrepancies in results for block-group aggregations to the tract level strongly suggests that a major problem for the housing unit method will be finding an accurate average occupied housing population for combinations of block-group geographies.

What about neighborhoods?

Table 4, next slide, shows the analytic set-up for applying the modified housing unit method to a Syracuse neighborhood.

Of notice is that for aggregations to a neighborhood level of geography, again there are major discrepancies that would occur between simply summing the component block group values compared to those predicted from a multiplication the sum of occupied HUs * some aggregated average household sizes.

Table 4: Eastside Neighborhood

		Table 25010		Table 25002				Table 25008							
Id2	Geography	ACS2012-16 AveHHSize	AveHHSizeMOE	ACS2012-16 OccHU	ObsOccHUMOE	AggMOE	RepMOE	PredPopOccHU	ObservPopOccHU	ObsPopOccHUMOE	AggMOE	RepMOE	Abs	PredPopOccHU	Abs(Diff2)
360670034001	Block Group 1, Census Tract 34, Ono	2	0.27	673	74			1346	1343	220				1346	3
360670035001	Block Group 1, Census Tract 35, Ono	2.48	0.44	352	76			872.96	873	254				872.96	0.04
360670035002	Block Group 2, Census Tract 35, Ono	2.18	0.59	300	80			654	655	242				654	1
360670035003	Block Group 3, Census Tract 35, Ono	2.27	0.61	359	76			814.93	814	268				814.93	0.93
360670036011	Block Group 1, Census Tract 36.01, C	2.68	0.34	392	86			1050.56	1051	260				1050.56	0.44
360670036012	Block Group 2, Census Tract 36.01, C	2.75	0.39	477	80			1311.75	1313	199				1311.75	1.25
360670036021	Block Group 1, Census Tract 36.02, C	1.97	0.23	596	71			1174.12	1176	176				1174.12	1.88
360670036022	Block Group 2, Census Tract 36.02, C	3.1	0.27	332	48			1029.2	1030	157				1029.2	0.8
360670043011	Block Group 1, Census Tract 43.01, C	1.52	0.14	555	50			843.6	843	95				843.6	0.6
360670043021	Block Group 1, Census Tract 43.02, C	1.68	0.53	101	43			169.68	170	87				169.68	0.32
360670043022	Block Group 2, Census Tract 43.02, C	2.45	0.67	31	20			75.95	76	56				75.95	0.05
360670043023	Block Group 3, Census Tract 43.02, C	1.78	0.32	414	67			736.92	735	177				736.92	1.92
360670044001	Block Group 1, Census Tract 44, Ono	2.44	0.41	212	46			517.28	517	136				517.28	0.28
360670044002	Block Group 2, Census Tract 44, Ono	3.47	0.37	432	62			1499.04	1500	271				1499.04	0.96
360670045001	Block Group 1, Census Tract 45, Ono	2.62	0.36	312	79			817.44	818	236				817.44	0.56
360670045002	Block Group 2, Census Tract 45, Ono	2.09	0.29	599	93			1251.91	1253	275				1251.91	1.09
360670045003	Block Group 3, Census Tract 45, Ono	2.88	0.53	353	87			1016.64	1015	333				1016.64	1.64
360670045004	Block Group 4, Census Tract 45, Ono	2.85	0.67	392	104			1117.2	1116	396				1117.2	1.2
360670046001	Block Group 1, Census Tract 46, Ono	2.67	0.6	273	72			728.91	728	236				728.91	0.91
360670046002	Block Group 2, Census Tract 46, Ono	2.38	0.37	433	75			1030.54	1032	251				1030.54	1.46
360670046003	Block Group 3, Census Tract 46, Ono	2.17	0.41	582	107			1262.94	1265	287				1262.94	2.06
360670046004	Block Group 4, Census Tract 46, Ono	2.42	0.5	382	81			924.44	923	304				924.44	1.44
360670046005	Block Group 5, Census Tract 46, Ono	1.97	0.48	275	93			541.75	542	208				541.75	0.25
360670055001	Block Group 1, Census Tract 55, Ono	1.66	0.37	423	98			702.18	703	234				702.18	0.82
360670055002	Block Group 2, Census Tract 55, Ono	2.08	0.21	734	127			1526.72	1528	230				1526.72	1.28
360670055003	Block Group 3, Census Tract 55, Ono	1.86	0.25	629	119			1169.94	1172	249				1169.94	2.06
360670056011	Block Group 1, Census Tract 56.01, C	2.11	0.13	675	51			1424.25	1426	100				1424.25	1.75
360670056021	Block Group 1, Census Tract 56.02, C	4.07	0.49	90	44			366.3	366	188				366.3	0.3
28	Count of BGs	66.6		11378		418	302		25983		1225	844		25977.15	5.85
	Average	2.38													
	Derived Average =ObservPopOccHU/OccHU	2.28													
	Derived Average=PredPopOccHU/OccHU	2.28													
	AggMOE for Neighborhood Average HH Size	0.14													
	Rep MOE for Neighborhood Average HH Size	0.10													

Modified Housing Unit Method Results

We found that when combining block-level data to either tract level or neighborhoods, two problems were repeatedly encountered.

Both problem relate to the average household size variable.

The first of these is being able to compute a correct “derived estimate” for average household size for some combinations of block-groups.

The second is deriving a way to estimate the uncertainty (MOEs) of such aggregated estimates.

We examine each problem in turn.

Modified Housing Unit Method Problems

First, unlike with counts & totals, computing the sum or average of the component BG estimates doesn't always yield the same estimate as the published census tract value.

See the derived average household size estimate (red) vs. the reported tract values (black).

The values in red were computed by adding up the component BGs and dividing by the number of BGs.

	Table 25010	
Geography	**ACS2012-16 AveHHSize**	**AveHHSizeMOE**
Block Group 1, Census Tract 1, Onc	1.45	0.14
# of BG	Sum of BG Estimates	
Census Tract 1	1.45	0.14
Block Group 1, Census Tract 2, Onc	2.22	0.36
Block Group 2, Census Tract 2, Onc	2.36	0.44
# of BG	2.29	0.569
Census Tract 2	2.29	0.24
AveHHSize Ratio Derived	2.29	0.32
Block Group 1, Census Tract 3, Onc	2.39	0.26
Block Group 2, Census Tract 3, Onc	2.65	0.47
# of BG	2.52	0.537
Census Tract 3	2.50	0.23
AveHHSize Ratio Derived	2.50	0.26
Block Group 1, Census Tract 4, Onc	1.90	0.25
Block Group 2, Census Tract 4, Onc	2.95	0.59
Block Group 3, Census Tract 4, Onc	2.24	0.34
# of BG	2.36	
Census Tract 4	2.30	0.20
AveHHSize Ratio Derived	2.30	0.07
Block Group 1, Census Tract 5.01, (	2.29	0.44
Block Group 2, Census Tract 5.01, (	2.52	0.42
# of BG	2.41	
Census Tract 5.01	2.40	0.29
AveHHSize Ratio Derived	2.40	0.33
Block Group 1, Census Tract 6, Onc	2.27	0.38
Block Group 2, Census Tract 6, Onc	4.12	0.85
Block Group 3, Census Tract 6, Onc	2.44	0.38
# of BG	2.94	
Census Tract 6	2.78	0.28
AveHHSize Ratio Derived	2.78	0.29

Modified Housing Unit Method Problems

While these computed vs. reported census tract average HH size values may appear reasonably close, notice what happens when comparing the tract level predicted to observed household population for tracts 3,4 and 6 in the third to last column of Table 4—wildly different—even though the same computations steps were made for individual and aggregations of block groups.

Table 5

	Table 25010		Table 25002			Table 25008					
Geography	ACS2012-16 AveHHSize	AveHHSizeMOE	ACS2012-16 OccHU	AggMOE	RepMOE	PredPopOccHU	ObservPopOccHU	ObsPopOccHUMOE	Abs(Diff1)	PredPopOccHU	Abs(Diff2)
Block Group 1, Census Tract 3, On	2.39	0.26	360	49		860	859		1.4	860.4	1.4
Block Group 2, Census Tract 3, On	2.65	0.47	288	56		763	763		0.2	763.2	0.2
# of BG Sum of BG Estimates	2.52	0.537	648	74.4	51	1633	1622		10.96	1623.6	1.6
Census Tract 3	2.50	0.23	648		51		1622	166			
AveHHSize Ratio Derived	2.50	0.26									
Block Group 1, Census Tract 4, On	1.90	0.25	679	87		1290	1288		2.1	1290.1	2.1
Block Group 2, Census Tract 4, On	2.95	0.59	450	91		1328	1326		1.5	1327.5	1.5
Block Group 3, Census Tract 4, On	2.24	0.34	430	84		963	965		1.8	963.2	1.8
# of BG Sum of BG Estimates	2.36		1559	151.35	99	3684	3579		105.4366667	3580.8	1.8
Census Tract 4	2.30	0.20	1559		99		3579	382			
AveHHSize Ratio Derived	2.30	0.07									
Block Group 1, Census Tract 6, On	2.27	0.38	593	95		1346	1346		0.11	1346.11	0.11
Block Group 2, Census Tract 6, On	4.12	0.85	330	76		1360	1360		0.4	1359.6	0.4
Block Group 3, Census Tract 6, On	2.44	0.38	416	101		1015	1015		0.04	1015.04	0.04
# of BG Sum of BG Estimates	2.94		1339	158.1	117	3941	3721		220.1233333	3720.75	0.25
Census Tract 6	2.78	0.28					3721	392			
AveHHSize Ratio Derived	2.78	0.29									

Modified Housing Unit Method Problems

A work-around fix for these combined averages, was—(1) aggregate the observed occupied housing unit populations for the block groups within the tract, and then (2) divide by the aggregated occupied housing units for that tract.

This produced a more accurate tract level AverHHsize.

Compare black colored tract values to the rust colored ones estimated via the work-around—nice fit.

Table 6

	Table 25010		Table 25008		
Geography	ACS2012-16 AveHHSize	AveHHSizeMOE	ObservPopOccHU	PredPopOccHU	Abs(Diff2)
Block Group 1, Census Tract 1, Onc	1.45	0.14	674	675.7	1.7
# of BG	Sum of BG Estimates				
Census Tract 1	1.45	0.14	674		
Block Group 1, Census Tract 2, Onc	2.22	0.36	1445	1447.44	2.44
Block Group 2, Census Tract 2, Onc	2.36	0.44	1473	1470.28	2.72
# of BG	2.29	0.569	2918	2917.72	0.28
Census Tract 2	2.29	0.24	2918		
AveHHSize Ratio Derived	2.29	0.32			
Block Group 1, Census Tract 3, Onc	2.39	0.26	859	860.4	1.4
Block Group 2, Census Tract 3, Onc	2.65	0.47	763	763.2	0.2
# of BG	2.52	0.537	1622	1623.6	1.6
Census Tract 3	2.50	0.23	1622		
AveHHSize Ratio Derived	2.50	0.26			
Block Group 1, Census Tract 4, Onc	1.90	0.25	1288	1290.1	2.1
Block Group 2, Census Tract 4, Onc	2.95	0.59	1326	1327.5	1.5
Block Group 3, Census Tract 4, Onc	2.24	0.34	965	963.2	1.8
# of BG	2.36		3579	3580.8	1.8
Census Tract 4	2.30	0.20	3579		
AveHHSize Ratio Derived	2.30	0.07			
Block Group 1, Census Tract 5.01, (	2.29	0.44	1113	1115.23	2.23
Block Group 2, Census Tract 5.01, (	2.52	0.42	1077	1076.04	0.96
# of BG	2.41		2190	2191.27	1.27
Census Tract 5.01	2.40	0.29	2190		
AveHHSize Ratio Derived	2.40	0.33			
Block Group 1, Census Tract 6, Onc	2.27	0.38	1346	1346.11	0.11
Block Group 2, Census Tract 6, Onc	4.12	0.85	1360	1359.6	0.4
Block Group 3, Census Tract 6, Onc	2.44	0.38	1015	1015.04	0.04
# of BG	2.94		3721	3720.75	0.25
Census Tract 6	2.78	0.28	3721		
AveHHSize Ratio Derived	2.78	0.29			

Table 7

The same problem was observed for neighborhoods and the same work around was applied to generate a more accurate value for neighborhood average household size.

		Table 25010		Table 25002				Table 25008							
Id2	Geography	ACS2012-16 AveHHSize	AveHHSizeMOE	ACS2012-16 OccHU	ObsOccHUMOE	AggMOE	RepMOE	PredPopOccHU	ObservPopOccHU	ObsPopOccHUMOE	AggMOE	RepMOE	Abs	PredPopOccHU	Abs(Diff2)
360670034001	Block Group 1, Census Tract 34, Ono	2	0.27	673	74			1346	1343	220				1346	3
360670035001	Block Group 1, Census Tract 35, Ono	2.48	0.44	352	76			872.96	873	254				872.96	0.04
360670035002	Block Group 2, Census Tract 35, Ono	2.18	0.59	300	80			654	655	242				654	1
360670035003	Block Group 3, Census Tract 35, Ono	2.27	0.61	359	76			814.93	814	268				814.93	0.93
360670036011	Block Group 1, Census Tract 36.01, C	2.68	0.34	392	86			1050.56	1051	260				1050.56	0.44
360670036012	Block Group 2, Census Tract 36.01, C	2.75	0.39	477	80			1311.75	1313	199				1311.75	1.25
360670036021	Block Group 1, Census Tract 36.02, C	1.97	0.23	596	71			1174.12	1176	176				1174.12	1.88
360670036022	Block Group 2, Census Tract 36.02, C	3.1	0.27	332	48			1029.2	1030	157				1029.2	0.8
360670043011	Block Group 1, Census Tract 43.01, C	1.52	0.14	555	50			843.6	843	95				843.6	0.6
360670043021	Block Group 1, Census Tract 43.02, C	1.68	0.53	101	43			169.68	170	87				169.68	0.32
360670043022	Block Group 2, Census Tract 43.02, C	2.45	0.67	31	20			75.95	76	56				75.95	0.05
360670043023	Block Group 3, Census Tract 43.02, C	1.78	0.32	414	67			736.92	735	177				736.92	1.92
360670044001	Block Group 1, Census Tract 44, Ono	2.44	0.41	212	46			517.28	517	136				517.28	0.28
360670044002	Block Group 2, Census Tract 44, Ono	3.47	0.37	432	62			1499.04	1500	271				1499.04	0.96
360670045001	Block Group 1, Census Tract 45, Ono	2.62	0.36	312	79			817.44	818	236				817.44	0.56
360670045002	Block Group 2, Census Tract 45, Ono	2.09	0.29	599	93			1251.91	1253	275				1251.91	1.09
360670045003	Block Group 3, Census Tract 45, Ono	2.88	0.53	353	87			1016.64	1015	333				1016.64	1.64
360670045004	Block Group 4, Census Tract 45, Ono	2.85	0.67	392	104			1117.2	1116	396				1117.2	1.2
360670046001	Block Group 1, Census Tract 46, Ono	2.67	0.6	273	72			728.91	728	236				728.91	0.91
360670046002	Block Group 2, Census Tract 46, Ono	2.38	0.37	433	75			1030.54	1032	251				1030.54	1.46
360670046003	Block Group 3, Census Tract 46, Ono	2.17	0.41	582	107			1262.94	1265	287				1262.94	2.06
360670046004	Block Group 4, Census Tract 46, Ono	2.42	0.5	382	81			924.44	923	304				924.44	1.44
360670046005	Block Group 5, Census Tract 46, Ono	1.97	0.48	275	93			541.75	542	208				541.75	0.25
360670055001	Block Group 1, Census Tract 55, Ono	1.66	0.37	423	98			702.18	703	234				702.18	0.82
360670055002	Block Group 2, Census Tract 55, Ono	2.08	0.21	734	127			1526.72	1528	230				1526.72	1.28
360670055003	Block Group 3, Census Tract 55, Ono	1.86	0.25	629	119			1169.94	1172	249				1169.94	2.06
360670056011	Block Group 1, Census Tract 56.01, C	2.11	0.13	675	51			1424.25	1426	100				1424.25	1.75
360670056021	Block Group 1, Census Tract 56.02, C	4.07	0.49	90	44			366.3	366	188				366.3	0.3
28	Count of BGs	66.6		11378		418	302		25983		1225	844		25977.15	5.85
	Average	2.38													
	Derived Average =ObservPopOccHU/OccHU	2.28													
	Derived Average=PredPopOccHU/OccHU	2.28													

Notice that the same estimated value for average household size

Modified Housing Unit Method Problems

A second problem encountered is that no MOEs were available for any derived combinations of block groups for the average household size variable.

Moreover, Successive Difference Variance Replicate tables are not made available for indices like average household size. (Also the case for medians, ratios, rates.)

By contrast MOEs could be computed for aggregations of occupied HUs and occupied housing unit population. (See appendix.)

Absent estimates of MOEs for a derived average household size estimate, I felt it was urgent to develop alternative work-around techniques for estimating MOEs for these derived estimate of average household size.

Otherwise, no hypothesis tests on average household size were testable.

The Modified Housing Unit Method

As a work around, realizing that the components of the modified housing unit formula could be rearranged to produce a ratio that mirrors the reported average household size (see Table 6 & 7), it seemed this may be a reasonable avenue to come up with an alternative way of estimating the MOEs for these derived averages.

$$\frac{\text{estimated occupied housing unit population}}{\text{total occupied housing units}} = \text{average household size}$$

Pursuing this idea, the average household size was derived for each tract from its aggregated block group components-- ∑ estimated aggregated occupied HU population / ∑ estimated aggregated total occupied HUs.

The Modified Housing Unit Method

In the ACS Handbooks, "Understanding and Using American Community Survey Data: What All Data Users Need to Know" (July 2018), the following formula is given for a derived ratio:

$$MOE(\widehat{R}) = \frac{1}{\widehat{Y}}\sqrt{[MOE(\widehat{X})]^2 + (\widehat{R}^2 * [MOE(\widehat{Y})]^2)}$$

where $\widehat{R}$ = occupied HU Population/occupied HUs,

$\widehat{Y}$ = estimated occupied HUs

$\widehat{X}$ = estimated occupied HU population

Because we now have these three estimates for each tract, this MOE formula could be and was computed for each census tract's derived ratio (average household size), using the replicate weighted MOEs for occupied HUs and occupied HH population. (See appendix)

Modified Housing Unit Method Problems

As results in Table 8 show, sometimes this work around produced reasonable MOE estimates compared to those for the for census tracts.

Other times, not so much.

Table 8

	Table 25010	
Geography	ACS2012-16 AveHHSize	AveHHSizeMOE
Block Group 1, Census Tract 1, Onc	1.45	0.14
# of BG	Sum of BG Estimates	
Census Tract 1	1.45	0.14
Block Group 1, Census Tract 2, Onc	2.22	0.36
Block Group 2, Census Tract 2, Onc	2.36	0.44
# of BG	2.29	0.569
Census Tract 2	2.29	0.24
AveHHSize Ratio Derived	2.29	0.32
Block Group 1, Census Tract 3, Onc	2.39	0.26
Block Group 2, Census Tract 3, Onc	2.65	0.47
# of BG	2.52	0.537
Census Tract 3	2.50	0.23
AveHHSize Ratio Derived	2.50	0.26
Block Group 1, Census Tract 4, Onc	1.90	0.25
Block Group 2, Census Tract 4, Onc	2.95	0.59
Block Group 3, Census Tract 4, Onc	2.24	0.34
# of BG	2.36	
Census Tract 4	2.30	0.20
AveHHSize Ratio Derived	2.30	0.07
Block Group 1, Census Tract 5.01, (	2.29	0.44
Block Group 2, Census Tract 5.01, (	2.52	0.42
# of BG	2.41	
Census Tract 5.01	2.40	0.29
AveHHSize Ratio Derived	2.40	0.33
Block Group 1, Census Tract 6, Onc	2.27	0.38
Block Group 2, Census Tract 6, Onc	4.12	0.85
Block Group 3, Census Tract 6, Onc	2.44	0.38

Summary of Results

The main discovery for the above exploration, combining block group level geographies into neighborhood aggregates, showed that the variable of average household size created the biggest problem for using a modified housing unit method to estimate population.

Table 9, next slide, shows the results of an effort to determine how stable these ACS estimates were for derived non-traditional geographies.

As can be seen, it appears that while some patterns of change (decline) have occurred, none were significantly different from Census 2010 to the ACS 2012-16 period.

Significant Change in Average Household Size

The trend in average household size shows a slow decline from the Census 2000 to ACS 2012-16 period for all neighborhoods but one (Northside). Northside and Valley neighborhoods were outside the ACS 90% confidence limits for Census 2000.

Table 9

Neighborhood	Census 2000	Census 2010	ACS 2012-16 Est.	Change from 2010	LCL (Approx Method)	UCL (Approx Method)	Sig	LCL (RepWt Method)	UCL (RepWt Method)	Sig
Lakefront	1.50	1.48	1.45	-0.03	1.17	1.72	No	1.17	1.72	No
Northside	2.23	2.38	2.41	0.03	2.28	2.54	No	2.34	2.47	No
Downtown	1.92	1.84	1.85	0.01	1.61	2.10	No	1.67	2.03	No
Eastwood	2.14	2.08	2.03	-0.05	1.81	2.26	No	1.88	2.18	No
Eastside	2.33	2.30	2.28	-0.02	2.15	2.42	No	2.19	2.38	No
Westside	2.18	2.44	2.41	-0.03	2.22	2.60	No	2.31	2.50	No
Southside	2.80	2.75	2.67	-0.08	2.55	2.80	No	2.55	2.80	No
Valley	2.26	2.17	2.12	-0.05	1.91	2.32	No	1.99	2.25	No

Conclusions

The reasonable statistical stability of average household size indices across time gives some confidence in the use of such an estimate for aggregations of geographies.

However, this conclusion is based on “iffy” MOEs for the neighborhoods’ derived average household size.

Hence, my main conclusion from this exercise is that unless an analyst has very reliable, accurate values for average household size for combinations of block-group data, the housing unit method will not work well with American Community Survey data.

Questions

Appendix

Background support materials for this analysis are provided on the following seven slides. They provide information on patterns of significant changes (or not) in many key demographic variables analyzed for Syracuse neighborhoods.

Significant Differences in Predicted vs. Observed Household Population

Tests for significant differences between the occupied household population predicted from the modified housing unit method and that observed showed no significant differences among any of the neighborhoods.

Neighborhood	Predicted HH Pop	Obs'ed HH Pop	Δ	LCL (Approx)	UCL (Approx)	Sig	LCL (RepWt)	UCL (RepWt)	Sig
Lakefront	675.7	674	1.7	589	759	NS	589	759	NS
Northside	42965.8	42957	8.8	41110.5	44803.5	NS	41913.0	44001.0	NS
Downtown	3695.5	3695	0.5	3312.0	4078.0	NS	3405.9	3984.1	NS
Eastwood	6754.5	6752	2.45	6174.0	7330.0	NS	6344.9	7159.1	NS
Eastside	25977.1	25983	-5.85	24758.3	27207.7	NS	25138.8	26827.2	NS
Westside	16377.3	16366	11.3	15344.98	17387.0	NS	15956.5	16775.5	NS
Southside	23292.6	23295	-2.41	22221.1	24368.9	NS	22555.5	24034.5	NS
Valley	10422.2	10427	-4.8	9622.2	11231.8	No	9940.5	10913.5	NS

Significant Change in Population

Because of the smaller variance generated under the successive difference variance replicate method, **four** out of the **eight** (50%) neighborhoods have significant change in population from 2010 to the ACS 2012-16 period.

By contrast, only one neighborhood was assessed to have had significant change in total population since 2010 when the approximation method was used to measure MOE.

Determining significance to change in Total Population since Census 2010

Neighborhood	Census 2010 Pop	ACS 2012-16 Pop	Change	% Change	LCL (Approx)	UCL (Approx)	Sig	LCL (RepWt)	UCL (RepWt)	Sig
Lakefront	579	674	95	16.4%	589	759	0.10↑	589	759	0.10↑
Northside	43881	44116	235	0.5%	42249.3	45982.7	NS	43059.2	45172.8	NS
Downtown	4257	4754	497	11.7%	4254.7	5253.3	NS	4357.8	5150.2	0.10↑
Eastwood	6576	6792	216	3.3%	6212.6	7371.4	NS	6385.6	7198.4	NS
Eastside	36671	36610	-61	-0.2%	35224.9	37995.1	NS	25468.2	47751.8	NS
Westside	17319	16549	-770	-4.4%	15529.1	17568.9	NS	15878.8	17219.2	0.10↓
Southside	25331	24394	-937	-3.7%	23296.3	25497.8	NS	23586.8	25201.2	0.10↓
Valley	10554	10461	-93	-0.9%	9657.9	11264.2	NS	9975.9	10946.1	NS

Significant Change in Housing Units

As was true for total population size and change in the Syracuse neighborhoods, the replicate variance method performed much better.

For **five** of the **eight** neighborhoods had significant change at 90% confidence limit using the replicate weighted MOE compared to one neighborhood for the approximate MOE

Determining significance to change in total Housing Units since Census 2010

Neighborhood	Census 2010 HUs	ACS 2012-16 HUs	Change	% Change	LCL (Approx)	UCL (Approx)	Sig	LCL (RepWt)	UCL (RepWt)	Sig
Lakefront	534	521	-13	-2.4%	457	585	NS	457	585	NS
Northside	21275	21675	400	1.9%	21095.5	22254.5	NS	21357.1	21992.9	0.10↑
Downtown	2153	2291	138	6.0%	2134.8	2447.2	NS	2221.8	2360.2	0.10↑
Eastwood	3356	3487	131	3.9%	3260.2	3713.8	NS	3382.4	3591.6	0.10↑
Eastside	12873	13160	287	2.2%	12739.4	13580.6	NS	12937	13383	0.10↑
Westside	8273	8429	156	1.9%	8112.9	8745.1	NS	8248.5	8609.5	NS
Southside	10513	9763	-750	-7.1%	9426.3	10099.7	0.10↓	9486.1	10039.9	0.10↓
Valley	5376	5352	-24	-0.4%	5057.5	5646.5	NS	5202.3	5501.7	NS

Significant Change in Occupied Units

The same **kinds** of results were found for change in occupied housing units since Census 2010 as were found above for total housing units. Six (6) out of 8 (75%) neighborhoods were deemed significant at the 10% confidence limit when the replicate variance estimates are used. Only 3 were so judged for the approximation method.

Determining significance to change in Occupied Housing Units since Census 2010

Neighborhood	Census 2010 HUs	ACS 2012-16 HUs	Change	% Change	LCL (Approx)	UCL (Approx	Sig	LCL (RepWt)	UCL (RepWt)	Sig
Lakefront	390	466	76	19.50%	401	531	0.10↑	401	531	0.10↑
Northside	18754	17845	-909	-4.80%	17282.5	18407.5	0.10↓	17410.9	18279.1	0.10↓
Downtown	1887	1994	107	5.70%	1832.5	2155.5	NS	1878	2110	NS
Eastwood	3144	3322	178	3.90%	3088.8	3555.2	NS	3183.2	3460.8	0.10↑
Eastside	12052	11378	-674	-5.60%	10959.7	11796.3	0.10↓	11075.8	11796.3	0.10↓
Westside	7043	6803	-240	-3.40%	6474.9	7131.1	NS	6588.3	7017.7	0.10↓
Southside	9018	8710	-308	-3.40%	8382.9	9037.1	NS	8430.6	8989.4	0.10↓
Valley	5065	4924	-141	-2.80%	4630.3	5217.7	NS	4730.1	5117.9	NS

Significant Change in Occupied Housing Population

Change in the occupied housing population were found to be significantly, at the 90% confidence limit, for five out of the eight (62.5%) neighborhoods since the 2010 Census when the variance replicate method was used.

By contrast, only two out of eight (25%) were so found when the approximate MOE method was employed.

Determining significant change in Occupied Housing Unit Population since 2010

Neighborhood	Census 2010 HUs	ACS 2012-16 HUs	Change	% Change	LCL (Approx)	UCL (Approx	Sig	LCL (RepWt)	UCL (RepWt)	Sig
Lakefront	579	674	95	16.40%	589	759	0.10↑	589	759	0.10↑
Northside	42902	42957	55	0.13%	41110.5	44803.5	NS	41913.0	44001.0	NS
Downtown	3241	3695	454	14.00%	3312.0	4078.0	0.10↑	3405.9	3984.1	0.10↑
Eastwood	6540	6752	212	3.20%	6174.0	7330.0	NS	6344.9	7159.1	NS
Eastside	27200	25983	-1217	-4.50%	24758.3	27207.7	NS	25138.8	26827.2	0.10↓
Westside	17130	16366	-764	-4.50%	15345.0	17387.0	NS	15956.5	16775.5	0.10↓
Southside	24265	23295	-970	-4.00%	22221.1	24368.9	NS	22555.5	24034.5	0.10↓
Valley	10523	10427	-96	-0.90%	9622.2	11231.8	NS	9940.5	10913.5	NS

Summary of Significant Changes

Neighborhood	Total Pop	Total HUs	Total Occup HUs	OccupHUPop	AveHHsize
Lakefront	0.10↑	NS	0.10↑	0.10↑	NS
Northside	NS	0.10↑	0.10↓	NS	NS
Downtown	0.10↑	0.10↑	NS	0.10↑	NS
Eastwood	NS	0.10↑	0.10↑	NS	NS
Eastside	0.10↓	0.10↑	0.10↓	0.10↓	NS
Westside	0.10↓	NS	0.10↓	0.10↓	NS
Southside	0.10↓	0.10↓	0.10↓	0.10↓	NS
Valley	NS	NS	NS	NS	NS