Methods to Account for Classification Error in County Assignment for a Periodic Dual-Frame Telephone Survey

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Abstract

State or local-area based surveys are often designed to make estimates at the county or county-group levels. Under a traditional random digit dial (RDD) design, the telephone exchange of a landline number could be used to accurately identify the county for which the associated household resides. However, initially, no good analogous data methods existed for the cellphone frame. This required survey methodologists to only draw random samples of cell numbers from the entire state; thus, making it difficult to target areas within a state. To overcome this shortcoming, sample vendors, such as Marketing System Group (MSG), have recently been able to identify a cellphone number's rate center (where the number was activated) and determine the county from which the rate center is located. Our paper shows that rate centers can be used to identify a respondent's county of residence, but may have classification error rates as high as 30%. These high classification error rates make it difficult to accurately devise a sample allocation using a cellphone frame. However, for periodic surveys, such as the Ohio Medicaid Assessment Survey (OMAS), our paper shows how past iterations of the survey can be used to estimate not only the overall classification error rate, but the probability that the cellphone owner will actually reside in the county assigned. This paper proposes a new method – the Rate Center Plus method – which uses rate centers to stratify and allocate the desired respondent sample to counties plus incorporates the classification error rates to improve accuracy. The results from the 2015 OMAS in which classification error rates from 2012 were used to allocate the 2015 sample are presented. We demonstrate how to use past survey information to inform a new survey's cellphone sampling strategy and how well this worked for the 2015 OMAS. The paper demonstrates that our proposed five step approach can accurately take into account the classification error in the rate center assignments to obtain the desired number of interviews at the county level. In addition, a comparison to alternative allocation methods, including the 2012 method, show that our design improves the accuracy of obtaining the number of desired interviews at the county level relative to the other designs.

Key Words: Cellphone, rate center, classification error, telephone survey, sample allocation

1. Introduction

State or local-area based surveys are often designed to make estimates at the county or county-group levels (see, for example, California Health Interview Survey, 2010; Ohio Medicaid Assessment Survey, 2012). Under a traditional random digit dial (RDD) design, the telephone exchange of a landline number could be used to accurately identify the county for which the associated household resides. However, initially, no good analogous data methods existed for the cellphone frame. This required survey methodologists to draw random samples of cell numbers from the entire state; thus, making it difficult to target areas within a state.

When the proportion of the sample allocated to the cellphone sample was relatively small and used mainly to ensure full coverage of the target population, the need to allocate the cellphone sample at the county level was not necessary. However, as the proportion of the population that are cellphone only or cellphone mostly users increases (Blumberg, et. al., 2013), especially among young adults with children and minorities (Lu, et. al., 2014), increasing cellphone allocations is needed to offset any loss in precision due to increased design effects (Peytchev & Neely, 2013).

In order to better allow cellphone samples to target sub-state areas, sample vendors, such as Marketing System Group (MSG), have recently been able to identify a cellphone number's *rate center* and determine the county from which the rate center most likely resides. A rate center is the location in which a cellphone number was activated. Rate centers can then be clustered into rate center counties based on the county in which the majority of a rate center falls. If the rate center county assignment accurately predicts where the cell phone user resides then it can be used in the same way exchanges are used on the landline frame. However, if there is classification error in where a person actually lives and their assigned rate center county then methods are required to increase the likelihood that the sub-state allocation is achieved. Classification error in the rate center has been found when sampling across state lines (see, for example, Kafka, Chattopadhyay, & Chan, 2015).

2. Motivation

2.1 Ohio Medicaid Assessment Survey

The Ohio Medicaid Assessment Survey (OMAS) is a periodic survey of residents in Ohio. OMAS measures health insurance coverage and access to medical services among adults and children. Because the outcomes of interest are highly correlated to where a person lives, county level estimates are critical to understanding the populations at greatest risk.

Since its inception in 2004, OMAS has utilized an RDD telephone design. Beginning in 2008, OMAS moved to a dual-frame design, but with a very limited cellphone sample (approximately 5% of the total sample). In 2012, OMAS increased the proportion of desired interviews from the cellphone sample to 25% (Ohio Medicaid Assessment Survey, 2012). The 2012 cellphone sample was a statewide random sample of cellphone numbers.

At the time of the 2015 survey the proportion of Ohio cellphone only or mostly households was estimated to be 52.9% of adults and 62.8% of households with children (Blumberg, et. al., 2013). Moreover, data from the 2012 OMAS indicated that minorities, households with children, and residents at or around the poverty level were more likely to be contacted

through the cellphone frame (Lu, et. al., 2014). Based on these findings, it was decided to increase the cellphone allocation to 55% of completed interviews.

Furthermore, the total number of interviews for the 2015 OMAS was targeted at 40,000 with the objective of producing direct estimates at the county level in the majority of the 88 counties in Ohio.

2.2 Assessing the Accuracy of Rate Centers

In order to get a sense of how accurate rate center county is at predicting a cellphone respondent's county of residence, we had the rate center county appended to the final set of respondents and compared them to the reported county of residence. ***Figure 1*** shows the distribution of respondents based on their assigned rate center county and their survey response by county and county type (metro, suburban, rural non-Appalachian, and rural Appalachian). As can be seen in the figure, in metro counties the rate center county assignment overestimates the number of residents while in the other county types the rate center county underestimates the number of residents in the county. Treating the reported county of residence as the truth, we find that (1) metro counties have a higher false positive rate (i.e., the rate center county indicator predicts more cell phone users reside in the county than actually reside there), (2) non-metro counties have a higher false negative rate (i.e., the rate center county indicator predicts a lower number of residents than actually live in the in the county). Due to the classification errors in rate center county, we do not think the accuracy of the rate center county is good enough to be a one-to-one proxy for county of residence.

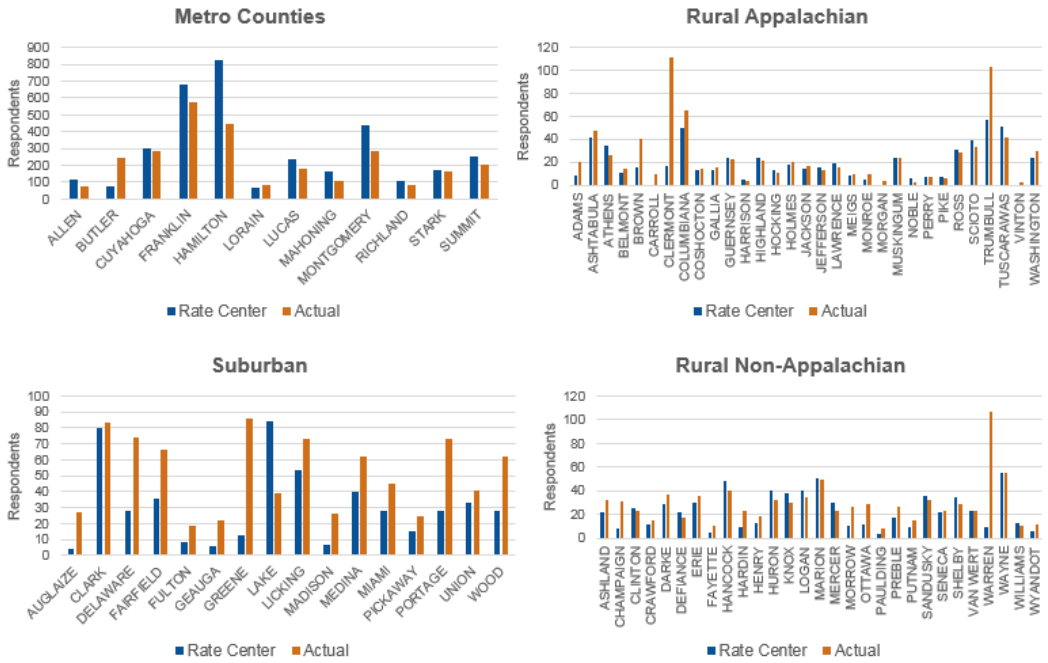

Figure 1: 2012 Rate Center County versus Actual County of Residence by County Type

2.3 Research Questions

While rate center county is not a perfect proxy for county of residence, it is the best measure for county currently available on the cellphone frame. Therefore, this paper develops a

method – the Rate Center Plus method – by which prior survey data can be used to account for the classification error in the rate center county assignments to properly allocate the cellphone sample across all of the counties to improve the chance that we complete desired number of interviews in each county. We then apply the method to the 2015 OMAS and assess how it preformed.

As such, we developed the following research questions:

1. How should we allocate the sample across rate centers?
2. How did the allocation process perform on the 2015 OMAS?
3. Did the classification error rates change over time (i.e., from 2012 to 2015)?
4. Does the Rate Center Plus method improve the accuracy in obtaining the desired number of interviews at the county level compared to alternative allocation methods?

3. Allocation Method

3.1 Basic approach

The Rate Center Plus method utilizes the known classification error rates from the prior survey (e.g., the 2012 OMAS) to determine how the desired number of completed interviews for a county should be allocated across rate center county for sampling. This approach can be completed in five basic steps.

1. Using prior survey data, for all counties, determine the probability that a phone number will be assigned to a rate center county given the actual county the user of the phone resides in, i.e., $P(Rate\ Center\ County \mid Actual\ County)$.
2. Create a $k \times k$ probability matrix, where k is the number of counties in the state or area of interest, of the conditional probabilities developed in (1). Let $p_{j|i}$represent the probability of a phone number being in rate center county j given the actual county is i where j=1,…,k and i=1,…,k.
3. Determine the desired number of completed interviews in each county (n_i)
4. Apply the desired allocation in (3) to the probability matrix in (2) to obtain the number of phone numbers to be selected from each rate center county to achieve desired sample size in county. For example, for county i, calculate $n_{j|i} = n_i \times p_{j|i}$.
5. Sum the desired sample size of phone numbers within each rate center county and county combination by rate center county to obtain the needed number of completed interviews in each rate center to achieve desired county allocation[1], i.e., $n_j = \sum_{i=1}^{k} n_{j|i}$ for j=1,…,k.

These steps require two key assumptions in order to produce desired results.

- *Assumption 1*: The distribution of cellphone users by county (or sub-state area) in the current period is similar to the distribution of cellphone users in the period used to develop the probability matrix
- *Assumption 2*: The classification error rates for each rate center county (or sub-state area) in the current period are similar to the classification error rates in the period used to produce the probability matrix

[1] The desired number of completed interviews for each rate center should then be adjusted to account for nonresponse and ineligible phone numbers (e.g., nonworking) to get the number of phone numbers that need to be selected in each rate center county.

Assumption 1 is needed to help ensure that the distribution of where a county's respondents will be found across rate center counties is similar. If the distribution of cellphone users has changed from the initial period to the current then it is likely that the distribution of where residents live according to rate center county has changed as well.

Assumption 2 is needed to help ensure that the allocation of rate center counties will produce the desired number of interviews in each county. For example, if a rate center county has a high false positive rate in the initial period, but not the current then too many interviews will be allocated to the rate center county (i.e., the actual county will obtain more interviews than desired while other counties will obtain fewer). Similarly, if the false negative rate for a county has changed then the allocation assumption regarding how many interviews for a county will come from a different rate center county will not hold leading to fewer than desired interviews in the county.

3.2 Simple Example of Approach

To illustrate the proposed approach we (1) look at the relationship between classification error rates and the matrix probabilities for a county and (2) present a simple example.

3.2.1 Different Types of Counties

As seen in ***Figure 1***, metro counties and non-metro counties have different classification error probabilities. To illustrate the impact that these differing classification error rates impact our proposed method, ***Figure 2*** and ***Figure 3*** show the distribution of the respondents in the 2012 OMAS from Hamilton County, a metro county, and Coshocton County, a rural county, in Ohio.

The rate center county for Hamilton County has a 4.0% false positive rate and only a 7.2% false negative rate. The relatively small false negative rate means that very few phone numbers assigned to counties other than the Hamilton rate center county belong to Ohio residents who live inside of Hamilton. In other words, to obtain residents of Hamilton county one needs to draw numbers largely from the Hamilton County rate center. The relatively large false positive rate means that phone numbers assigned to the Hamilton rate center belong to residents in other counties. In other words, respondents from other counties will come in large part from metro counties like Hamilton. This finding is representative of the other metro counties in Ohio and means that more phone numbers from the metro county rate centers need to be drawn than needed in the particular metro county because these numbers will be the main supplier for the metro county interviews and the interviews for other counties as well.

The rate center county for Coshocton County has a false positive rate of only 0.12% and a false negative rate of 32.5%. The relatively large false negative rate means that a large portion of phone numbers that are really in Coshocton are assigned to numbers in rate center counties other than Coshocton. In other words, in order to obtain interviews from residents of Coshocton a larger number of phone numbers from counties other than Coshocton need to be sampled. The relatively small false positive rate means that phone numbers assigned to the Coshocton rate center belong to Coshocton residents. In other words, phone numbers selected in the Coshocton rate center are highly likely to belong to residents of Coshocton. These findings are representative of other non-metro counties and mean that fewer phone numbers from the non-metro rate center should be drawn than needed in that particular county because respondents in that county will come from both

phone numbers in that rate center county for that county as well as other rate center counties.

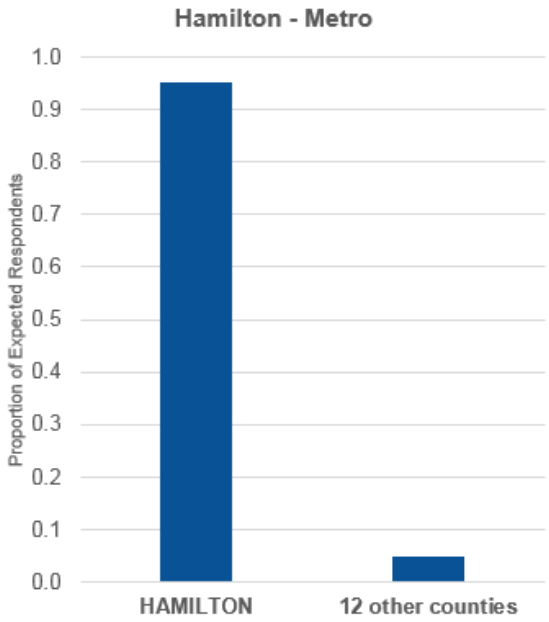

Figure 2: Distribution of Hamilton county respondent's rate center county, 2012 OMAS

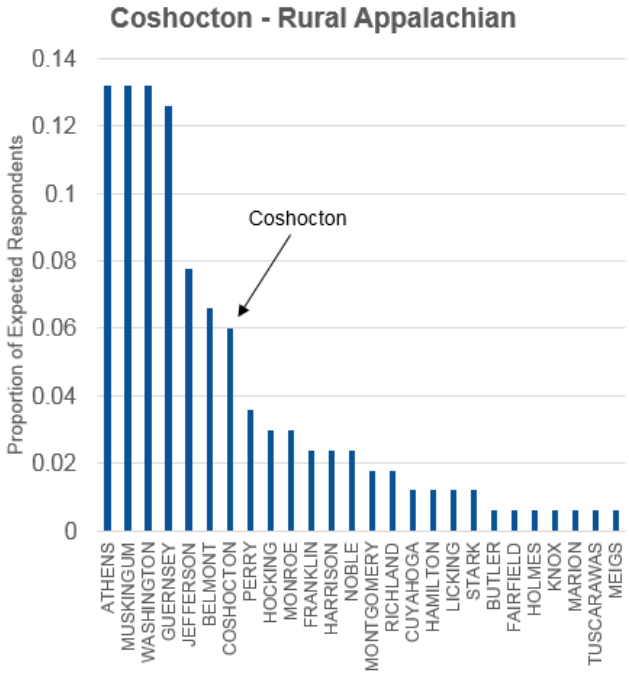

Figure 3: Distribution of Coshocton county respondent's rate center county, 2012 OMAS

3.2.2 Simple Example

To fully illustrate the Rate Center Plus method, a state with five counties from which 400 interviews are desired will be used. County 1 and County 4 are metro counties and County 2, County 3, and County 5 are non-metro counties.

Table 1 presents the allocation for the 400 total interviews across the five counties (n_i), the conditional probability of a phone number being in a rate center county given the actual county the user of the phone number resides ($p_{j|i}$), and the resulting sample size to be selected from each rate center (n_j). These numbers correspond with the Steps 1 – 5 described in Section 3.1.

For County 1, a metro county, ***Table 1*** shows that the design desires 100 interviews from County 1. To obtain those interviews, in expectation, 80 will come from the County 1 rate center, 5 will come from the County 2 rate center, 0 will come from the County 3 rate center, 1 will come from the County 4 rate center and 15 will come from the County 5 rate center. However, because County 1 is a metro county, numbers assigned to its rate center will, in expectation, supply 17.5 interviews to County 2, 2.4 interviews to County 3, 0 interviews to County 4, and 3 interviews to County 5. Therefore, the sample that will be allocated to the County 1 rate center will be large enough to obtain 103 interviews in the County 1 rate center. By contrast, County 3, a non-metro county, has a desired 80 completed interviews, but will only have 45 interviews allocated to the County 3 rate center because many of the interviews will come from other rate center counties including 12 from County 2 and 24 from County 4.

Table 1: Desired Number of Interviews, Probability Matrix, and Rate Center County Sample Size for State with Five Counties

		Rate Center									
Actual	**Desired**	**County 1**		**County 2**		**County 3**		**County 4**		**County 5**		**Total**
	n	Prob.	n	Prob.	n	Prob.	n	Prob.	n	Prob.	n	
County 1	100	80%	80	5%	5	0%	0	1%	1	14%	14	100%
County 2	50	35%	17.5	40%	20	10%	5	15%	7.5	0%	0	100%
County 3	80	3%	2.4	15%	12	45%	36	30%	24	7%	5.6	100%
County 4	140	0%	0	2%	2.8	2%	2.8	95%	133	1%	1.4	100%
County 5	30	10%	3	5%	1.5	5%	1.5	60%	18	20%	6	100%
Sample Size	**400**		**103**		**41**		**45**		**184**		**27**	

4. Application to 2015 OMAS

In applying the process to the 2015 OMAS, we had two main goals: (1) apply the proposed allocation approach to understand any issues or complications with the process, and (2) assess how well the process worked in terms of the two key assumptions and how well the final distribution of respondents matched the desired distribution.

4.1 Sample Allocation

Using 2012 OMAS data, we implemented our proposed approach.

- For Step 1, we calculated the conditional probabilities using the approximately 5,000 completed cellphone interviews conducted during the 2012 survey. Interestingly, 3 counties in Ohio do not have any rate centers. In other words, all of the desired interviews from those counties need to come from other counties (i.e., all interviews are dependent on the false negative rates of other rate center counties).
- For Step 2 we created a 90 x 90 matrix. Ohio has 88 counties, but we split their two mostly urban counties – Cuyahoga County where Cleveland is located and Franklin County where Columbus is located – in two based on rate centers identified as having a higher density of African Americans. This was done to better oversample African Americans. One issue we encountered was that there were too few cellphone respondents in some counties in 2012 (< 20) in order to obtain reliable classification errors and distributions of respondents across rate center county. When this occurred we collapsed counties with neighboring counties of the same county type (i.e., metro, suburban, rural Appalachian, or rural non-Appalachian) to develop combined probabilities. For the probability matrix 26 counties required a combined probability. The combined probabilities were assigned to the counties with 20 or fewer cellphone respondents in 2012.
- For Step 3, we initially allocated the desired 26,000 cellphone respondents proportionally across the 90 strata. Adjustments were made to the allocation to ensure a minimum of 45 completed interviews were obtained in each stratum. The desired sample size of the two high density African-American strata were increased to account for the oversample. See Berzofsky, et al., (in press) for more details on the sample allocation.
- For Step 4, given the allocation of the 26,000 desired cellphone respondents across the 90 strata from Step 3 and the probability matrix from Step 2, we determined the desired number of interviews within each strata by rate center strata combination.
- For Step 5, within each rate center strata we summed across all 90 county strata to obtain the desired number of interviews within each rate center strata.

Figure 4 presents the final allocation across rate center strata compared to the desired number of interviews in each county strata. Strata with a dot right on the 45-degree line have the exact same desired number of interviews in a rate center strata as the county strata. As expected, metro counties/strata, for the most part, will obtain a lot more interviews in the rate center strata than the actual county. For example, Butler county has almost 2,500 interviews drawn from its rate center county, but only desires about 1,250 interviews from residents in that county. In total, 38 strata have a larger desired sample in the rate center strata than their equivalent county strata and 50 strata have a smaller desired sample in the rate center strata than their equivalent county strata.

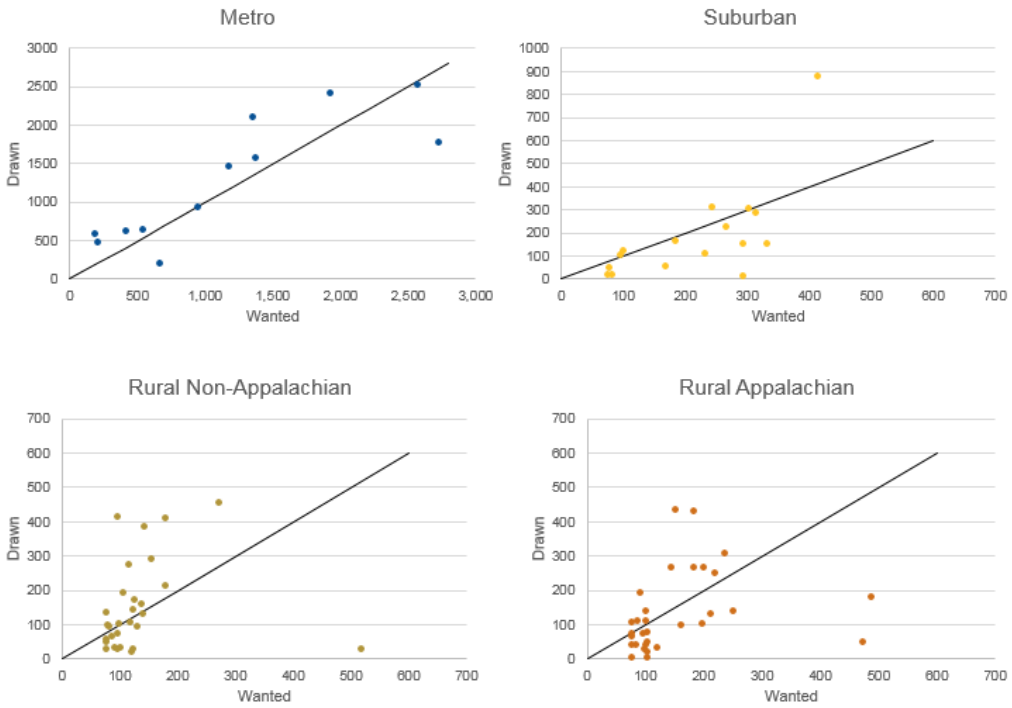

Figure 4: Sample size drawn versus target sample wanted by county type for OMAS 2015

4.2 Assessing the Performance of the Approach

The assessment of how well the Rate Center Plus method performed for the 2015 OMAS sample consisted of four components: (1) assess if key Assumption 1 was appropriate, (2) assess if key Assumption 2 was appropriate, (3) assess the final distribution of respondents to the desired distribution of respondents based on the proposed approach, and (4) assess the accuracy gained in targeting counties relative to alternative methods for allocating the sample.

4.2.1 Assumption 1: Distribution of Cellphone Numbers

While the 2012 distribution of cellphone numbers was not used in the proposed allocation process, key Assumption 1 – the probability matrix based on 2012 results can be applied to the 2015 desired sample – may not be valid if the 2015 distribution differs greatly from the 2012 distribution. This is because if the general distribution of the cellphone frame has shifted over time, it is likely that distribution of how the cellphone residents of a county are distributed across rate center county has likely shifted as well.

Figure 5 presents a comparison of the distribution of cellphone users by county (i.e., the distribution of cellphone users taking into account their final survey weight to adjust for unequal probabilities of selection). As the figure shows, with only a few exceptions, the distributions from the two survey years track closely together across all county types. This gives us confidence that Assumption 1 holds and the probability matrix used for the allocation is valid for the 2015 allocation.

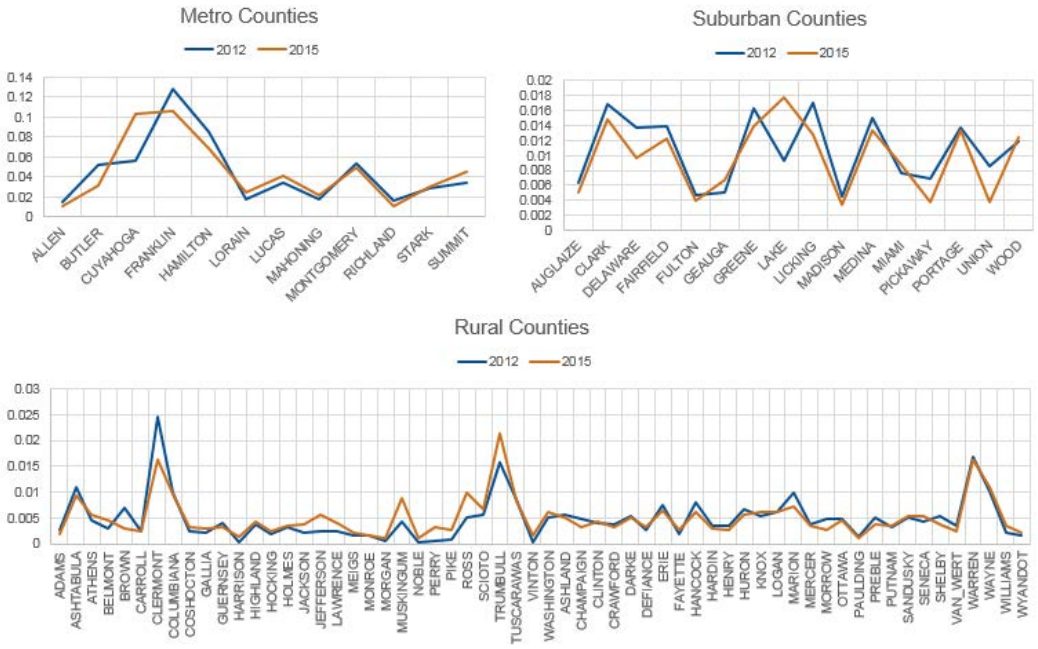

Figure 5: Comparison of the 2012 and 2015 true proportion of cellphone users by county

4.2.2 Assumption 2: Classification Error Rates

Key Assumption 2 to the proposed allocation approach is that the classification error rates in 2015 are roughly the same as 2012. This is an important assumption because, if not correct, the sample may be over or under allocated to a rate center county. For example, if the assumption that metro counties have a high false positive rate and small false negative is no longer correct more numbers than necessary will be allocated to the rate center metro counties. This error would likely result in too many completed interviews in the metro counties and not enough interviews in the non-metro counties.

Table 2 presents the average false positive and false negative rates in 2012 and 2015 by county type. The table shows that both classification error rates have been stable over time. This gives us confidence that Assumption 2 holds and the number of phone numbers allocated to a rate center county will appropriately result in the number of desired interviews within each actual county.

Table 2: Average False Positive and False Negative Rates in the 2012 and 2015 OMAS Surveys by County Type

	False Positive Rate		**False Negative Rate**	
County Type	**2012**	**2015**	**2012**	**2015**
Metro	2.74%	2.09%	16.94%	21.76%
Rural Appalachian	0.13%	0.18%	38.61%	41.36%
Rural Non- Appalachian	0.15%	0.22%	44.24%	47.15%
Suburban	0.28%	0.40%	58.76%	60.12%

While it is reassuring that the average classification error rates did not change over time, if the classification error rates at the county level changed for a few counties, then the allocation for those rate center counties may not lead to the desired number of interviews within the county. ***Figure 6*** presents a comparison of the false positive rates and false negative rates between 2012 and 2015 for each county. As the figure shows, most counties have dots around the 45-degree line indicating very similar classification error rates. There are a few exceptions to this finding. For example, the false positive rate for Hamilton County changed from around 8% in 2012 to closer to 4% in 2015. Also, the false negative rate for Perry County changed from around 14% in 2012 to 7.6% in 2015.

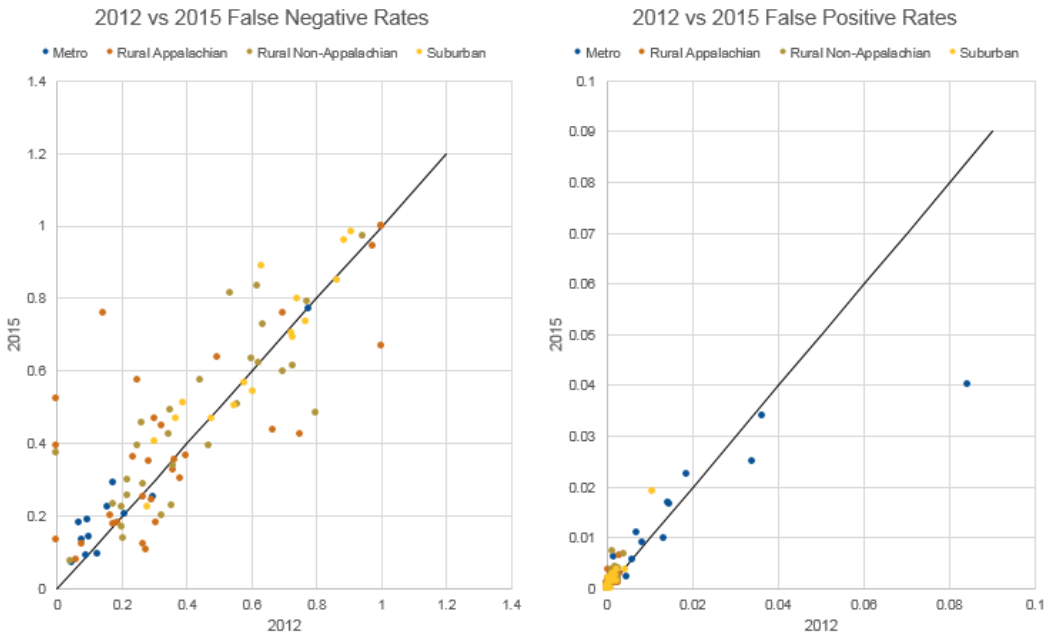

Figure 6: Comparison of 2012 and 2015 False Negative and False Positive Rates

4.2.3 Final Distribution of Completed Interviews

Figure 7 presents a comparison of the actual number of completed interviews in each strata to the desired number of completed interviews. As can be seen, the distribution tracks fairly closely with the 45-degree line. In fact, in 55% of strata, we achieved or exceeded our desired number of interviews. As the breakout of strata with a target less than 600 interviews in ***Figure 7*** shows, 40 counties fall short of their target and the majority of those counties are still very close to their desired goal – 20 of these counties where between 80-99% of target.

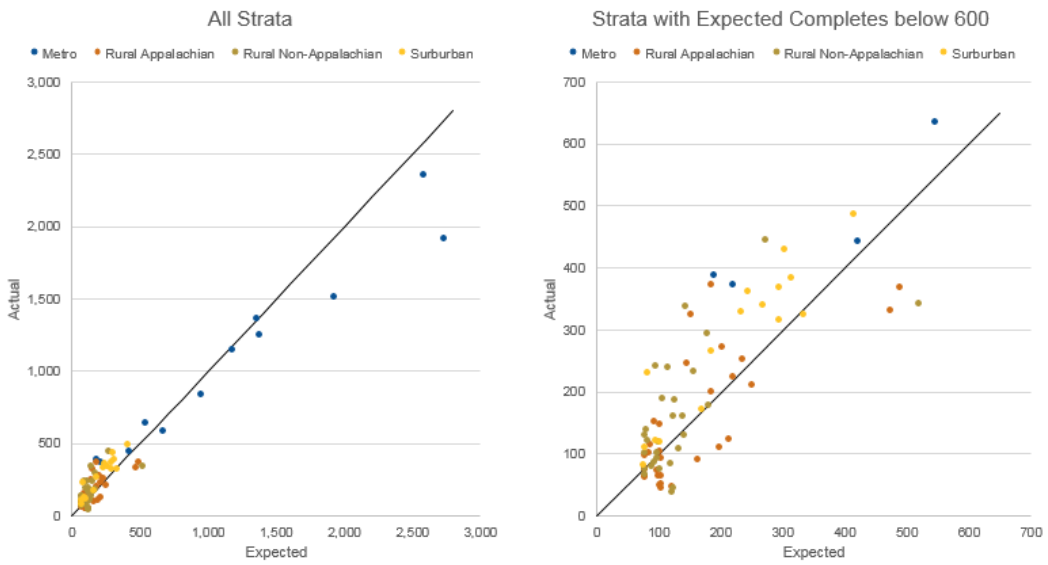

Figure 7: Actual number of completed interviews verses desired number of completed interviews for all strata and strata with expected number of 400 or less in OMAS 2015

4.2.4 Accuracy of Proposed Method Relative to Alternative Methods

In order to assess the accuracy of the Rate Center Plus method, we compare it to two alternative methods that survey designers might employ. The alternative methods are:

- *Simple random sample (SRS)*. This method draws a simple random sample of phone numbers from the state without taking rate center into account. In expectation, this sample should be proportionately allocated across the cellphone 1000-banks in the state. This is the approach used in the 2012 OMAS.
- *Naïve Rate Center*. This method treats rate center county as an error-free proxy for the actual county. As such, the exact sample size desired in a county is selected from each rate center.

The comparison compared, for each county, the absolute difference between the targeted number of interviews and the estimated or actual number of interviews. The targeted number of interviews was based on a quasi-proportional allocation that set a minimum floor of 45 interviews in each county (Berzofsky, et. al., in press). The estimated number of completed interviews for the SRS and Naïve Rate Center methods was simulated based on the known distributions of the cellphone 1000-banks[2] and 2012 probability matrix[3], respectively.

Figure 8 presents the comparison of the three methods to the targeted number of interviews in each county by county type. Overall, the Rate Center Plus method had the smallest absolute difference in 35 of the 88 counties; the SRS approach had the smallest absolute difference in 36 counties; and the Naïve Rate Center approach

[2] The SRS method was assumed to be proportional across 1000-banks. The actual county assigned to each number sampled was determined based on 2015 probability matrix from the rate center the 1000-bank is assigned.

[3] Using the 2012 matrix, a number selected from a rate center was randomly assigned an actual county based on the probability of being in that county given the rate center county assignment

had the smallest absolute difference in 17 counties. However, as shown ***Table 3***, the average absolute difference between the target number of interviews and the actual number was smallest for the Rate Center Plus method – average absolute difference of 75 for the Rate Center Plus compared to 99 and 96 for the SRS and Naïve Rate Center methods, respectively. In addition, the Rate Center Plus method had the smallest absolute difference in all county types except rural non-Appalachia. Moreover, the Rate Center Plus method was either the most accurate or tied for the most accurate in all county types except rural non-Appalachia.

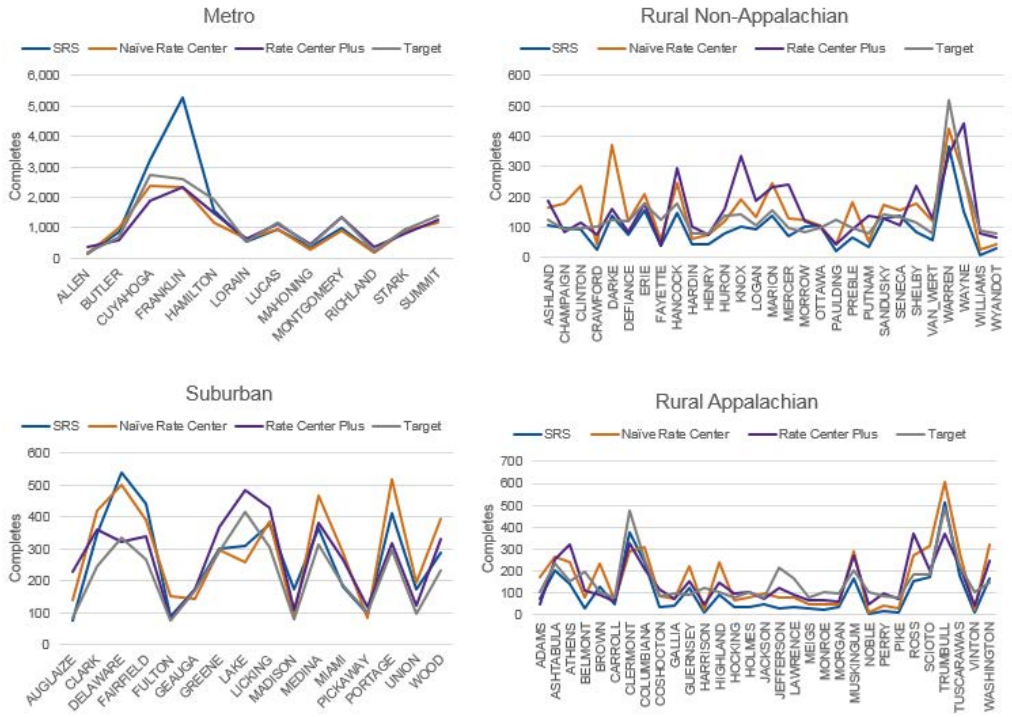

Figure 8: Comparison of the three methods to the targeted number of interviews in each county by county type

Table 3: Number of Counties with Smallest Absolute Difference and Average Absolute Difference between Targeted Number of Interviews in a County and Number of Completes by Allocation Method

	Simple Random Sample		Naïve Rate Center		Rate Center Plus	
	Number Smallest Difference	Average Absolute Difference	Number Smallest Difference	Average Absolute Difference	Number Smallest Difference	Average Absolute Difference
Metro	5	381	2	241	5	193
Rural Appalachian	10	59	4	78	17	54
Rural non-Appalachian	14	42	9	54	6	58
Suburban	7	68	2	101	7	59
Total	36	99	17	96	35	75

5. Conclusions

This paper proposes the Rate Center Plus method – a sample allocation method for cellphone samples that stratify below the state level. For periodic surveys that have been previously conducted, such as with the OMAS, this paper shows how prior cellphone results can be used to estimate the classification error rates and probability matrix for the implementation of the method.

The Rate Center Plus method can also be used with surveys that have moved to a continuous data collection method, such as the California Health Interview Survey (see, e.g., California Health Interview Survey, 2014). In this case, initial periods where a simple random samples from the state or area of interest can be used to gather information about the classification error rates.

Our application to the 2015 OMAS showed that the method does successfully allocate sample across rate center strata to obtain the desired number of interviews in the actual strata. Moreover, compared to the two logical alternative designs – SRS and Naïve Rate Center – the Rate Center Plus method is more consistently accurate. Furthermore, the estimated classification errors were based on about 5,000 interviews from the 2012 survey. These estimates proved to be pretty stable when compared to a sample of 26,000 cases in 2015. From this we recommend that surveys that want to utilize this approach only need a sample around 60 per strata to make useable estimates of the classification errors. For future iterations of the OMAS we will be able to use the 26,000 cellphone respondents from 2015 to develop the probability matrix. This will improve the probability matrix developed because the need to collapse counties will no longer be necessary.

References

Berzofsky, M. E., Weston, D., Lu, B., Peterson, K. C., Blanton, C. W., & Sahr, T. (in press). *Considerations for the use of small area analysis in survey analysis for health policy: Example from the 2015 Ohio Medicaid Assessment Survey*. Proceedings for the 70th Association of American Public Opinion Research Conference, Hollywood, FL.

Blumberg, S.J., Ganesh, N., Luke, J.V., Gonzales, G. (2013). *Wireless Substitution: State-level Estimates from the National Health Interview Survey, 2012. National Health Statistics Report, Number 70*. Retrieved from http://www.cdc.gov/ nchs/data/nhsr/nhsr070.pdf on May 1, 2015.

California Health Interview Survey. *CHIS 2011-2012 Methodology Series: Report 1 - Sample Design*. Los Angeles, CA: UCLA Center for Health Policy Research, 2014.

Kafka, S.M., Chattopadhyay, M., Chan, A. (2015). *Cellphone Sampling at the State Level: Geographic Accuracy and Coverage Concerns*. Presented at the 70th Association of American Public Opinion Research Conference, Hollywood, FL.

Lu, B., Berzofsky, M. E., Sahr, T., Ferketich, A., Blanton, C. W., & Tumin, R. (2014, May). *Capturing minority populations in telephone surveys: Experiences from the Ohio Medicaid Assessment Survey series*. Poster presented at 69th Annual American Association for Public Opinion Research Conference, Anaheim, CA.

Ohio Medicaid Assessment Survey (2012). 2012 Ohio Medicaid Assessment Survey: Sample Design and Methodology. Retrieved from https://osuwmcdigital.osu.edu/sitetool/sites/omaspublic/documents/2012_OMAS_SampleDesignMethodolgy_Final.pdf

Peytchev, A., & Neely, B. (2013). RDD telephone surveys toward a single-frame cell-phone design. *Public Opinion Quarterly, 77*(1), 283-304. doi:10.1093/Poq/Nft003.