# 2022 ACS Analysis using Ratio Estimators

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### Introduction

The following packages in R (R Core Team (2023)) were used in the data analysis process: tidyverse (Wickham et al. (2023b)), dplyr (Wickham, François, et al. (2023)), knitr (Xie (2021)), readr (Wickham, Hester, and Bryan (2024)), and ggplot2 (Wickham et al. (2023a)).

Instructions of how to obtain the data

- 1. Create a user/log into IPUMS account
- 2. Navigate to IPUMS USA site
- 3. Create a custom data set by clicking on the "Get Data" button
- 4. Select samples for only ACS 2022 and submit sample selection from (Ruggles et al. 2021)
- 5. Under select harmonized variables select 'geographic' from the 'household' dropdown menu
  - 1. Select the 'STATEICP' variable
- 6. Under select harmonized variables select 'demographic' from the 'person' dropdown menu
  - 1. Select the 'SEX' variable
- 7. Under select harmonized variables select 'education' from the 'person' dropdown menu
  - 1. Section the 'EDUC' variable
- 8. Click view cart and create data extract
- 9. Set up data format to be .csv and submit extract
- 10. Wait for data to be processed for download
- 11. Download the .csv when the status of the data is completed
- 12. Read the datafile once downloaded using the read\_csv() function in R from the readr package

## **Ratio Estimators Approach**

Ratio estimator is a statistical method used to estimate a total population by looking at the ratio between two related variables in a sample, since it is difficult to measure the entire population directly. By finding the ratio of a specific characteristic to the total sample size, this ratio can then be applied to estimate the full population based on available sample data.

In our case, we aim to estimate the total number of respondents in each state using the ratio estimator approach, based on the number of individuals with doctoral degrees (EDUCD) in California. Since we know that California has a total of 391,171 respondents across all education levels and the number of respondents with doctoral degrees, we can calculate the ratio of doctoral degree holders to the total population in California. Assuming this ratio is similar across other states, we can then use it to estimate the total number of respondents in each state. This is done by dividing the number of doctoral degree holders in each state by the ratio calculated for California, giving an estimate of the total population of respondents for each state.

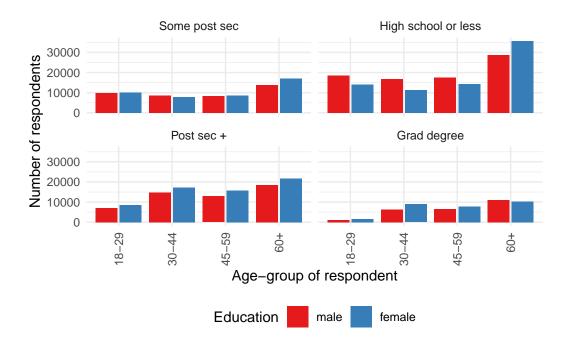


Figure 1: Number of Respondents Based on Education Level and Age

In Table 1 , the estimate is significantly greatly then the actual count of number of respondents with doctoral degrees. This is likely because we assumed that the ratio for California is similar to the ratio for other states.

Table 1: Difference Estimate vs Actual Number of Respondants per State

maine         19         7992         1860         6133           massachusetts         303         127446         9056         118396           new hampshire         38         15983         1774         14206           rhode island         32         13460         1321         12136           vermont         25         10515         884         963           delaware         20         8412         1184         722           new jersey         215         90432         11263         7916           new york         385         161936         25282         13665-           pemsylvania         227         95479         16317         7916-           illinois         214         90011         15548         7446-           indiana         95         39958         8403         3155-           inidiana         95         39958         8403         3155-           michigan         151         63513         12418         5109-           ohio         199         83702         14646         6905-           wisconsin         86         36173         7571         2860-           iowa	stateicp	$doctoral\_count$	$estimated\_total$	actual_count	difference
massachusetts         303         127446         9056         118396           new hampshire         38         15983         1774         14208           rhode island         32         13460         1321         1213           vermont         25         10515         884         963           delaware         20         8412         1184         722           new jersey         215         90432         11263         79163           new york         385         161936         25282         13665-           pennsylvania         227         95479         16317         79163           illinois         214         90011         15548         74463           indiana         95         39958         8403         3155           michigan         151         63513         12418         51093           ohio         199         83702         14646         69050           wisconsin         86         36173         7571         28600           iowa         45         18928         4028         14900           kansas         46         19348         3496         15855           mininesota	connecticut	88	37014	4610	32404
new hampshire rhode island	maine	19	7992	1860	6132
rhode island 32 13460 1321 12132 vermont 25 10515 884 9633 delaware 20 8412 1184 7222 new jersey 215 90432 11263 79163 new york 385 161936 25282 13665- pennsylvania 227 95479 16317 79163 illinois 214 90011 15548 74463 indiana 95 39958 8403 31555 michigan 151 63513 12418 51099 83702 14646 69050 nichigan 151 63513 7571 28603 iowa 45 18928 4028 14900 kansas 46 19348 3496 15855 minnesota 73 30705 7066 23633 missouri 87 36593 7795 28799 north dakota 13 5468 962 4500 south dakota 13 5468 1074 4399 virginia 232 97582 10842 86740 alabama 73 30705 6404 24300 georgia 210 88329 13118 75213 louisiana 68 28602 5474 23129 mississippi 32 13460 3583 9875 north carolina 206 86646 13370 73276 south carolina 103 43323 6704 36618 kentucky 68 28602 5581 2302 maryland 241 101368 7503 93866 south maryland 241 101368 7503 93866 south maryland 241 101368 7503 93866 south carolina 206 86802 5581 2302 maryland	massachusetts	303	127446	9056	118390
vermont         25         10515         884         963           delaware         20         8412         1184         722           new jersey         215         90432         11263         79163           new york         385         161936         25282         13665-           pennsylvania         227         95479         16317         79163           illinois         214         90011         15548         74463           indiana         95         39958         8403         31553           michigan         151         63513         12418         51093           ohio         199         83702         14646         69050           wisconsin         86         36173         7571         28603           iowa         45         18928         4028         14906           kansas         46         19348         3496         15853           minnesota         73         30705         7066         2363           missouri         87         36593         7795         2879           nebraska         27         11357         2381         897           north dakota <t< td=""><td>new hampshire</td><td>38</td><td>15983</td><td>1774</td><td>14209</td></t<>	new hampshire	38	15983	1774	14209
delaware         20         8412         1184         7228           new jersey         215         90432         11263         79163           new york         385         161936         25282         13665           pennsylvania         227         95479         16317         7916           illinois         214         90011         15548         7446           indiana         95         39958         8403         3155           michigan         151         63513         12418         51093           ohio         199         83702         14646         69056           wisconsin         86         36173         7571         2860           iowa         45         18928         4028         1490           kansas         46         19348         3496         1585           minnesota         73         30705         7066         2363           missouri         87         36593         7795         2879           nebraska         27         11357         2381         897c           north dakota         13         5468         962         450c           south dakota <t< td=""><td>rhode island</td><td>32</td><td>13460</td><td>1321</td><td>12139</td></t<>	rhode island	32	13460	1321	12139
new jersey         215         90432         11263         79163           new york         385         161936         25282         13665           pennsylvania         227         95479         16317         79163           illinois         214         90011         15548         74463           indiana         95         39958         8403         31553           michigan         151         63513         12418         51090           ohio         199         83702         14646         69050           wisconsin         86         36173         7571         28603           iowa         45         18928         4028         14900           kansas         46         19348         3496         15853           minnesota         73         30705         7066         23633           missouri         87         36593         7795         28799           nebraska         27         11357         2381         897           north dakota         13         5468         962         4500           virginia         232         97582         10842         86740           alabama	vermont	25	10515	884	9631
new york         385         161936         25282         136656           pennsylvania         227         95479         16317         79167           illinois         214         90011         15548         74463           indiana         95         39958         8403         31557           michigan         151         63513         12418         51099           ohio         199         83702         14646         69056           wisconsin         86         36173         7571         28600           iowa         45         18928         4028         14900           kansas         46         19348         3496         15855           minnesota         73         30705         7066         23633           missouri         87         36593         7795         2879           nebraska         27         11357         2381         897           north dakota         13         5468         962         4500           south dakota         13         5468         1074         4394           virginia         232         97582         10842         86740           alabama	delaware	20	8412	1184	7228
pennsylvania         227         95479         16317         79160           illinois         214         90011         15548         74460           indiana         95         39958         8403         31550           michigan         151         63513         12418         51090           ohio         199         83702         14646         69050           wisconsin         86         36173         7571         28600           iowa         45         18928         4028         14900           kansas         46         19348         3496         15850           minnesota         73         30705         7066         23633           missouri         87         36593         7795         2879           nebraska         27         11357         2381         897           north dakota         13         5468         962         4500           south dakota         13         5468         1074         4394           virginia         232         97582         10842         86740           alabama         73         30705         6404         24300           arkansas <t< td=""><td>new jersey</td><td>215</td><td>90432</td><td>11263</td><td>79169</td></t<>	new jersey	215	90432	11263	79169
illinois	new york	385	161936	25282	136654
indiana         95         39958         8403         31555           michigan         151         63513         12418         51093           ohio         199         83702         14646         69056           wisconsin         86         36173         7571         28602           iowa         45         18928         4028         14906           kansas         46         19348         3496         15855           minnesota         73         30705         7066         23633           missouri         87         36593         7795         28793           nebraska         27         11357         2381         8976           north dakota         13         5468         962         4506           south dakota         13         5468         1074         4394           virginia         232         97582         10842         86746           alabama         73         30705         6404         24300           arkansas         41         17245         3708         13537           florida         434         182546         27447         15509           georgia         210	pennsylvania	227	95479	16317	79162
michigan         151         63513         12418         51099           ohio         199         83702         14646         69056           wisconsin         86         36173         7571         28602           iowa         45         18928         4028         14900           kansas         46         19348         3496         1585           minnesota         73         30705         7066         2363           missouri         87         36593         7795         2879           nebraska         27         11357         2381         8970           north dakota         13         5468         962         4500           south dakota         13         5468         1074         4399           virginia         232         97582         10842         86740           alabama         73         30705         6404         24300           arkansas         41         17245         3708         1353           florida         434         182546         27447         15509           georgia         210         88329         13118         75212           louisiana         68<	illinois	214	90011	15548	74463
ohio         199         83702         14646         69056           wisconsin         86         36173         7571         28602           iowa         45         18928         4028         14900           kansas         46         19348         3496         15852           minnesota         73         30705         7066         23633           missouri         87         36593         7795         28792           nebraska         27         11357         2381         8970           north dakota         13         5468         962         4500           south dakota         13         5468         1074         4394           virginia         232         97582         10842         86740           alabama         73         30705         6404         2430           arkansas         41         17245         3708         1353           florida         434         182546         27447         15509           georgia         210         88329         13118         7521           louisiana         68         28602         5474         23126           mississippi         3	indiana	95	39958	8403	31555
wisconsin         86         36173         7571         28600           iowa         45         18928         4028         14900           kansas         46         19348         3496         15850           minnesota         73         30705         7066         23633           missouri         87         36593         7795         28790           nebraska         27         11357         2381         8970           north dakota         13         5468         962         4500           south dakota         13         5468         1074         4394           virginia         232         97582         10842         86740           alabama         73         30705         6404         24300           arkansas         41         17245         3708         1353           florida         434         182546         27447         15509           georgia         210         88329         13118         7521           louisiana         68         28602         5474         23126           mississisppi         32         13460         3583         987           north carolina	michigan	151	63513	12418	51095
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kansas       46       19348       3496       1585         minnesota       73       30705       7066       2363         missouri       87       36593       7795       2879         nebraska       27       11357       2381       8976         north dakota       13       5468       962       4506         south dakota       13       5468       1074       4394         virginia       232       97582       10842       86740         alabama       73       30705       6404       2430         arkansas       41       17245       3708       1353         florida       434       182546       27447       15509         georgia       210       88329       13118       7521         louisiana       68       28602       5474       23128         mississisppi       32       13460       3583       987         south carolina       206       86646       13370       73270         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68 <td>wisconsin</td> <td>86</td> <td>36173</td> <td>7571</td> <td>28602</td>	wisconsin	86	36173	7571	28602
minnesota     73     30705     7066     23633       missouri     87     36593     7795     28793       nebraska     27     11357     2381     8976       north dakota     13     5468     962     4500       south dakota     13     5468     1074     4394       virginia     232     97582     10842     86740       alabama     73     30705     6404     24300       arkansas     41     17245     3708     13530       florida     434     182546     27447     15509       georgia     210     88329     13118     7521       louisiana     68     28602     5474     23128       mississippi     32     13460     3583     987       north carolina     206     86646     13370     73270       south carolina     103     43323     6704     36619       texas     487     204839     34990     169849       kentucky     68     28602     5581     2302       maryland     241     101368     7503     93861	iowa	45	18928	4028	14900
missouri         87         36593         7795         28798           nebraska         27         11357         2381         8976           north dakota         13         5468         962         4506           south dakota         13         5468         1074         4394           virginia         232         97582         10842         86746           alabama         73         30705         6404         2430           arkansas         41         17245         3708         1353           florida         434         182546         27447         155099           georgia         210         88329         13118         75213           louisiana         68         28602         5474         23128           mississisppi         32         13460         3583         987           north carolina         206         8646         13370         73276           south carolina         103         43323         6704         36619           texas         487         204839         34990         169849           kentucky         68         28602         5581         2302           maryla	kansas	46	19348	3496	15852
nebraska     27     11357     2381     8970       north dakota     13     5468     962     4500       south dakota     13     5468     1074     4394       virginia     232     97582     10842     86740       alabama     73     30705     6404     24300       arkansas     41     17245     3708     13530       florida     434     182546     27447     15509       georgia     210     88329     13118     75210       louisiana     68     28602     5474     23128       mississippi     32     13460     3583     9870       north carolina     206     86646     13370     73270       south carolina     103     43323     6704     36619       texas     487     204839     34990     169849       kentucky     68     28602     5581     23020       maryland     241     101368     7503     93861	minnesota	73	30705	7066	23639
north dakota       13       5468       962       4500         south dakota       13       5468       1074       4394         virginia       232       97582       10842       86740         alabama       73       30705       6404       24301         arkansas       41       17245       3708       13537         florida       434       182546       27447       155099         georgia       210       88329       13118       75213         louisiana       68       28602       5474       23128         mississippi       32       13460       3583       9877         north carolina       206       86646       13370       73276         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23025         maryland       241       101368       7503       93866	missouri	87	36593	7795	28798
south dakota       13       5468       1074       4394         virginia       232       97582       10842       86746         alabama       73       30705       6404       2430         arkansas       41       17245       3708       1353         florida       434       182546       27447       155099         georgia       210       88329       13118       75213         louisiana       68       28602       5474       23128         mississippi       32       13460       3583       987         north carolina       206       86646       13370       73276         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23025         maryland       241       101368       7503       93868	nebraska	27	11357	2381	8976
virginia       232       97582       10842       86740         alabama       73       30705       6404       24302         arkansas       41       17245       3708       13533         florida       434       182546       27447       155099         georgia       210       88329       13118       75213         louisiana       68       28602       5474       23128         mississippi       32       13460       3583       9873         north carolina       206       86646       13370       73276         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23025         maryland       241       101368       7503       93868	north dakota	13	5468	962	4506
alabama       73       30705       6404       24305         arkansas       41       17245       3708       13535         florida       434       182546       27447       155099         georgia       210       88329       13118       75215         louisiana       68       28602       5474       23128         mississisippi       32       13460       3583       9877         north carolina       206       86646       13370       73276         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23025         maryland       241       101368       7503       93868	south dakota	13	5468	1074	4394
arkansas 41 17245 3708 1353′ florida 434 182546 27447 155099 georgia 210 88329 13118 7521.5 louisiana 68 28602 5474 23128 mississippi 32 13460 3583 987′ north carolina 206 86646 13370 73276 south carolina 103 43323 6704 36619 texas 487 204839 34990 169849 kentucky 68 28602 5581 23025 maryland 241 101368 7503 93868	virginia	232	97582	10842	86740
florida 434 182546 27447 155099 georgia 210 88329 13118 75213 louisiana 68 28602 5474 23128 mississippi 32 13460 3583 9877 north carolina 206 86646 13370 73276 south carolina 103 43323 6704 36619 texas 487 204839 34990 169849 kentucky 68 28602 5581 23023 maryland 241 101368 7503 93863	alabama	73	30705	6404	24301
georgia       210       88329       13118       75213         louisiana       68       28602       5474       23128         mississippi       32       13460       3583       9873         north carolina       206       86646       13370       73276         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23023         maryland       241       101368       7503       93868	arkansas	41	17245	3708	13537
louisiana 68 28602 5474 23128 mississippi 32 13460 3583 9877 north carolina 206 86646 13370 73276 south carolina 103 43323 6704 36618 texas 487 204839 34990 169849 kentucky 68 28602 5581 23027 maryland 241 101368 7503 93868	florida	434	182546	27447	155099
mississippi     32     13460     3583     9877       north carolina     206     86646     13370     73276       south carolina     103     43323     6704     36619       texas     487     204839     34990     169849       kentucky     68     28602     5581     23027       maryland     241     101368     7503     93869	georgia	210	88329	13118	75211
north carolina       206       86646       13370       73276         south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23023         maryland       241       101368       7503       93869	louisiana	68	28602	5474	23128
south carolina       103       43323       6704       36619         texas       487       204839       34990       169849         kentucky       68       28602       5581       23027         maryland       241       101368       7503       93869	mississippi	32	13460	3583	9877
texas 487 204839 34990 169849 kentucky 68 28602 5581 23027 maryland 241 101368 7503 93869	north carolina	206	86646	13370	73276
kentucky 68 28602 5581 23027 maryland 241 101368 7503 93868	south carolina	103	43323	6704	36619
maryland 241 101368 7503 93868	texas	487	204839	34990	169849
U .	kentucky	68	28602	5581	23021
oklahoma 46 19348 4622 14726	maryland	241	101368	7503	93865
	oklahoma	46	19348	4622	14726

Table 1: Difference Estimate vs Actual Number of Respondants per State

stateicp	$doctoral\_count$	$estimated\_total$	$actual\_count$	difference
tennessee	119	50053	8829	41224
west virginia	18	7571	2229	5342
arizona	137	57624	9004	48620
colorado	160	67298	7299	59999
idaho	32	13460	2301	11159
montana	16	6730	1316	5414
nevada	46	19348	3669	15679
new mexico	55	23134	2456	20678
utah	66	27761	3886	23875
wyoming	13	5468	718	4750
california	930	391171	47881	343290
oregon	93	39117	5410	33707
washington	190	79917	9940	69977
alaska	6	2524	786	1738
hawaii	35	14721	1838	12883
district of columbia	55	23134	899	22235

## Difference in estimate vs actual number of respondents

#### 1. Sampling variability

The ratio estimator is based on the assumption that the ratio of doctoral degree holders to the total respondents in California applies to all other states. However, the true ratio may differ from state to state due to differences in educational attainment across regions. Some states might have a higher or lower proportion of doctoral degree holders compared to California, leading to inaccuracies when applying the California ratio to other states.

#### 2. Non-uniform education attainment

Educational attainment, including the proportion of respondents with doctoral degrees, is not uniform across the U.S. Factors such as state demographics, local economies, and educational infrastructure affect the number of people with higher degrees. States with large research universities (e.g., Massachusetts) may have more doctoral degree holders, whereas others may have fewer.

#### 3. Survey non-response

Not all selected participants respond to the ACS survey. If the non-response rate is high and if those who don't respond differ systematically from those who do (for instance, in their level of education), the actual total counts could deviate from the estimates. The ratio estimator does not account for non-response bias.

## Reference

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