

# What's black and white and sheds all over? The Python Pandas DataFrame, the Open-Source Data Structure Supplanting the SAS® Data Set

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## ABSTRACT

Python is a general-purpose, object-oriented programming (OOP) language, consistently rated among the most popular and widely utilized languages, owing to powerful processing, user-friendly syntax, and an unparalleled, abundant open-source community of developers. The Pandas library, a freely downloadable resource, extends Python functionality, and has become the predominant Python analytic toolkit. The Pandas DataFrame is the primary Pandas data structure, akin to the SAS® data set in the SAS ecosystem. Just as SAS built-in procedures, functions, subroutines, and statements manipulate and interact with SAS data sets to transform data and to deliver business value, so, too, do Python and Pandas methods, functions, and statements deliver similar functionality. And what's more, Python does it for free!!! This text demonstrates basic data manipulation and analysis performed on US Census and Centers for Disease Control and Prevention (CDC) data, providing functionally equivalent SAS (9.4M7) and Python (3.10.5) syntax, with the goal of introducing SAS practitioners to open-source alternatives. Discover the fattest counties and states in the US, and do so while learning Python Pandas!

## SETUP

A primary folder should be established, in which SAS and Python programs will reside, and in which subfolders can be created—these examples use the following:

```
c:\shedder\
```

Create subordinate folders for Census and CDC:

```
c:\shedder\Census\  
c:\shedder\CDC\  
c:\shedder\tables\
```

This location can be initialized to a SAS macro variable:

```
%let path_base=c:\shedder\  
%let path_census=&path_base.census\  
%let path_cdc=&path_base.cdc\;
```

Within Python, two libraries are imported—`os`, which contains operating system information and functionality, and `pandas`, which defines the Pandas library. By convention, Pandas is imported using the alias `pd`:

```
import os  
import pandas as pd  
import csv
```

At this point, save your python program to the primary folder; the filename does not matter, but it must be saved so that the `cwd` method can evaluate the “current working directory” (i.e., where the file is saved):

```
c:\shedder\my_little_python.py
```

Global variables are initialized to the following folder locations, and are equivalent to SAS global macro variables:

```
path_base=os.getcwd()  
path_census=os.path.join(path_base, 'census')  
path_cdc=os.path.join(path_base, 'CDC')
```

The first thing to note is that Python is a case-sensitive language, unlike Base SAS, so CWD is not the same as cwd. Also note that Python statements are not terminated with those pesky semicolons. Finally, comments in Python are prefaced by octothorps rather than asterisks (i.e., # not \*).

The following files should be downloaded:

- From the US Census (<https://www2.census.gov/programs-surveys/popest/datasets/2020-2021/counties/totals/>), download the CSV file (co-est2021-alldata.csv) to the Census folder.
- From the US Census (<https://www2.census.gov/programs-surveys/popest/datasets/2020-2021/state/totals/>), download CSV file (NST-EST2021-alldata.csv) to the Census folder.
- From the US Census (<https://www2.census.gov/programs-surveys/popest/geographies/2017/all-geocodes-v2017.xlsx>), download the XLSX workbook to the Census folder; subsequently save this workbook as a CSV file: all-geocodes-v2017.csv.
- CDC obesity data are downloaded in a subsequent section.

## INGESTING NATIONAL, STATE, AND COUNTY POPULATION DATA

National- and state-level population estimates for 2021 are maintained within NST-EST2021-alldata.csv, as demonstrated in Table 1.

	A	B	C	D	E	F	G	H
1	SUMLEV	REGION	DIVISION	STATE	NAME	ESTIMATESBASE2020	POPESTIMATE2020	POPESTIMATE2021
2	10	0	0	0	United States	331449281	331501080	331893745
3	20	1	0	0	Northeast Region	57609148	57525633	57159838
4	20	2	0	0	Midwest Region	68985454	68935174	68841444
5	20	3	0	0	South Region	126266107	126409007	127225329
6	20	4	0	0	West Region	78588572	78631266	78667134
7	40	3	6	1	Alabama	5024279	5024803	5039877
8	40	4	9	2	Alaska	733391	732441	732673

**Table 1. National- and State-Level Population Estimates for 2021**

Similarly, county-level population estimates for 2021 are maintained within co-est2021-alldata.csv, as demonstrated in Table 2.

	A	B	C	D	E	F	G	H	I	J
1	SUMLEV	REGION	DIVISION	STATE	COUNTY	STNAME	CTYNAME	ESTIMATESBASE2020	POPESTIMATE2020	POPESTIMATE2021
2	40	3	6	1	0	Alabama	Alabama	5024279	5024803	5039877
3	50	3	6	1	1	Alabama	Autauga County	58805	58877	59095
4	50	3	6	1	3	Alabama	Baldwin County	231767	233140	239294
5	50	3	6	1	5	Alabama	Barbour County	25223	25180	24964
6	50	3	6	1	7	Alabama	Bibb County	22293	22223	22477

**Table 2. County-Level Population Estimates for 2021**

Three data sets will be created, representing national-, state-, and county-level population data:

- df\_pop\_us
- df\_pop\_states
- df\_pop\_counties

Note that regional-level data are not utilized in these analyses, so these observations will be deleted.

## INGESTING POPULATION USING SAS

PROC IMPORT fails to ingest the data because it incorrectly interprets FIPS values (many of which contain leading zeros) as numeric data, so DATA steps must be created that explicitly specify FIPS codes are character data type. This is not uncommon, and is similarly required when importing FIPS into Python.

DF\_pop\_us\_temp is a temporary data set that is used as an intermediate step to create both DF\_pop\_us and DF\_pop\_states:

```

data df_pop_us_temp (rename=(state=FIPS_state popestimate2021=population));
infile "&path_census.NST-EST2021-alldata.csv" delimiter=',' dsd firstobs=2;
length sumlev $2 region $1 division $1 state $2 name $50 estimatebase2020 8
popestimate2020 8 popestimate2021 8;
input sumlev $ region $ division $ state $ name $ estimatebase2020
popestimate2020 popestimate2021;
run;

```

Thereafter, three successive DATA steps create DF\_pop\_us, DF\_pop\_states, and DF\_pop\_counties:

```

data df_pop_us (keep=FIPS_state population pop_mil);
set df_pop_us_temp;
where name='United States';
length pop_mil 8;
pop_mil = pop / 1000000;
run;

data df_pop_states (keep=FIPS_state population pop_mil);
set df_pop_us_temp;
where FIPS_state^='00';
length pop_mil 8;
pop_mil = population / 1000000;
run;

data df_pop_counties (rename=(state=FIPS_state county=FIPS_county
popestimate2021=population) keep=state county popestimate2021 pop_mil);
infile "&path_census.co-est2021-alldata.csv" delimiter=',' dsd firstobs=2;
length sumlev $2 region $1 division $1 state $2 county $5 stname $50 ctyname $50
estimatebase2020 8 popestimate2020 8 popestimate2021 8;
input sumlev $ region $ division $ state $ county $ stname $ ctyname $
estimatebase2020 popestimate2020 popestimate2021;
if county^='000';
length pop_mil 8;
pop_mil = popestimate2021 / 1000000;
county=state || county;
run;

```

Presto! The data sets have been created.

## INGESTING POPULATION USING PYTHON

The equivalent Python steps follow, in which the create\_df\_pop\_us, create\_df\_pop\_states, and create\_df\_pop\_counties functions instantiate three DataFrames:

```

# create dataframe with national population
def create_df_pop_us(fil):
    global df_pop_us
    df_pop_us = pd.read_csv(
        os.path.join(path_census, fil), header = 0, sep = ',', quotechar = '"',
        index_col = False, dtype = {'STATE': str, 'POPESTIMATE2021': float, 'NAME':
str},
        usecols = ['STATE', 'POPESTIMATE2021', 'NAME'])
    df_pop_us.rename(columns = {'STATE': 'fips_state', 'POPESTIMATE2021':
'population'}, inplace=True)
    df_pop_us['pop_mil'] = df_pop_us['population']/1000000
    df_pop_us = df_pop_us.loc[df_pop_us['NAME'] == 'United States']
    # remove FIPS 00 which is the entire US
    df_pop_us.drop(columns=['NAME'], inplace=True)

# create dataframe with state populations
def create_df_pop_states(fil):
    global df_pop_states
    df_pop_states = pd.read_csv(
        os.path.join(path_census, fil), header = 0, sep = ',', quotechar = '"',

```

```

        index_col = False, dtype = {'STATE': str, 'POPESTIMATE2021': float},
        usecols = ['STATE', 'POPESTIMATE2021'])
    df_pop_states.rename(columns = {'STATE': 'fips_state', 'POPESTIMATE2021':
'population'}, inplace=True)
    df_pop_states['pop_mil'] = df_pop_states['population']/1000000
    # remove FIPS 00 which is the entire US
    df_pop_states = df_pop_states.loc[df_pop_states['fips_state'] != '00']

# create dataframe with county populations
def create_df_pop_counties(fil):
    global df_pop_counties
    df_pop_counties = pd.read_csv(
        os.path.join(path_census, fil), header = 0, sep = ',', quotechar = '',
        encoding = 'utf-8', encoding_errors = 'ignore',
        index_col = False, dtype = {'STATE': str, 'COUNTY': str, 'POPESTIMATE2021':
float},
        usecols = ['STATE', 'COUNTY', 'POPESTIMATE2021'])
    df_pop_counties.rename(columns = {'STATE': 'fips_state', 'COUNTY':
'fips_county_temp',
                                'POPESTIMATE2021': 'population'},
inplace=True)
    df_pop_counties['pop_mil'] = df_pop_counties['population']/1000000
    df_pop_counties['fips_county'] = df_pop_counties['fips_state'] +
df_pop_counties['fips_county_temp']
    # remove FIPS 000 which is the entire state
    df_pop_counties = df_pop_counties.loc[df_pop_counties['fips_county_temp'] !=
'000']
    df_pop_counties.drop(columns=['fips_county_temp'], inplace=True)

create_df_pop_us(r'NST-EST2021-alldata.csv')

create_df_pop_states(r'NST-EST2021-alldata.csv')

create_df_pop_counties(r'co-est2021-alldata.csv')

```

Looking more closely at the `create_df_pop_counties` function, the `def` statement declares the function, in which a single parameter (`fil`) is declared:

```
def create_df_pop_counties(fil):
```

The `global` statement declares the `df_pop_counties` variable as having global scope, indicating that the variable will be available after function execution:

```
global df_pop_counties
```

The `pd.read_csv` method instantiates `df_pop_counties` as a `DataFrame`, with multiple arguments specifying the manner in which the CSV file should be ingested. For example, the `dtype` argument specifies the data type for each variable, similar to the `LENGTH` statement in SAS:

```
dtype = {'STATE': str, 'COUNTY': str, 'POPESTIMATE2021': float}
```

And the `usecols` argument specifies the variables to retain from the CSV file, similar to the `KEEP` option in SAS:

```
usecols = ['STATE', 'COUNTY', 'POPESTIMATE2021']
```

The `rename` method renames CSV variables, and `inplace=True` designates that the changes should be made in place (i.e., in the `df_pop_counties` `DataFrame`) as opposed to on a copy of the `DataFrame`:

```
df_pop_counties.rename(columns = {'STATE': 'fips_state', 'COUNTY':
'fips_county_temp', 'POPESTIMATE2021': 'population'}, inplace=True)
```

A new column (`fips_county`) in the `DataFrame` is created by overloading the `+` operator; that is, two columns within the `DataFrame` (holding string data) are concatenated to each other:

```
df_pop_counties['fips_county'] = df_pop_counties['fips_state'] +
df_pop_counties['fips_county_temp']
```

Because a county FIPS value of 000 represents the state-level FIPS, all rows for which the `fips_county_temp` is 000 are removed. The `loc` function “slices” the DataFrame to remove the 000 rows:

```
df_pop_counties = df_pop_counties.loc[df_pop_counties['fips_county_temp'] != '000']
```

Finally, the `drop` method drops the `fips_county_temp` column, the original three-character county FIPS code, now that the `fips_county` column has been created that denotes not only the county FIPS but also the state FIPS codes:

```
df_pop_counties.drop(columns=['fips_county_temp'], inplace=True)
```

Three function calls execute the respective functions, and the three DataFrames are created:

```
create_df_pop_us(r'NST-EST2021-alldata.csv')
create_df_pop_states(r'NST-EST2021-alldata.csv')
create_df_pop_counties(r'co-est2021-alldata.csv')
```

The three DataFrames that are created have identical content to the three SAS data sets created in the prior subsection.

## INGESTING STATE AND COUNTY FIPS CODES

State FIPS codes are two-digit numbers that uniquely identify states (and US territories), and by convention, leading zeros are always retained; thus, California corresponds to 06 but not 6. County FIPS codes are three-digit numbers that uniquely identify a county (within a state), but because county codes are repeated across states, identifying counties at the national level requires concatenating the state FIPS and county FIPS codes to yield a five-digit FIPS code.

FIPS codes maintained in `all-geocodes-v2017.csv` are demonstrated in Table 3; note the multiple header rows that must be handled when importing these data.

	A	B	C	D	E	F	G
1	<b>Estimates Geography File: Vintage 2017</b>						
2	Source: U.S. Census Bureau, Population Division						
3	Internet Release Date: May 2018						
4							
	<b>Summary</b>	<b>State Code</b>	<b>County Code</b>	<b>County Subdivision</b>	<b>Place Code</b>	<b>Consolidated City</b>	<b>Area Name (including</b>
5	<b>Level</b>	<b>(FIPS)</b>	<b>(FIPS)</b>	<b>Code (FIPS)</b>	<b>(FIPS)</b>	<b>Code (FIPS)</b>	<b>legal/statistical area description)</b>
6	010	00	000	00000	00000	00000	United States
7	040	01	000	00000	00000	00000	Alabama
8	050	01	001	00000	00000	00000	Autauga County
9	050	01	003	00000	00000	00000	Baldwin County
10	050	01	005	00000	00000	00000	Barbour County
11	050	01	007	00000	00000	00000	Bibb County

**Table 3. FIPS Codes**

FIPS codes are powerful because they overcome the occasional spelling variations or errors that can occur in state or county names—even within federal databases—as demonstrated subsequently. FIPS reliability also means that tables can be more reliably joined by FIPS codes than, for example, state names or county names.

## INGESTING FIPS CODES USING SAS

The following SAS code ingests the FIPS CSV file and creates the `DF_fips` data set:

```
%let fil=all-geocodes-v2017.csv;

data df_fips (drop=summary_level FIPS_state_temp FIPS_county_temp subdiv_code
```

```

        place_code city_code name);
length FIPS_state $2 state $50 county $50 FIPS_county $5;
infile "&path_census&fil" dsd delimiter=',' firstobs=6 end=eof;
length summary_level $3 FIPS_state_temp $2 FIPS_county_temp $5 subdiv_code $5
        place_code $5 city_code $5 name $50;
input summary_level $ FIPS_state_temp $ FIPS_county_temp $ subdiv_code $
        place_code $ city_code $ name $;
retain FIPS_state state;
/* 040 is the FIPS summary code for state-level region */
if summary_level='040' then do;
    FIPS_state=FIPS_state_temp;
    state=name;
end;
/* 010 is the FIPS summary code for the entire US */
else if summary_level^='010' and subdiv_code='00000' and place_code='00000'
        and city_code='00000' and FIPS_state^='72' then do;
    FIPS_county=FIPS_state || FIPS_county_temp;
    county=name;
    output;
end;
run;

```

A user-defined SAS format is both a straightforward and efficient method to map values, and the following code creates the COUNTY\_FIPS\_DICT format that maps five-digit FIPS county codes to their associated county names:

```

data county_fips_dict_temp;
    set df_fips (rename=(FIPS_county=start county=label));
    length fmtname $20 type $1;
    retain fmtname 'county_fips_dict' type 'c';
run;

proc format cntlin=county_fips_dict_temp;
run;

```

Similarly, the following code creates the STATE\_FIPS\_DICT user-defined format that maps the two-digit FIPS state codes to their associated state (or territory) names:

```

proc sort data=df_fips (keep=fips_state state) out=df_fips_temp nodupkey;
    by fips_state;
run;

data state_fips_dict_temp;
    set df_fips_temp (rename=(FIPS_state=start state=label));
    length fmtname $20 type $1;
    retain fmtname 'state_fips_dict' type 'c';
run;

proc format cntlin=state_fips_dict_temp;
run;

```

User-defined formats reside in memory, facilitate faster data transformations, and eliminate the need to join the DF\_fips data set to other data sets via DATA step MERGE statements or SQL procedure JOIN statements.

## INGESTING FIPS CODES USING PYTHON

Python similarly leverages FIPS data to create equivalent dictionary objects that map FIPS codes to both county and state names—but first, a refined CSV file is created, from which the dictionaries can be built:

```

path_tables=os.path.join(path_base,'tables')

def create_fips_table(fil):
    global df_fips

```

```

df = pd.read_csv(
    os.path.join(path_census, fil),
    header=4, sep=',', quotechar='"', index_col=False, encoding='latin1',
    dtype = {'Summary Level': str, 'State Code (FIPS)': str, 'County Code
(FIPS)': str,
            'County Subdivision Code (FIPS)': str,
            'Place Code (FIPS)': str, 'Consolidtated City Code (FIPS)': str,
            'Area Name (including legal/statistical area description)': str},
    usecols = ['Summary Level', 'State Code (FIPS)', 'County Code (FIPS)',
'County Subdivision Code (FIPS)',
            'Place Code (FIPS)', 'Consolidtated City Code (FIPS)',
            'Area Name (including legal/statistical area description)'])
df.rename(columns={'State Code (FIPS)': 'fips_state', 'County Code (FIPS)':
'county_code',
                'County Subdivision Code (FIPS)': 'subdiv', 'Place Code
(FIPS)': 'place',
                'Consolidtated City Code (FIPS)': 'consolidated',
                'Area Name (including legal/statistical area description)':
'name'}, inplace=True)
df_states = df.loc[df['Summary Level'] == '040']
df_states = df_states.rename(columns={'name': 'state'})
df_states.drop(columns=['Summary Level', 'county_code', 'subdiv', 'place'],
inplace=True)
df_counties = df.loc[(df['county_code'] != '000') & (df['subdiv'] == '00000') &
                    (df['place'] == '00000') & (df['consolidated'] ==
'00000'), ['fips_state', 'county_code', 'name']]
df_counties.rename(columns={'name': 'county'}, inplace=True)
df_fips = pd.merge(df_states, df_counties, on='fips_state', how='left')
df_fips['fips_county'] = df_fips['fips_state'] + df_fips['county_code']
df_fips.drop(columns=['county_code', 'consolidated'], inplace=True)
# remove Puerto Rico counties
df_fips = df_fips.loc[df_fips['fips_state'] != '72']
df_fips.to_csv(os.path.join(path_tables, 'FIPS_table.csv'), index=False)

create_fips_table(r'all-geocodes-v2017.csv')

```

Examining the function more closely, the `global` statement declares the `df_fips` variable, which is instantiated as a `DataFrame` by the subsequent `read_csv` method:

```

def create_fips_table(fil):
    global df_fips
    df = pd.read_csv(

```

The `dtype` and `usecols` parameters declare the column data types and columns to keep, respectively:

```

dtype = {'Summary Level': str, 'State Code (FIPS)': str, 'County Code (FIPS)': str,
        'County Subdivision Code (FIPS)': str,
        'Place Code (FIPS)': str, 'Consolidtated City Code (FIPS)': str,
        'Area Name (including legal/statistical area description)': str},
    usecols = ['Summary Level', 'State Code (FIPS)', 'County Code (FIPS)',
'County Subdivision Code (FIPS)',
            'Place Code (FIPS)', 'Consolidtated City Code (FIPS)',
            'Area Name (including legal/statistical area description)']

```

The `rename` method renames columns; although Pandas supports column names with spaces, they are removed here to facilitate readability, as well as to enable “dot notation” (discussed later):

```

df.rename(columns={'State Code (FIPS)': 'fips_state', 'County Code (FIPS)':
'county_code', 'County Subdivision Code (FIPS)': 'subdiv', 'Place Code (FIPS)':
'place', 'Consolidtated City Code (FIPS)': 'consolidated',
                'Area Name (including legal/statistical area description)': 'name'}, inplace=True)

```

A temporary `DataFrame` `df_states` is created, which includes only state-level data:

```
df_states = df.loc[df['Summary Level'] == '040']
df_states = df_states.rename(columns={'name': 'state'})
df_states.drop(columns=['Summary Level', 'county_code', 'subdiv', 'place'],
inplace=True)
```

Similarly, a DataFrame `df_counties` is created, which includes only county-level data:

```
df_counties = df.loc[(df['county_code'] != '000') & (df['subdiv'] == '00000') &
(df['place'] == '00000') & (df['consolidated'] ==
'00000'), ['fips_state', 'county_code', 'name']]
df_counties.rename(columns={'name': 'county'}, inplace=True)
```

The `merge` method performs a left join between `df_states` and `df_counties`; this effectively creates the `df_fips` DataFrame by appending the state-level columns (including state abbreviation and name) to `df_counties`:

```
df_fips = pd.merge(df_states, df_counties, on='fips_state', how='left')
```

The `fips_county` column is created in the `df_fips` DataFrame, and unnecessary columns are dropped using the `drop` method:

```
df_fips['fips_county'] = df_fips['fips_state'] + df_fips['county_code']
df_fips.drop(columns=['county_code', 'consolidated'], inplace=True)
```

Finally, Puerto Rico values are removed, and the `df_fips` DataFrame is saved to `FIPS_table.csv` using to `to_csv` method:

```
df_fips = df_fips.loc[df_fips['fips_state'] != '72']
df_fips.to_csv(os.path.join(path_tables, 'FIPS_table.csv'), index=False)
```

At this point, `FIPS_table.csv` has been created, and this can be used for subsequent data transformations. For example, two dictionaries are created by reading the CSV file into memory:

```
# table columns are 0) FIPS_state, 1) state name, 2) county, 3) FIPS_county
with open(os.path.join(path_tables, 'FIPS_table.csv'), mode='r') as infile:
    reader = csv.reader(infile)
    next(reader, None)
    county_fips_dict = {rows[3]:[rows[2], rows[0], rows[1]] for rows in reader}
with open(os.path.join(path_tables, 'FIPS_table.csv'), mode='r') as infile:
    reader = csv.reader(infile)
    next(reader, None)
    state_fips_dict = {rows[0]:[rows[1]] for rows in reader}
```

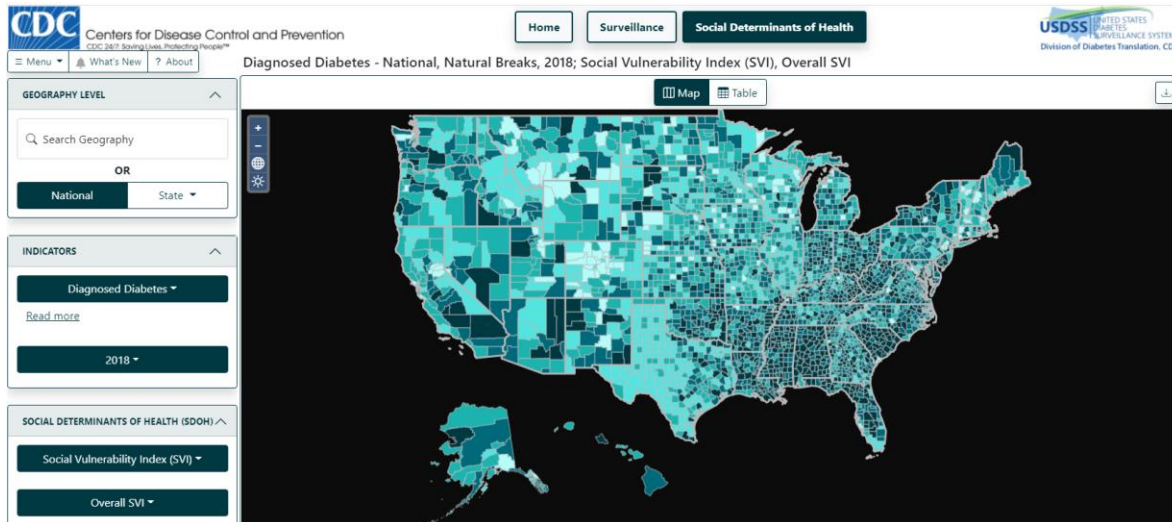
The `county_fips_dict` dictionary maps the five-digit county FIPS codes to the associated county name, state FIPS code, and state name.

Similarly, `state_fips_dict` maps the two-digit state FIPS codes to the associated state name. Python dictionaries, by definition, cannot maintain non-unique keys, so only the first row for each state is read into this second dictionary, which yields a total of 51 key-value pairs—the 50 states and the District of Columbia.

## INGESTING CDC OBESITY DATA

The United States Diabetes Surveillance System (USDSS) is managed by the Centers for Disease Control and Prevention (CDC), and collects and longitudinally monitors diabetes incidence across the nation, including diabetes-related contributors such as obesity and physical inactivity. Their interactive “Social Determinants of Health” dashboard (<https://gis.cdc.gov/grasp/diabetes/diabetesatlas-sdoh.html>) demonstrates county-level diabetes incidence, shown for 2018 in Figure 1, with darker regions denoting higher incidence.





**Figure 1. County-Level Diabetes Incidence for 2018 (USDSS)**

Obesity data are obtained from the CDC Behavioral Risk Factor Surveillance System (BRFSS), a monthly telephonic survey, with CDC providing the following description of its methodology: (CDC, 2022)

- To have diagnosed diabetes if they responded "yes" to the question, "Has a doctor ever told you that you have diabetes?" Women who indicated that they only had diabetes during pregnancy were not considered to have diagnosed diabetes. People who reported having diagnosed diabetes were then asked at what age they were diagnosed.
- To have been diagnosed with diabetes in the last year if they reported having diagnosed diabetes and the difference between their age at the time of the survey and the age they provided to the question, "How old were you when you were told you have diabetes?" was less than one. If the difference was between one year and two years, the person was weighted as half a newly diagnosed case.
- To be obese if their body mass index was 30 or greater. Body mass index (weight [kg]/height [m]<sup>2</sup>) was derived from self-report of height and weight.
- To be physically inactive if they answered "no" to the question, "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?"

Obesity data are demonstrated in Figure 2, and can be downloaded to a CSV file.

Year	County FIPS	County	State	Obesity (Percentage)	Overall SVI (Percentile)
2018	01001	Autauga County	Alabama	29.6	0.4254
2018	01003	Baldwin County	Alabama	28.3	0.2162
2018	01005	Barbour County	Alabama	29.3	0.9959
2018	01007	Bibb County	Alabama	23.1	0.6003
2018	01009	Blount County	Alabama	27.8	0.4242
2018	01011	Bullock County	Alabama	18.7	0.8898
2018	01013	Butler County	Alabama	30.8	0.8653
2018	01015	Calhoun County	Alabama	39.2	0.8252
2018	01017	Chambers County	Alabama	31.2	0.7382
2018	01019	Cherokee County	Alabama	32.4	0.4516

**Figure 2. CDC 2018 County-Level Obesity Data**

Download this table to the following location:

c:\shedder\cdc\DiabetesAtlasData.csv

Table 4 demonstrates the obesity CSV file; note the headers that will need to be removed programmatically:

	A	B	C	D	E	F
1	SVI Theme: Overall SVI; Overall SVI (Percentile); NaturalBreaks					
2	Data downloaded on 11-October-2022					
3	Year	County_FIPS	County	State	Obesity Percentage	Overall SVI
4	2018	1001	Autauga County	Alabama	29.6	0.4354
5	2018	1003	Baldwin County	Alabama	28.3	0.2162
6	2018	1005	Barbour County	Alabama	29.3	0.9959
7	2018	1007	Bibb County	Alabama	23.1	0.6003

**Table 4. CDC 2018 County-Level Obesity Data (betesAtlasData.csv)**

With obesity data downloaded, the next two subsections demonstrate how to ingest this CSV file using SAS and Python, respectively.

### INGESTING OBESITY DATA USING SAS

The following DATA step ingests the CDC obesity data:

```
%let fil=DiabetesAtlasData.csv;

data df_fat (drop=year svi);
  length year $4 fips_county $5 county $40 state $20 fat_pct 8 svi 8;
  infile "&path_cdc&fil" dsd delimiter=',' firstobs=4 end=eof;
  input year $ fips_county $ county $ state $ fat_pct svi;
run;
```

Note the LOST CARD comment in the log, which results from the final line of the file, which lists reference information for the data, and which thus does not conform to columnar input:

```
US Diabetes Surveillance System; www.cdc.gov/diabetes/data; Division of Diabetes
Translation - Centers for Disease Control and
```

The df\_fat data set is created, as demonstrated in Table 5.

	fips_county	county	state	fat_pct
1	01001	Autauga County	Alabama	29.6
2	01003	Baldwin County	Alabama	28.3
3	01005	Barbour County	Alabama	29.3
4	01007	Bibb County	Alabama	23.1
5	01009	Blount County	Alabama	27.8

**Table 5. DF\_fat Data Set Containing CDC County-Level Obesity Data**

Note that the SVI variable, not the focus of this text, has been removed from the data.

### INGESTING OBESITY DATA USING PYTHON

The following Python function reads the CDC CSV file, and creates the df\_fat DataFrame:

```
def create_df_fat(fil):
    global df_fat
    df_fat = pd.read_csv(
        os.path.join(path_cdc, fil), header = None, sep = ',', quotechar = '"',
        skiprows = 3, usecols = [1,2,3,4],
        names=['fips_county','county','state','fat_pct'],
```

```

        dtype={'fips_county': str, 'county': str, 'state': str, 'fat_pct':
'float64'})
        df_fat.dropna(inplace=True)

create_df_fat(r'DiabetesAtlasData.csv')

```

The `create_df_fat` function again relies on the `read_csv` method to ingest the CSV file, with the `names` and `dtype` arguments specifying variables to retain and their data types, respectively. The `dropna` method removes any rows in the `df_fat` DataFrame that are missing at least one column, and this statement is required to remove the final row in the CSV file containing reference information:

```
df_fat.dropna(inplace=True)
```

With obesity data uploaded into both SAS and Python, the next step is to inspect these data, and because they represent county-level statistics, to compare the data with respect to county-level US Census FIPS codes (i.e., master data).

## INSPECTING CDC OBESITY DATA

At this point, the savvy analyst may have noticed that the `df_fips` data set (and DataFrame) contains 3,142 observations (rows), whereas the `df_fat` data set (and DataFrame) contains only 3,141 observations (rows). Thus, without even inspecting individual values, one is aware that some discrepancy exists between these two federal data sources.

## INSPECTING OBESITY DATA USING SAS

The following SAS code identifies discrepancies between the FIPS county codes listed in the two data sets:

```

proc sort data=df_fat out=df_fat_sorted;
  by fips_county;
run;

proc sort data=df_fips out=df_fips_sorted;
  by fips_county;
run;

data df_fat_merged;
  merge df_fat_sorted (in=a keep=fips_county) df_fips_sorted (in=b);
  by fips_county;
  if a and ^b then put 'Extra FIPS in CDC' fips_county;
  else if b and ^a then put 'Missing FIPS in CDC' fips_county;
run;

```

The log demonstrates that 35039 (i.e., Rio Arriba, New Mexico) is missing from the CDC data:

```

Missing FIPS in CDC    35039
NOTE: There were 3141 observations read from the data set WORK.DF_FAT_SORTED.
NOTE: There were 3142 observations read from the data set WORK.DF_FIPS_SORTED.
NOTE: The data set WORK.DF_FAT_MERGED has 3142 observations and 4 variables.

```

A second point to interrogate is whether state and county names are spelled identically between US Census and CDC data—and were the federal government exercising master data management (MDM), you would expect this would be the case. The following DATA step now applies the `STATE_FIPS_DICT` and `COUNTY_FIPS_DICT` user-defined formats, created previously, to compare CDC state and county names to US Census equivalents:

```

data df_fat_check_state_county;
  set df_fat;
  length state_census $30 county_census $40;
  state_census=put(substr(fips_county,1,2), $state_fips_dict.);
  county_census=put(fips_county, $county_fips_dict.);
  if state^=state_census then put @1 fips_county @7 state @40 state_census;
  if county^=county_census then put @1 fips_county @7 county @40 county_census;

```

```
run;
```

Only the first five exceptions are shown, and they demonstrate a variety of issues—with some variation occurring from capitalization, other variation occurring from word discrepancy, and with some values truncated in the CDC data:

01049 Dekalb County	DeKalb County
02195 Petersburg Census Area	Petersburg Borough
02198 Prince of Wales-Hyder Censu	Prince of Wales-Hyder Census Area
11001 District Of Columbia	District of Columbia
12027 Desoto County	DeSoto County

To remove the capitalization issue, the DATA step can be updated to include UPCASE:

```
data df_fat_check_state_county;
  set df_fat;
  length state_census $30 county_census $40;
  state_census=put(substr(fips_county,1,2), $state_fips_dict.);
  county_census=put(fips_county, $county_fips_dict.);
  if upcase(state)~=upcase(state_census) then put @1 fips_county @7 state
    @40 state_census;
  if upcase(county)~=upcase(county_census) then put @1 fips_county @7 county
    @40 county_census;
run;
```

The following seven county names are different (i.e., wrong) in the CDC data:

02195 Petersburg Census Area	Petersburg Borough
02198 Prince of Wales-Hyder Censu	Prince of Wales-Hyder Census Area
19141 O&#39;brien County	O'Brien County
24033 Prince George&#39;s County	Prince George's County
24035 Queen Anne&#39;s County	Queen Anne's County
24037 St. Mary&#39;s County	St. Mary's County
35013 Doña Ana County	Doña Ana County

Opening the raw CDC CSV file in a text editor reveals that values truly are being truncated by CDC:

```
2018,02198,Prince of Wales-Hyder Censu,Alaska,19.9,0.7662
```

Similarly, the text file reveals that escape characters (like #39; representing a single quote) really are maintained within the raw CDC data:

```
2018,19141,O&#39;brien County,Iowa,25.4,0.2322
```

With this confirmation that some CDC counties are incorrectly named, it is best to overwrite the CDC county names and to instead rely on the US Census master data for county names.

```
data df_fat_county_corrected;
  set df_fat (drop=county);
  length county $40;
  county=put(fips_county, $county_fips_dict.);
run;
```

At this point, one county remains missing from the CDC data, but state names have been validated, and county names have been corrected.

## INSPECTING OBESITY DATA USING PYTHON

The differences in FIPS county codes can be assessed in Python with a single line of code:

```
print(set(df_fips.fips_county) - set(df_fat.fips_county))
```

The `set` function creates a unique series of data, which removes any non-unique values that may exist. Thus, by setting the `fips_county` column in these two DataFrames, the difference is demonstrated, and matches the missing county revealed by equivalent SAS code:

```
{ '35039' }
```

The following code identifies the seven CDC county names that do not match US Census names, as well as the missing county:

```
df_merge = pd.merge(left=df_fips[['fips_county','county']],
                    right=df_fat[['fips_county','county']], how='left',
                    on='fips_county')
df_merge_2 = df_merge[df_merge.county_x.str.upper() !=
                      df_merge.county_y.str.upper()]
print(df_merge_2)
```

Note that the `merge` method by default creates new columns whenever identically named columns occur in DataFrames being joined; thus, because the county column appears in both `df_fips` and `df_fat`, an `_x` and `_y`, respectively, are appended to create `county_x` (representing the master FIPS data) and `county_y` (that includes erroneous CDC county names).

The `print` function writes rows containing non-matching county names to the log:

	fips_county		county_x		county_y
87	02195		Petersburg Borough		Petersburg Census Area
88	02198	Prince of Wales-Hyder	Census Area	Prince of Wales-Hyder	Census Area
859	19141		O'Brien County		O'Brien County
1208	24033		Prince George's County		Prince George's County
1209	24035		Queen Anne's County		Queen Anne's County
1210	24037		St. Mary's County		St. Mary's County
1802	35013		Doña Ana County		Doña Ana County
1816	35039		Rio Arriba County		NaN

Instead of applying the `merge` method, the `county_fips_dict` dictionary instead could be applied to the county FIPS code to transform it, and to initialize the new column `county_census`:

```
df_fat_check_state_county = df_fat.copy(deep=True)
df_fat_check_state_county['county_census'] =
df_fat_check_state_county.fips_county.map(county_fips_dict).str[0]
df_fat_check_state_county =
df_fat_check_state_county.loc[df_fat_check_state_county.county.str.upper() !=
                              df_fat_check_state_county.county_census.str.upper()]
print(df_fat_check_state_county[['fips_county','county','county_census']])
```

The `copy` method first creates a copy of the `df_fat` DataFrame, thus ensuring that changes made to the copy will not modify the original `df_fat` DataFrame:

```
df_fat_check_state_county = df_fat.copy(deep=True)
```

The `county_census` column is created by applying the `map` method to the five-digit FIPS county code; the `county_fips_dict` dictionary is mapped, and because the dictionary was defined as having a list of three elements (county name, state FIPS code, and state name), the string method selects the first element (county name), as designated by the `[0]` index:

```
df_fat_check_state_county.fips_county.map(county_fips_dict).str[0]
```

The `loc` function creates a slice of the DataFrame that includes only rows in which the county column and `county_census` column values do not match:

```
df_fat_check_state_county =
df_fat_check_state_county.loc[df_fat_check_state_county.county.str.upper() !=
                              df_fat_check_state_county.county_census.str.upper()]
```

When the DataFrame is examined, its results mirror the exceptions that were noted in the previous `merge` method, with the exception that the single missing county is not listed:

	fips_county		county		county_census
87	02195		Petersburg Census Area		Petersburg Borough

88	02198	Prince of Wales-Hyder Censu	Prince of Wales-Hyder Census Area
859	19141	O&#39;brien County	O'Brien County
1209	24033	Prince George&#39;s County	Prince George's County
1210	24035	Queen Anne&#39;s County	Queen Anne's County
1212	24037	St. Mary&#39;s County	St. Mary's County
1802	35013	Doña Ana County	Doña Ana County

Finally, with the Python evaluation demonstrating that the CDC county names cannot be trusted, the `merge` method is utilized again to overwrite the errant county names with trusted US Census names:

```
df_fat_county_corrected = pd.merge(left=df_fat[['fips_county', 'fat_pct']],
                                   right=df_fips, how='left', on='fips_county')
```

Application of dictionaries with the `map` method most closely mirrors the application of SAS formats (including user-defined formats) to variables, whereas the `merge` method most closely mirrors DATA step MERGE statements or SQL JOIN statements. Thus, in both languages, multiple methods exist for performing data lookup operations that cull, standardize, or clean data based on master data values.

## ANALYZING CDC OBESITY DATA

With county names now cleaned, some basic data analysis can be performed to answer obesity questions:

- What are the ten fattest counties in the nation?
- What are the ten skinniest counties in the nation?
- What are the ten fattest states? *Note that as only county-level obesity data have been downloaded, this will require computing a weighted average (by county population size) to estimate state-level obesity rates.*

Note again, in answering these questions, the obesity criteria supplied by CDC that state these metrics are gathered over the telephone, and computed only by measuring reported weight and reported height; thus, numerous biases do exist, none of which are explored in this text.

## WHAT ARE THE TEN FATTEST COUNTIES IN THE US?

This can be computed in SAS by first sorting the data by fat percentage, and subsequently selecting the top ten observations in a DATA step:

```
proc sort data=df_fat_county_corrected;
  by descending fat_pct;
run;
data df_fattest;
  set df_fat_county_corrected (obs=10);
  length county_st $50;
  format fat_pct 8.1;
  county_st=catx(' ', county, state);
  put @1 county_st @40 fat_pct;
run;
```

The log demonstrates the ten fattest counties:

Thurston County, Nebraska	43.8
Cass County, Nebraska	43.1
Williamsburg County, South Carolina	43.0
Rolette County, North Dakota	41.6
Sunflower County, Mississippi	41.5
Ziebach County, South Dakota	41.5
Lawrence County, Kentucky	41.4
Hidalgo County, Texas	41.4
Marengo County, Alabama	41.3
Jefferson County, Texas	40.8

A single line of Python code leverages the `nlargest` method to select the ten fattest counties:

```
df_fat_county_corrected.nlargest(10, 'fat_pct')[['county','state','fat_pct']]
```

The columnar output is demonstrated:

	county	state	fat_pct
1740	Thurston County	Nebraska	43.8
1666	Cass County	Nebraska	43.1
2359	Williamsburg County	South Carolina	43.0
2028	Rolette County	North Dakota	41.6
1467	Sunflower County	Mississippi	41.5
2426	Ziebach County	South Dakota	41.5
1056	Lawrence County	Kentucky	41.4
2629	Hidalgo County	Texas	41.4
45	Marengo County	Alabama	41.3
2644	Jefferson County	Texas	40.8

### WHAT ARE THE TEN SKINNIEST COUNTIES IN THE US?

Similarly, the SAS data set can be sorted in ascending order by fat percentage, after which the DATA step selects the ten skinniest counties:

```
proc sort data=df_fat_county_corrected;
  by fat_pct;
run;
data df_skinniest;
  set df_fat_county_corrected (obs=10);
  length county_st $50;
  county_st=catx(' ', county, state);
  put @1 county_st @40 fat_pct;
run;
```

The log demonstrates the top ten skinniest counties:

Teton County, Wyoming	10.5
Boulder County, Colorado	13.6
Routt County, Colorado	13.7
Gunnison County, Colorado	13.8
Pitkin County, Colorado	14.2
Summit County, Utah	14.2
Chaffee County, Colorado	14.4
Taos County, New Mexico	14.6
Summit County, Colorado	15.2
San Francisco County, California	15.4

A single line of Python code leverages the `nsmallest` method to select the ten skinniest counties:

```
df_fat_county_corrected.nsmallest(10, 'fat_pct')[['county','state','fat_pct']]
```

The columnar output is demonstrated:

	county	state	fat_pct
3137	Teton County	Wyoming	10.5
250	Boulder County	Colorado	13.6
298	Routt County	Colorado	13.7
270	Gunnison County	Colorado	13.8
293	Pitkin County	Colorado	14.2
2797	Summit County	Utah	14.2
252	Chaffee County	Colorado	14.4
1823	Taos County	New Mexico	14.6
303	Summit County	Colorado	15.2
223	San Francisco County	California	15.4

## WHAT ARE THE TEN FATTEST STATES IN THE US?

Because these CDC obesity statistics are calculated at the county level, a simple mean cannot be utilized to aggregate county-level percentages to calculate state-level obesity; rather, weighted averages (by county population) must be utilized to approximate state-level obesity. *This is not to imply that state-level obesity data are unpublished, but rather to demonstrate how to calculate weighted averages.*

The SAS SQL procedure first joins county population to the obesity data, after which the MEANS procedure computes the weighted averages utilizing the WEIGHT statement to weight by county population:

```
proc sql;
  create table df_fat_pop as
    select a.*, b.population from df_fat_county_corrected as a
      left join df_pop_counties as b on a.fips_county = b.fips_county;
quit;

proc means data=df_fat_pop sum sumwgt mean;
  class state;
  weight population;
  var fat_pct;
  output out=df_fat_weighted_avg mean=fat_avg;
run;
```

The output, shown in Table 6, demonstrates that Alabama is the fattest state in the US.

The MEANS Procedure				
Analysis Variable : fat_pct				
state	N Obs	Sum	Sum Wgts	Mean
Alabama	67	164758811	5039877.00	32.6910382
Alaska	29	21223043.40	723102.00	29.3499996
Arizona	15	205462794	7276316.00	28.2372005
Arkansas	75	93653940.90	3025891.00	30.9508640
California	58	974923452	39237836.00	24.8465143
Colorado	64	129719737	5812069.00	22.3190291
Connecticut	8	94799282.40	3605597.00	26.2922568
Delaware	3	32854487.20	1003384.00	32.7436826
District of Columbia	1	16483230.00	670050.00	24.6000000
Florida	67	602427824	21781128.00	27.6582473

**Table 6. Fattest Ten States in the US, Calculated by Weighted Means of County-Level CDC Data**

As in SAS, multiple methods also exist to calculate weighted means in Python. For example, the following code creates the df\_grouped DataFrame, which orders the states by mean obesity percentage:

```
df_fat_pop = pd.merge(left=df_fat,
  right=df_pop_counties[['fips_county', 'population']],
  how='inner', on='fips_county')
df_fat_pop['fat_pct_x_pop'] = df_fat_pop.fat_pct * df_fat_pop.population
df_grouped = df_fat_pop.groupby('state').sum()
df_grouped['fat_pct_state'] = df_grouped.fat_pct_x_pop / df_grouped.population
print(df_grouped)
```

The ten fattest states within the df\_grouped DataFrame follow, and mirror the SAS results:



state	fat_pct	population	fat_pct_x_pop	fat_pct_state
Alabama	2071.4	5039877.0	164758811.4	32.691038
Alaska	720.5	723102.0	21223043.4	29.350000
Arizona	448.0	7276316.0	205462794.1	28.237201
Arkansas	2124.8	3025891.0	93653940.9	30.950864
California	1398.6	39237836.0	974923451.7	24.846514
Colorado	1352.9	5812069.0	129719736.9	22.319029
Connecticut	215.5	3605597.0	94799282.4	26.292257
Delaware	102.8	1003384.0	32854487.2	32.743683
District of Columbia	24.6	670050.0	16483230.0	24.600000
Florida	2052.3	21781128.0	602427823.8	27.658247

In addition to demonstrating that some counties are in dire need of some gym time, these simple analytic examples have only scratched the surface of SAS and Python capabilities, by demonstrating that functionally equivalent solutions can be designed in either language.

## CONCLUSION

SAS and Python are widely popular industry leaders that occupy two discrete corners of the analytics arena—proprietary and open-source systems. Although programming language selection is often made at the organization, team, customer, or product owner level, many developers and analysts do have the ability to select their *langue de choix*, so long as they can demonstrate that a language can deliver a functional solution. And in these flexible environments, open-source, freely available programming languages, such as Python, should be considered and explored as viable alternatives to pricey, proprietary software. The Pandas library and its DataFrame data structure are especially well-equipped for data analysis, and this text has demonstrated only a handful of its ever-expanding array of tools.

## REFERENCES

CDC. (2022). *Behavioral Risk Factor Surveillance System (BFRSS)*. Retrieved from Centers for Disease Control and Prevention (CDC): <https://gis.cdc.gov/grasp/diabetes/diabetesatlas-sdoh.html>

## CONTACT INFORMATION

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