Your Title

PS4: Due Sat Nov 2 at 5:00PM Central. Worth 100 points. We use (*) to indicate a problem that we think might be time consuming.

Style Points (10 pts)

Please refer to the minilesson on code style **here**.

Submission Steps (10 pts)

1. This problem set is a paired problem set.
2. Play paper, scissors, rock to determine who goes first. Call that person *Partner 1*.
    - Partner 1 (name and cnet ID):
    - Partner 2 (name and cnet ID):
3. Partner 1 will accept the `ps4` and then share the link it creates with their partner. You can only share it with one partner so you will not be able to change it after your partner has accepted.
4. "This submission is our work alone and complies with the 30538 integrity policy." Add your initials to indicate your agreement: **___** **___**
5. "I have uploaded the names of anyone else other than my partner and I worked with on the problem set **here**" (1 point)
6. Late coins used this pset: **___** Late coins left after submission: **___**
7. Knit your `ps4.qmd` to an PDF file to make `ps4.pdf`,
    - The PDF should not be more than 25 pages. Use `head()` and re-size figures when appropriate.
8. (Partner 1): push `ps4.qmd` and `ps4.pdf` to your github repo.
9. (Partner 1): submit `ps4.pdf` via Gradescope. Add your partner on Gradescope.
10. (Partner 1): tag your submission in Gradescope

Important: Repositories are for tracking code. **Do not commit the data or shapefiles to your repo.** The best way to do this is with `.gitignore`, which we have covered in class. If you do accidentally commit the data, Github has a guide. The best course of action depends on whether you have pushed yet. This also means that both partners will have to download the initial raw data and any data cleaning code will need to be re-run on both partners' computers.

Download and explore the Provider of Services (POS) file (10 pts)

```
import pandas as pd

# 1: Load the 2016 POS Data
pos2016 = pd.read_csv('data/Q4_2016.csv')
pos2017 = pd.read_csv('data/Q4_2017.csv')
pos2018 = pd.read_csv('data/Q4_2018.csv')
pos2019 = pd.read_csv('data/Q4_2019.csv')
pos2016['Year'] = '2016'
pos2017['Year'] = '2017'
pos2018['Year'] = '2018'
pos2019['Year'] = '2019'
# 2: Filter for Short-Term Hospitals
short_term_hospitals_6 = pos2016[(pos2016['PRVDR_CTGRY_CD'] == 1.0) &
 ↪  (pos2016['PRVDR_CTGRY_SBTYP_CD'] == 1)]
num_hospitals_6 = short_term_hospitals_6.shape[0]

print(f"Number of short-term hospitals reported in 2016 data:
 ↪  {num_hospitals_6}")

unique_hospitals = short_term_hospitals_6.drop_duplicates(subset='FAC_NAME')
print(f"Number of unique hospitals: {len(unique_hospitals)}")
```

```
Number of short-term hospitals reported in 2016 data: 7245
Number of unique hospitals: 6770
```

```
short_term_hospitals_7 = pos2017[(pos2017['PRVDR_CTGRY_CD'] == 1) &
 ↪  (pos2017['PRVDR_CTGRY_SBTYP_CD'] == 1)]
num_hospitals_7 = short_term_hospitals_7.shape[0]

print(f"Number of short-term hospitals reported in 2017 data:
 ↪  {num_hospitals_7}")
```

```
short_term_hospitals_8 = pos2018[(pos2018['PRVDR_CTGRY_CD'] == 1) &
 ↪  (pos2018['PRVDR_CTGRY_SBTYP_CD'] == 1)]
num_hospitals_8 = short_term_hospitals_8.shape[0]

print(f"Number of short-term hospitals reported in 2018 data:
 ↪  {num_hospitals_8}")

short_term_hospitals_9 = pos2019[(pos2019['PRVDR_CTGRY_CD'] == 1) &
 ↪  (pos2019['PRVDR_CTGRY_SBTYP_CD'] == 1)]
num_hospitals_9 = short_term_hospitals_9.shape[0]

print(f"Number of short-term hospitals reported in 2019 data:
 ↪  {num_hospitals_9}")
```

```
Number of short-term hospitals reported in 2017 data: 7260
Number of short-term hospitals reported in 2018 data: 7277
Number of short-term hospitals reported in 2019 data: 7303
```

```
import altair as alt

years = ['2016', '2017', '2018', '2019']
dataframes = []

for year in years:
    df = eval(f'pos{year}')
    df['Year'] = year
    dataframes.append(df)

all_data = pd.concat(dataframes)

short_term_hospitals = all_data[(all_data['PRVDR_CTGRY_CD'] == 1) &
 ↪  (all_data['PRVDR_CTGRY_SBTYP_CD'] == 1)]

total_hospitals_per_year =
 ↪  short_term_hospitals['Year'].value_counts().reset_index()
total_hospitals_per_year.columns = ['Year', 'Total Hospitals']
chart_unique_hospitals =
 ↪  alt.Chart(total_hospitals_per_year).mark_bar().encode(
    x=alt.X('Year:O', title='Year'),
    y=alt.Y('Total Hospitals', title='Number of Total Hospitals',),
    color=alt.value('blue')
```

```
).properties(
    title='Number of Total Short-Term Hospitals by Year'
).transform_calculate(
    adjusted_value='datum["Total Hospitals"]-7000'
).encode(
    y=alt.Y('adjusted_value:Q', title='Number of Total Hospitals (Adjusted)',
 ↪  scale=alt.Scale(domain=[0, 350]), axis=alt.Axis(labelExpr='datum.value +
 ↪  7000'))
)

chart_unique_hospitals.display()

unique_hospitals_per_year =
 ↪  short_term_hospitals.groupby('Year')['PRVDR_NUM'].nunique().reset_index()
unique_hospitals_per_year.columns = ['Year', 'Unique Hospitals']

chart_unique_hospitals =
 ↪  alt.Chart(unique_hospitals_per_year).mark_bar().encode(
    x=alt.X('Year:O', title='Year'),
    y=alt.Y('Unique Hospitals', title='Number of Unique Hospitals',),
    color=alt.value('skyblue')
).properties(
    title='Number of Unique Short-Term Hospitals by Year'
).transform_calculate(
    adjusted_value='datum["Unique Hospitals"]-7000'
).encode(
    y=alt.Y('adjusted_value:Q', title='Number of Unique Hospitals
 ↪  (Adjusted)', scale=alt.Scale(domain=[0, 350]),
 ↪  axis=alt.Axis(labelExpr='datum.value + 7000'))
)

chart_unique_hospitals.display()
```

```
alt.Chart(...)
```

```
alt.Chart(...)
```

```
active_2016 = short_term_hospitals[short_term_hospitals['Year'] == '2016']
active_2016_hospitals = active_2016[['PRVDR_NUM', 'FAC_NAME',
 ↪  'ZIP_CD']].drop_duplicates()

suspected_closures = []
```

```
for year, df in zip(['2017', '2018', '2019'], [pos2017, pos2018, pos2019]):
    year_hospitals = df[(df['PRVDR_CTGRY_CD'] == 1) &
 ↪  (df['PRVDR_CTGRY_SBTYP_CD'] == 1)]
    closed_hospitals = active_2016_hospitals[

         ↪  ~active_2016_hospitals['PRVDR_NUM'].isin(year_hospitals[year_hospitals['PGM_TRMN
         ↪  == 0]['PRVDR_NUM'])
    ]

    closed_hospitals = closed_hospitals.assign(Suspected_Closure_Year=year)
    suspected_closures.append(closed_hospitals)

suspected_closures_df =
 ↪  pd.concat(suspected_closures).drop_duplicates(['PRVDR_NUM'])

closures_count = suspected_closures_df.shape[0]
print(f"Number of suspected closures: {closures_count}")
print(suspected_closures_df[['FAC_NAME', 'ZIP_CD',
 ↪  'Suspected_Closure_Year']])
```

```
Number of suspected closures: 3996
                                                FAC_NAME   ZIP_CD  \
1                                NORTH JACKSON HOSPITAL  35740.0
6                              HARTSELLE MEDICAL CENTER  35640.0
7                         MARSHALL MEDICAL CENTER NORTH  35976.0
10                     SOUTHWEST ALABAMA MEDICAL CENTER  36784.0
12                                 FAIRVIEW MEDICAL CTR  36108.0
...                                                 ...      ...
133498                           TEXAS GENERAL HOSPITAL  75051.0
133501  BAYLOR SCOTT & WHITE EMERGENCY MEDICAL CENTER ...  78613.0
133508           LITTLE RIVER HEALTHCARE CAMERON HOSPITAL  76520.0
133511                    BAYLOR EMERGENCY MEDICAL CENTER  75087.0
133529                  TEXAS GENERAL HOSPITAL- VZRMC LP  75140.0

       Suspected_Closure_Year
1                        2017
6                        2017
7                        2017
10                       2017
12                       2017
...                       ...
```

```
133498                    2019
133501                    2019
133508                    2019
133511                    2019
133529                    2019

[3996 rows x 3 columns]
```

```
sorted_closures_top10 =
 ↪  suspected_closures_df.sort_values('FAC_NAME').head(10)

print(sorted_closures_top10[['FAC_NAME', 'Suspected_Closure_Year']])
```

```
                                          FAC_NAME
                                          Suspected_Closure_Year
106772      (CLOSED) BAPTIST HICKMAN COMMUNITY HOSPITAL
2017
106779        (CLOSED) BAPTIST HOSPITAL OF ROANE COUNTY
2017
106844    (CLOSED) BAPTIST MEMORIAL HOSPITAL LAUDERDALE
2017
106924  (CLOSED) BAPTIST MEMORIAL HOSPITAL-COLLIERVILLE
2017
106875                (CLOSED) BLEDSOE COUNTY HOSPITAL
2017
106864                (CLOSED) CAMDEN GENERAL HOSPITAL
2017
106914        (CLOSED) COLUMBIA CHEATHAM MEDICAL CENTER
2017
106831    (CLOSED) COLUMBIA WHITWELL MEDICAL CENTER INC
2017
106891               (CLOSED) COLUMIBA EAST RIDGE HOSP
2017
106795             (CLOSED) COPPER BASIN MEDICAL CENTER
2017
```

```
suspected_closures_df =
 ↪  pd.concat(suspected_closures).drop_duplicates(['PRVDR_NUM'])
suspected_closures_df
active_hospitals_zip_year =
 ↪  short_term_hospitals[short_term_hospitals['PGM_TRMNTN_CD'] ==
 ↪  0].groupby(['ZIP_CD', 'Year']).size().unstack(fill_value=0)
```

```
merger_candidates = []

for _, row in suspected_closures_df.iterrows():
    zip_code = row['ZIP_CD']
    closure_year = row['Suspected_Closure_Year']

    if closure_year in ['2016', '2017', '2018']:
        next_year = str(int(closure_year) + 1)
        if zip_code in active_hospitals_zip_year.index:
            if active_hospitals_zip_year.loc[zip_code, next_year] >=
            ↪  active_hospitals_zip_year.loc[zip_code, closure_year]:
               merger_candidates.append(row)

merger_candidates_df = pd.DataFrame(merger_candidates)

merger_count = merger_candidates_df.shape[0]
print(f"Number of potential mergers/acquisitions: {merger_count}")
print(merger_candidates_df[['FAC_NAME', 'ZIP_CD', 'Suspected_Closure_Year']])
```

```
Number of potential mergers/acquisitions: 995
                                     FAC_NAME   ZIP_CD
                                     Suspected_Closure_Year
21            COLUMBIA REGIONAL MEDICAL CENTER  36420.0
2017
25                   PHENIX REGIONAL HOSPITAL  36867.0
2017
35                     CHILTON MEDICAL CENTER  35045.0
2017
44                   ATMORE COMMUNITY HOSPITAL  36502.0
2017
45      DECATUR MORGAN HOSPITAL-PARKWAY CAMPUS  35601.0
2017
...                                        ...      ...
...
126562  WHEATON FRANCISCAN HEALTHCARE FRANKLIN  53132.0
2018
129056         MOUNTAIN VIEW REGIONAL HOSPITAL  82605.0
2018
133442            NORTH CYPRESS MEDICAL CENTER  77429.0
2018
133473                        EMERUS HOSPITAL  77479.0
2018
```

```
133510   BAY AREA REGIONAL MEDICAL CENTER, LLC  77598.0
2018

[995 rows x 3 columns]
```

```
corrected_closures_df =
 ↪  suspected_closures_df[~suspected_closures_df['PRVDR_NUM'].isin(merger_candidates_df['PRVI

corrected_closures_count = corrected_closures_df.shape[0]

sorted_corrected_closures_top10 =
 ↪  corrected_closures_df.sort_values('FAC_NAME').head(10)

print(f"Number of corrected hospital closures: {corrected_closures_count}")
print(sorted_corrected_closures_top10[['FAC_NAME', 'ZIP_CD',
 ↪  'Suspected_Closure_Year']])
```

```
Number of corrected hospital closures: 3001
                                              FAC_NAME   ZIP_CD  \
106772      (CLOSED) BAPTIST HICKMAN COMMUNITY HOSPITAL  37033.0
106779        (CLOSED) BAPTIST HOSPITAL OF ROANE COUNTY  37854.0
106844    (CLOSED) BAPTIST MEMORIAL HOSPITAL LAUDERDALE  38063.0
106924  (CLOSED) BAPTIST MEMORIAL HOSPITAL-COLLIERVILLE  38017.0
106875                 (CLOSED) BLEDSOE COUNTY HOSPITAL  37367.0
106864                 (CLOSED) CAMDEN GENERAL HOSPITAL  38320.0
106914        (CLOSED) COLUMBIA CHEATHAM MEDICAL CENTER  37015.0
106831    (CLOSED) COLUMBIA WHITWELL MEDICAL CENTER INC  37397.0
106891                (CLOSED) COLUMIBA EAST RIDGE HOSP  37412.0
106795             (CLOSED) COPPER BASIN MEDICAL CENTER  37317.0

       Suspected_Closure_Year
106772                   2017
106779                   2017
106844                   2017
106924                   2017
106875                   2017
106864                   2017
106914                   2017
106831                   2017
106891                   2017
106795                   2017
```

1.

2. a.
   b.
3.
4. a.
   b.

Identify hospital closures in POS file (15 pts) (*)

1.
2.
3. a.
   b.
   c.

Download Census zip code shapefile (10 pt)

1. a. -rw-r–r– 1 15535 197609 6.2M Oct 30 23:58 gz_2010_us_860_00_500k.dbf

   -rw-r–r– 1 15535 197609 165 Oct 30 23:58 gz_2010_us_860_00_500k.prj

   -rw-r–r– 1 15535 197609 799M Oct 30 23:58 gz_2010_us_860_00_500k.shp

   -rw-r–r– 1 15535 197609 259K Oct 30 23:58 gz_2010_us_860_00_500k.shx

   -rw-r–r– 1 15535 197609 16K Oct 30 23:58 gz_2010_us_860_00_500k.xml

   b.

2.

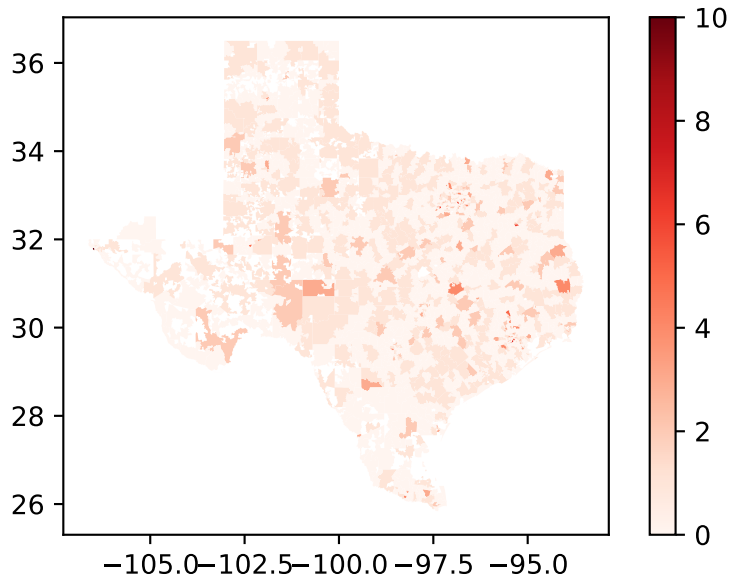
```
import geopandas as gpd
import pandas as pd
import matplotlib.pyplot as plt

# Load the shapefile
zip_shapefile = gpd.read_file('data/gz_2010_us_860_00_500k.shp')
```

```
# texas_choropleth
```

```
# Filter for Texas ZIP codes (first two digits between 75 and 79)
texas_zip_codes = zip_shapefile[zip_shapefile['ZCTA5'].str[:3].isin(['733'])
 ↪  | zip_shapefile['ZCTA5'].str[:2].isin(['75', '76', '77', '78', '79'])]

# Filter and count hospitals per ZIP code in Texas
texas_hospitals = short_term_hospitals_6[
    short_term_hospitals_6['ZIP_CD'].astype(str).str[:3].isin(['733']) |
    short_term_hospitals_6['ZIP_CD'].astype(str).str[:2].isin(['75', '76',
 ↪  '77', '78', '79'])
]
hospitals_per_zip = texas_hospitals['ZIP_CD'].value_counts().reset_index()
hospitals_per_zip.columns = ['ZIP_CD', 'Hospital_Count']

# Merge hospital count with Texas ZIP shapefile
texas_zip_codes['ZIP_CD'] =
 ↪  texas_zip_codes['ZCTA5'].astype(int).astype(str).str.zfill(5)
hospitals_per_zip['ZIP_CD'] =
 ↪  hospitals_per_zip['ZIP_CD'].astype(int).astype(str).str.zfill(5)
texas_choropleth = texas_zip_codes.merge(hospitals_per_zip, on='ZIP_CD',
 ↪  how='left').fillna(0)
```

```
C:\Users\15535\anaconda3\envs\dap2\lib\site-packages\geopandas\geodataframe.py:1538:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  super().__setitem__(key, value)
C:\Users\15535\AppData\Local\Temp\ipykernel_20816\4246071884.py:15:
DeprecationWarning: ExtensionArray.fillna added a 'copy' keyword in pandas
2.1.0. In a future version, ExtensionArray subclasses will need to implement
this keyword or an exception will be raised. In the interim, the keyword is
ignored by GeometryArray.
  texas_choropleth = texas_zip_codes.merge(hospitals_per_zip, on='ZIP_CD',
  how='left').fillna(0)
```

```
texas_choropleth.plot(column="Hospital_Count", cmap='Reds', legend=True)
```



Calculate zip code's distance to the nearest hospital (20 pts) (*)

1.

```
zips_all_centroids = zip_shapefile.copy()
zips_all_centroids['geometry'] = zips_all_centroids.centroid

dimensions = zips_all_centroids.shape
columns_info = zips_all_centroids.columns

dimensions, columns_info
```

```
C:\Users\15535\AppData\Local\Temp\ipykernel_20816\4255734715.py:2:
UserWarning: Geometry is in a geographic CRS. Results from 'centroid' are
likely incorrect. Use 'GeoSeries.to_crs()' to re-project geometries to a
projected CRS before this operation.

  zips_all_centroids['geometry'] = zips_all_centroids.centroid
```

```
((33120, 6),
 Index(['GEO_ID', 'ZCTA5', 'NAME', 'LSAD', 'CENSUSAREA', 'geometry'],
 dtype='object'))
```

2.

```
texas_prefixes = ['75', '76', '77', '78', '79', '733']
bordering_states_prefixes = texas_prefixes + ['73', '74', '70', '71', '87',
 ↪  '88']

zips_texas_centroids =
 ↪  zips_all_centroids[zips_all_centroids['ZCTA5'].str[:3].isin(['733']) |
 ↪  zips_all_centroids['ZCTA5'].str[:2].isin(['75', '76', '77', '78', '79'])]

zips_texas_borderstates_centroids =
 ↪  zips_all_centroids[zips_all_centroids['ZCTA5'].str[:2].isin(bordering_states_prefixes)]

texas_zip_count = zips_texas_centroids['ZCTA5'].nunique()
texas_borderstates_zip_count =
 ↪  zips_texas_borderstates_centroids['ZCTA5'].nunique()

texas_zip_count, texas_borderstates_zip_count
```

```
(1935, 3596)
```

3.

```
zips_texas_borderstates_centroids['ZIP_CD'] =
 ↪  zips_texas_borderstates_centroids['ZCTA5'].astype(int).astype(str).str.zfill(5)
zips_withhospital_centroids = zips_texas_borderstates_centroids.merge(
    hospitals_per_zip[hospitals_per_zip['Hospital_Count'] > 0],
    on='ZIP_CD',
    how='inner'
)
print(f"Number of ZIP codes with at least one hospital:
 ↪  {zips_withhospital_centroids.shape[0]}")
zips_withhospital_centroids
```

```
Number of ZIP codes with at least one hospital: 490
```

```
C:\Users\15535\anaconda3\envs\dap2\lib\site-packages\geopandas\geodataframe.py:1538:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  super().__setitem__(key, value)
```

	GEO_ID	ZCTA5	NAME	LSAD	CENSUSAREA	geometry	ZIP_C
0	8600000US78624	78624	78624	ZCTA5	708.041	POINT (-98.87707 30.28160)	78624
1	8600000US78626	78626	78626	ZCTA5	93.046	POINT (-97.59733 30.66535)	78626
2	8600000US78636	78636	78636	ZCTA5	349.689	POINT (-98.41885 30.30504)	78636
3	8600000US78640	78640	78640	ZCTA5	91.662	POINT (-97.82814 29.99496)	78640
4	8600000US78643	78643	78643	ZCTA5	704.140	POINT (-98.69472 30.69029)	78643
...	...	...	...	...	...	...	...
485	8600000US75035	75035	75035	ZCTA5	23.643	POINT (-96.77269 33.15530)	75035
486	8600000US78028	78028	78028	ZCTA5	250.675	POINT (-99.15819 30.03424)	78028
487	8600000US78222	78222	78222	ZCTA5	21.890	POINT (-98.37787 29.36619)	78222
488	8600000US78412	78412	78412	ZCTA5	8.798	POINT (-97.34297 27.70383)	78412
489	8600000US78586	78586	78586	ZCTA5	176.313	POINT (-97.63110 26.10507)	78586

4. a.

```
from shapely.geometry import Point
import time

# Select a subset of 10 ZIP codes for testing
zips_texas_centroids_subset = zips_texas_centroids.head(10)

# Start timer
start_time = time.time()

# Calculate distance to the nearest ZIP code with a hospital for each ZIP in
 ↪  the subset
zips_texas_centroids_subset['nearest_hospital_distance'] =
 ↪  zips_texas_centroids_subset.geometry.apply(
    lambda x: zips_withhospital_centroids.distance(x).min()
)

# End timer and calculate duration
duration = time.time() - start_time
print(f"Time taken for 10 ZIP codes: {duration:.2f} seconds")
```

```
Time taken for 10 ZIP codes: 0.07 seconds
```

b.

```
# Start timer
start_time_full = time.time()

# Calculate distance to the nearest ZIP code with a hospital for each ZIP in
 ↪  the full dataset
zips_texas_centroids['nearest_hospital_distance'] =
 ↪  zips_texas_centroids.geometry.apply(
    lambda x: zips_withhospital_centroids.distance(x).min()
)

# End timer and calculate full duration
duration_full = time.time() - start_time_full
print(f"Time taken for full calculation: {duration_full:.2f} seconds")
```

```
Time taken for full calculation: 11.83 seconds
```

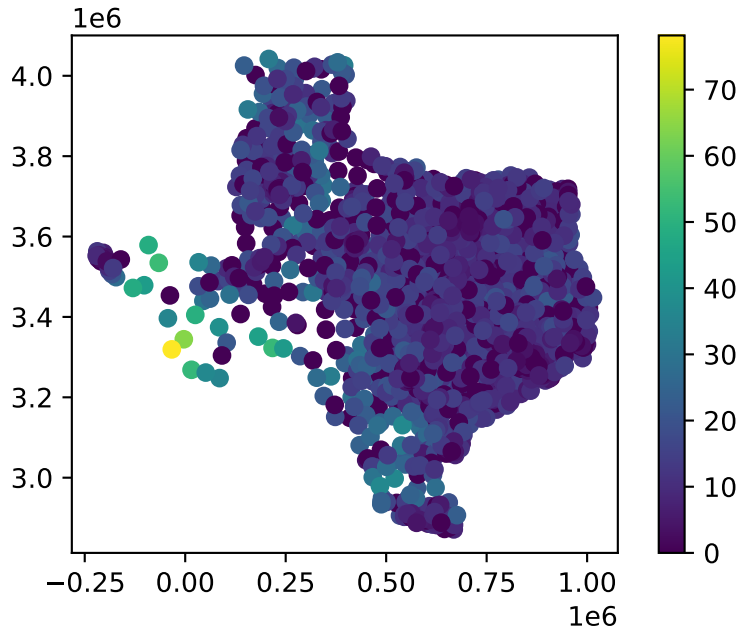
c.

5.

```
zips_texas_centroids = zips_texas_centroids.to_crs(epsg=32614)
zips_withhospital_centroids = zips_withhospital_centroids.to_crs(epsg=32614)

# Calculate distance to the nearest ZIP code with a hospital for each ZIP in
 ↪  Texas
start_time = time.time()
zips_texas_centroids['nearest_hospital_distance_meters'] =
 ↪  zips_texas_centroids.geometry.apply(
    lambda x: zips_withhospital_centroids.distance(x).min()
)
duration = time.time() - start_time
print(f"Time taken for full calculation: {duration:.2f} seconds")

# Convert distances from meters to miles
zips_texas_centroids['nearest_hospital_distance_miles'] =
 ↪  zips_texas_centroids['nearest_hospital_distance_meters'] * 0.000621371

# Verify results
print(zips_texas_centroids.head())
```

```
C:\Users\15535\anaconda3\envs\dap2\lib\site-packages\geopandas\geoseries.py:645:
FutureWarning: the convert_dtype parameter is deprecated and will be removed
in a future version.  Do ``ser.astype(object).apply()`` instead if you want
``convert_dtype=False``.
  result = super().apply(func, convert_dtype=convert_dtype, args=args,
  **kwargs)

Time taken for full calculation: 0.37 seconds
              GEO_ID  ZCTA5   NAME   LSAD  CENSUSAREA  \
9207  8600000US78624  78624  78624  ZCTA5     708.041
9208  8600000US78626  78626  78626  ZCTA5      93.046
9209  8600000US78628  78628  78628  ZCTA5      73.382
9210  8600000US78631  78631  78631  ZCTA5     325.074
9211  8600000US78632  78632  78632  ZCTA5      96.278

                            geometry  nearest_hospital_distance  \
9207  POINT (511821.952 3349995.446)                   0.000000
9208  POINT (634379.375 3393353.916)                   0.000000
9209  POINT (619673.774 3390490.062)                   0.110844
9210  POINT (470656.159 3356247.486)                   0.337251
9211  POINT (647977.209 3286114.947)                   0.164115

      nearest_hospital_distance_meters  nearest_hospital_distance_miles
9207                          0.000000                         0.000000
9208                          0.000000                         0.000000
9209                      12197.957777                         7.579457
9210                      36489.136097                        22.673291
9211                      15883.346164                         9.869451

a.
b.
c.
```

```
zips_texas_centroids.plot(column='nearest_hospital_distance_miles',
 ↪  legend=True)
```



Effects of closures on access in Texas (15 pts)

1.
2.
3.
4.

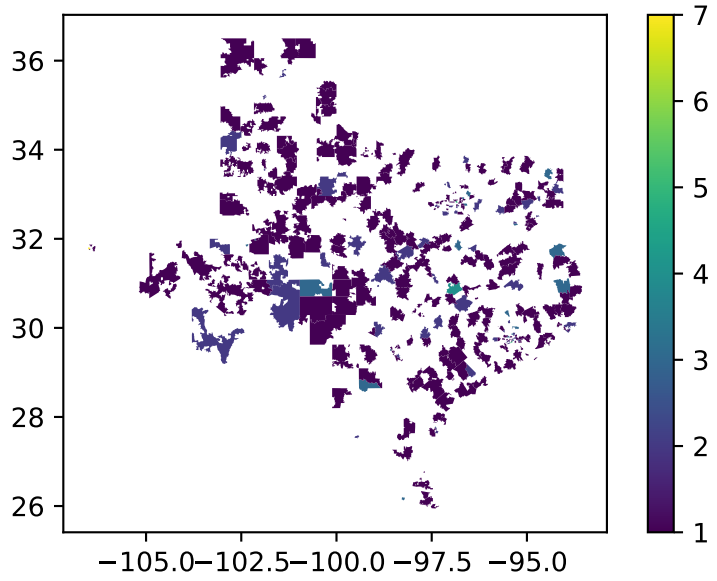
```
suspected_closures_df['ZIP_CD'] =
 ↪  suspected_closures_df['ZIP_CD'].astype(int).astype(str).str.zfill(5)

closure_table =
 ↪  suspected_closures_df[suspected_closures_df['ZIP_CD'].str[:3].isin(['733'])
 ↪  | suspected_closures_df['ZIP_CD'].str[:2].isin(['75', '76', '77', '78',
 ↪  '79'])]
closure_table = closure_table['ZIP_CD'].value_counts().reset_index()
closure_table.columns = ['ZIP_CD', 'Total Closure']
closure_table
```

	ZIP_CD	Total Closure
0	79902	7
1	75235	5

	ZIP_CD	Total Closure
2	77054	5
3	76520	4
4	75570	3
...	...	...
338	79744	1
339	79546	1
340	77063	1
341	79901	1
342	75087	1

```
closure_choropleth = texas_zip_codes.merge(closure_table, on='ZIP_CD',
 ↪  how='right')
```

```
closure_choropleth.plot(column = 'Total Closure', legend = True)
```



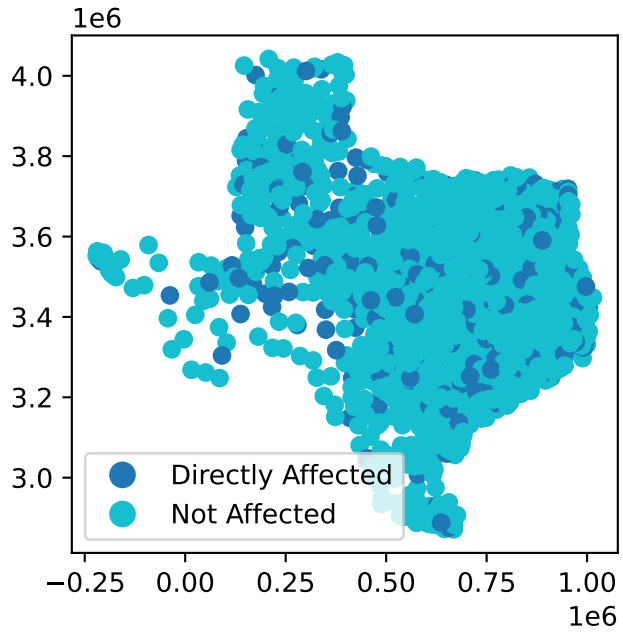

```
closure_choropleth = closure_choropleth.to_crs(epsg=32614)

closure_choropleth['buffer_10_miles'] =
 ↪  closure_choropleth.geometry.buffer(16093.4)

# Create a GeoDataFrame containing just the buffered areas
```

```
buffers = closure_choropleth[['ZIP_CD', 'buffer_10_miles']]
buffers = buffers.set_geometry('buffer_10_miles')

# Perform a spatial join between the Texas ZIP codes and the buffers to find
 ↪  indirectly affected ZIP codes
indirectly_affected_zips = gpd.sjoin(zips_texas_centroids, buffers,
 ↪  how='inner', predicate='intersects')

# Count unique indirectly affected ZIP codes
indirectly_affected_zip_count = indirectly_affected_zips['ZIP_CD'].nunique()

# Display results
print(f"Number of indirectly affected ZIP codes in Texas:
 ↪  {indirectly_affected_zip_count}")
```

```
Number of indirectly affected ZIP codes in Texas: 333
```

```
zips_texas_centroids['Category'] = 'Not Affected'

# Label directly affected ZIP codes
directly_affected_zips = closure_choropleth['ZIP_CD'].tolist()
zips_texas_centroids.loc[zips_texas_centroids['ZCTA5'].isin(directly_affected_zips),
 ↪  'Category'] = 'Directly Affected'

# Label indirectly affected ZIP codes (within 10 miles, but not directly
 ↪  affected)
indirectly_affected_zips_only =
 ↪  indirectly_affected_zips[~indirectly_affected_zips['ZIP_CD'].isin(directly_affected_zips)
indirectly_affected_zip_codes =
 ↪  indirectly_affected_zips_only['ZIP_CD'].tolist()
zips_texas_centroids.loc[zips_texas_centroids['ZCTA5'].isin(indirectly_affected_zip_codes),
 ↪  'Category'] = 'Indirectly Affected'
```

```
zips_texas_centroids.plot(
    column='Category',
    legend=True
)
```



Reflecting on the exercise (10 pts)