Assignment 10: More on Choropleth, Folium Map, and Raster Data

```
!pip install mapclassify #helper package
!pip install osmnx
!pip install rioxarray

import geopandas as gpd # import geopandas
import osmnx as ox # import osmnx
import folium as fm # import folium
import rioxarray as rxr #import rioxarray

# packages you already familiar
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import os
import warnings
warnings.filterwarnings('ignore')
import shapely.geometry
```

```
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas!=1.5.0,>=1.4->mapclassify) (2023.4)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-learn>=1.0->mapclassify) (1.3.2)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn>=1.0->mapclassify) (3.4.0)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.1->pandas!=1.5.0,>=1.4->mapclassify) (1.16.0)
Installing collected packages: mapclassify
Successfully installed mapclassify-2.6.1
Collecting osmnx
  Downloading osmnx-1.9.1-py3-none-any.whl (104 kB)
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Requirement already satisfied: geopandas>=0.12 in /usr/local/lib/python3.10/dist-packages (from osmnx) (0.13.2)
Requirement already satisfied: networkx>=2.5 in /usr/local/lib/python3.10/dist-packages (from osmnx) (3.2.1)
Requirement already satisfied: numpy>=1.20 in /usr/local/lib/python3.10/dist-packages (from osmnx) (1.25.2)
Requirement already satisfied: pandas>=1.1 in /usr/local/lib/python3.10/dist-packages (from osmnx) (1.5.3)
Requirement already satisfied: requests>=2.27 in /usr/local/lib/python3.10/dist-packages (from osmnx) (2.31.0)
Requirement already satisfied: shapely>=2.0 in /usr/local/lib/python3.10/dist-packages (from osmnx) (2.0.3)
Requirement already satisfied: fiona>=1.8.19 in /usr/local/lib/python3.10/dist-packages (from geopandas>=0.12->osmnx) (1.9.6)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from geopandas>=0.12->osmnx) (24.0)
Requirement already satisfied: pyproj>=3.0.1 in /usr/local/lib/python3.10/dist-packages (from geopandas>=0.12->osmnx) (3.6.1)
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Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests>=2.27->osmnx) (3.3.2)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests>=2.27->osmnx) (3.6)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests>=2.27->osmnx) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests>=2.27->osmnx) (2024.2.2)
Requirement already satisfied: attrs>=19.2.0 in /usr/local/lib/python3.10/dist-packages (from fiona>=1.8.19->geopandas>=0.12->osmnx) (23.2.0)
Requirement already satisfied: click~=8.0 in /usr/local/lib/python3.10/dist-packages (from fiona>=1.8.19->geopandas>=0.12->osmnx) (8.1.7)
Requirement already satisfied: click-plugins>=1.0 in /usr/local/lib/python3.10/dist-packages (from fiona>=1.8.19->geopandas>=0.12->osmnx) (1.1.1)
Requirement already satisfied: cligj>=0.5 in /usr/local/lib/python3.10/dist-packages (from fiona>=1.8.19->geopandas>=0.12->osmnx) (0.7.2)
Requirement already satisfied: six in /usr/local/lib/python3.10/dist-packages (from fiona>=1.8.19->geopandas>=0.12->osmnx) (1.16.0)
Installing collected packages: osmnx
Successfully installed osmnx-1.9.1
Collecting rioxarray
  Downloading rioxarray-0.15.1-py3-none-any.whl (53 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 53.7/53.7 kB 804.6 kB/s eta 0:00:00
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from rioxarray) (24.0)
Collecting rasterio>=1.3 (from rioxarray)
  Downloading rasterio-1.3.9-cp310-cp310-manylinux2014_x86_64.whl (20.6 MB)
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Requirement already satisfied: xarray>=2022.3.0 in /usr/local/lib/python3.10/dist-packages (from rioxarray) (2023.7.0)
Requirement already satisfied: pyproj>=3.3 in /usr/local/lib/python3.10/dist-packages (from rioxarray) (3.6.1)
Requirement already satisfied: numpy>=1.23 in /usr/local/lib/python3.10/dist-packages (from rioxarray) (1.25.2)
Requirement already satisfied: certifi in /usr/local/lib/python3.10/dist-packages (from pyproj>=3.3->rioxarray) (2024.2.2)
Collecting affine (from rasterio>=1.3->rioxarray)
  Downloading affine-2.4.0-py3-none-any.whl (15 kB)
Requirement already satisfied: attrs in /usr/local/lib/python3.10/dist-packages (from rasterio>=1.3->rioxarray) (23.2.0)
Requirement already satisfied: click>=4.0 in /usr/local/lib/python3.10/dist-packages (from rasterio>=1.3->rioxarray) (8.1.7)
Requirement already satisfied: cligj>=0.5 in /usr/local/lib/python3.10/dist-packages (from rasterio>=1.3->rioxarray) (0.7.2)
Collecting snuggs>=1.4.1 (from rasterio>=1.3->rioxarray)
  Downloading snuggs-1.4.7-py3-none-any.whl (5.4 kB)
Requirement already satisfied: click-plugins in /usr/local/lib/python3.10/dist-packages (from rasterio>=1.3->rioxarray) (1.1.1)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from rasterio>=1.3->rioxarray) (67.7.2)
Requirement already satisfied: pandas>=1.4 in /usr/local/lib/python3.10/dist-packages (from xarray>=2022.3.0->rioxarray) (1.5.3)
Requirement already satisfied: python-dateutil>=2.8.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.4->xarray>=2022.3.0->rioxarray) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas>=1.4->xarray>=2022.3.0->rioxarray) (2023.4)
Requirement already satisfied: pyparsing>=2.1.6 in /usr/local/lib/python3.10/dist-packages (from snuggs>=1.4.1->rasterio>=1.3->rioxarray) (3.1.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.1->pandas>=1.4->xarray>=2022.3.0->rioxarray) (1
Installing collected packages: snuggs, affine, rasterio, rioxarray
Successfully installed affine-2.4.0 rasterio-1.3.9 rioxarray-0.15.1 snuggs-1.4.7
```

NOTE: YOU MAY ENCOUNTER WARNING MESSGAE WHEN RUNNING THE GIVEN CODE AND SOLUTION, PLEASE INGORE IT

Q1. Health Network Fairness in Choropleth

Q1a

Your Text Answer

1. Key: 'amenity'; Value: 'hospital'
2. Key: 'amenity'; Value: 'clinic'
3. Key: 'amenity'; Vlaue: 'doctor'

Q1b

```
### DO NOT MODIFY ###
warnings.filterwarnings('ignore')
place = 'toronto, ontario, canada'
tag = {'amenity': ['hospital', 'clinic']}
toronto_hospital = gpd.read_file('https://raw.githubusercontent.com/MIE223-2024/course-datasets/main/toronto_hospital.geojson')
#toronto_hospital = toronto_hospital[toronto_hospital['emergency'] == 'yes'][['name', 'geometry']].reset_index(drop=True)
toronto_hospital['proerpty_type'] = 'hospital'
toronto_hospital['geometry'] = toronto_hospital['geometry'].apply(lambda x: x.centroid)
toronto_hospital.head()
```

	name	proerpty_type	geometry
0	Scarborough Health Network - Centenary Hospital	hospital	POINT (-79.20481 43.78025)
1	Centre For Addiction and Mental Health - Queen...	hospital	POINT (-79.41864 43.64300)
2	Sunnybrook Health Sciences Centre - Bayview Ca...	hospital	POINT (-79.37479 43.72270)
3	Toronto Western Hospital	hospital	POINT (-79.40548 43.65351)
4	St. Joseph's Health Centre	hospital	POINT (-79.45006 43.64030)

Next steps: Generate code with toronto_hospital View recommended plots

```
### DO NOT MODIFY ###
warnings.filterwarnings('ignore')
!wget https://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/files-fichiers/2016/lfsa000a16a_e.zip
!unzip lfsa000a16a_e.zip -d lfsa000a16a_e

toronto_FSA = gpd.read_file('lfsa000a16a_e')
# 'CFSAUID' start with m
toronto_FSA = toronto_FSA[toronto_FSA['CFSAUID'].str.startswith('M')]
toronto_FSA = toronto_FSA[['CFSAUID', 'geometry']]
toronto_FSA['proerpty_type'] = 'FSA'
toronto_FSA.columns = ['name', 'geometry', 'proerpty_type']
toronto_FSA.head()
```

```
--2024-03-31 23:21:51--  https://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/files-fich
Resolving www12.statcan.gc.ca (www12.statcan.gc.ca)... 167.44.105.15
Connecting to www12.statcan.gc.ca (www12.statcan.gc.ca)|167.44.105.15|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 15662579 (15M) [application/x-zip-compressed]
Saving to: ‘lfsa000a16a_e.zip.4’

lfsa000a16a_e.zip.4 100%[===================>]  14.94M  2.49MB/s    in 7.7s

2024-03-31 23:21:59 (1.94 MB/s) - ‘lfsa000a16a_e.zip.4’ saved [15662579/15662579]

Archive:  lfsa000a16a_e.zip
replace lfsa000a16a_e/lfsa000a16a_e.dbf? [y]es, [n]o, [A]ll, [N]one, [r]ename: A
  inflating: lfsa000a16a_e/lfsa000a16a_e.dbf
  inflating: lfsa000a16a_e/lfsa000a16a_e.prj
  inflating: lfsa000a16a_e/lfsa000a16a_e.shp
  inflating: lfsa000a16a_e/lfsa000a16a_e.shx
  inflating: lfsa000a16a_e/forward_sortation_area.html
  inflating: lfsa000a16a_e/92-179-g2016001-eng.pdf
```

	name	geometry	proerpty_type
637	M9R	POLYGON ((7209908.140 928259.897, 7209816.766 ...	FSA
638	M9V	POLYGON ((7206682.694 937743.451, 7206631.563 ...	FSA
639	M9W	POLYGON ((7210531.760 934710.503, 7210542.117 ...	FSA
701	M1P	POLYGON ((7233594.731 942118.174, 7233584.157 ...	FSA
702	M1R	MULTIPOLYGON (((7231166.760 939882.914, 723135...	FSA

Next steps: Generate code with toronto_FSA View recommended plots

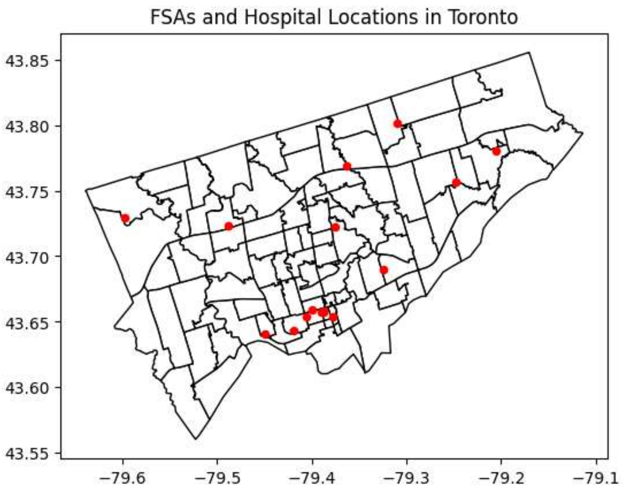
```
### Your code here ###
#check and update CRS; concat gdf
def prepare_gdf(hospitals, fsa):
    #check and update CRS to EPSG:4326 if they are not the same
    if hospitals.crs.to_string() != 'EPSG:4326':
        hospitals = hospitals.to_crs(epsg=4326)
    if fsa.crs.to_string() != 'EPSG:4326':
        fsa = fsa.to_crs(epsg=4326)

    #concat the two gdf
    gdf_all = gpd.GeoDataFrame(pd.concat([hospitals, fsa], ignore_index=True))

    return gdf_all

#prepare the combined gdf
gdf_all = prepare_gdf(toronto_hospital, toronto_FSA)

gdf_all.head()
```

	name	proerpty_type	geometry
0	Scarborough Health Network - Centenary Hospital	hospital	POINT (-79.20481 43.78025)
1	Centre For Addiction and Mental Health - Queen...	hospital	POINT (-79.41864 43.64300)
2	Sunnybrook Health Sciences Centre - Bayview Ca...	hospital	POINT (-79.37479 43.72270)
3	Toronto Western Hospital	hospital	POINT (-79.40548 43.65351)
4	St. Joseph's Health Centre	hospital	POINT (-79.45006 43.64030)

Next steps: Generate code with gdf_all View recommended plots

Q1c

```
### Your code here ###
#diplay the choropleth
ax = gdf_all[gdf_all['proerpty_type'] == 'FSA'].plot(color='white', edgecolor='black')
gdf_all[gdf_all['proerpty_type'] == 'hospital'].plot(ax=ax, color='red', markersize=20)
ax.set_title('FSAs and Hospital Locations in Toronto')

plt.show()
```



Your Text Answer

Yes, the choropleth indicates an imbalance in hospital distribution, with hospitals concentrated centrally and fewer in outlying areas.

Q1d

```
# calculate the centroid of each row in gdf_all if it is a polygon or MultiPolygon
## Your code here ###
from shapely.geometry import Point, Polygon, MultiPolygon

def calc_centroid(gdf):
    #adds a 'centroid' column to the GeoDataFrame
    #if it a polygon or multipolygon, the centroid is calculated
    #otw it uses the existing geometry
    gdf['centroid'] = gdf.apply(
        lambda row: row['geometry'].centroid if isinstance(row['geometry'],
         (Polygon, MultiPolygon))
        else row['geometry'],
        axis=1
    )
    return gdf

gdf_all = calc_centroid(gdf_all)

gdf_all
##your code end here ###
```

	name	proerpty_type	geometry	centroid
0	Scarborough Health Network - Centenary Hospital	hospital	POINT (-79.20481 43.78025)	POINT (-79.20481 43.78025)
1	Centre For Addiction and Mental Health - Queen...	hospital	POINT (-79.41864 43.64300)	POINT (-79.41864 43.64300)
2	Sunnybrook Health Sciences Centre - Bayview Ca...	hospital	POINT (-79.37479 43.72270)	POINT (-79.37479 43.72270)
3	Toronto Western Hospital	hospital	POINT (-79.40548 43.65351)	POINT (-79.40548 43.65351)
4	St. Joseph's Health Centre	hospital	POINT (-79.45006 43.64030)	POINT (-79.45006 43.64030)
...	...	...	...	...
107	M6M	FSA	POLYGON ((-79.46802 43.70291, -79.46710 43.699...	POINT (-79.48531 43.69389)
108	M6N	FSA	POLYGON ((-79.48663 43.68739, -79.48322 43.685...	POINT (-79.48394 43.67458)

Next steps: Generate code with gdf_all View recommended plots

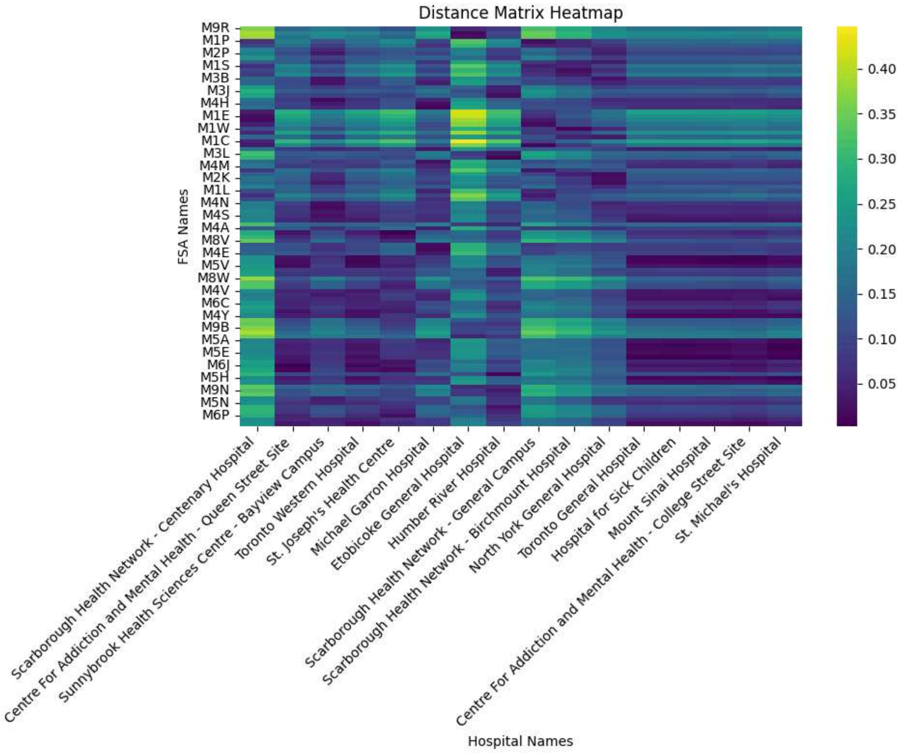
```
# calculate the distance matrix between each FSA centroid and hospital
## Your code here ###
def calc_distance_matrix(gdf_all, fsa_col='FSA', hospital_col='hospital') -> pd.DataFrame:

    #filter FSAs and hospitals from gdf_all
    fsas = gdf_all[gdf_all['proerpty_type'] == fsa_col].reset_index(drop=True)
    hospitals = gdf_all[gdf_all['proerpty_type'] == hospital_col].reset_index(drop=True)

    #init the distance matrix with zeros
    distance_matrix = np.zeros((len(fsas), len(hospitals)))

    #calc distance
    for i in range(len(fsas)):
        for j in range(len(hospitals)):
            distance = fsas.at[i, 'centroid'].distance(hospitals.at[j, 'centroid'])
            distance_matrix[i, j] = distance

    #conv the distance matrix to a df
    distance_df = pd.DataFrame(distance_matrix, index=fsas['name'], columns=hospitals['name'])
    return distance_df

distance_df = calc_distance_matrix(gdf_all)
distance_df
```

name	Scarborough Health Network - Centenary Hospital	Centre For Addiction and Mental Health - Queen Street Site	Sunnybrook Health Sciences Centre - Bayview Campus	Toronto Western Hospital	St. Joseph's Health Centre	Michael Garron Hospital	Etobicoke General Hospital	Humber River Hospital	Scarborough Health Network - General Campus
name									
M9R	0.365086	0.146369	0.186494	0.156309	0.117911	0.233066	0.057618	0.078006	0.317728
M9V	0.391324	0.202029	0.220449	0.208868	0.176941	0.274522	0.013983	0.107479	0.346817
M9W	0.385836	0.178507	0.209764	0.187347	0.151057	0.259992	0.023838	0.096522	0.339601
M1P	0.067660	0.190490	0.111969	0.173655	0.217406	0.090713	0.329641	0.222007	0.022906
M1R	0.097361	0.161511	0.082105	0.144695	0.187853	0.065660	0.301504	0.193196	0.049884
...	...	...	...	...	...	...	...	...	..
M6M	0.293495	0.083878	0.114210	0.089463	0.064147	0.160427	0.118097	0.029711	0.245643
M6N	0.298467	0.072537	0.119286	0.081238	0.048196	0.159750	0.126477	0.049066	0.249968
M6P	0.285114	0.048019	0.108432	0.058355	0.024037	0.141657	0.151200	0.067982	0.236166
M5R	0.223942	0.053771	0.045937	0.043473	0.067544	0.087772	0.188410	0.080785	0.175306

Next steps: Generate code with `distance_df` View recommended plots

Q1e

```
warnings.filterwarnings('ignore')
import seaborn as sns
### you code here##
#plot the heatmap
distance_matrix = distance_df.apply(pd.to_numeric)
plt.figure(figsize=(10,8))
sns.heatmap(distance_matrix, annot=False, cmap='viridis')
plt.title('Distance Matrix Heatmap')
plt.xlabel('Hospital Names')
plt.ylabel('FSA Names')
plt.xticks(rotation=45, ha='right')
plt.yticks(rotation=0)
plt.tight_layout()
plt.show()
```



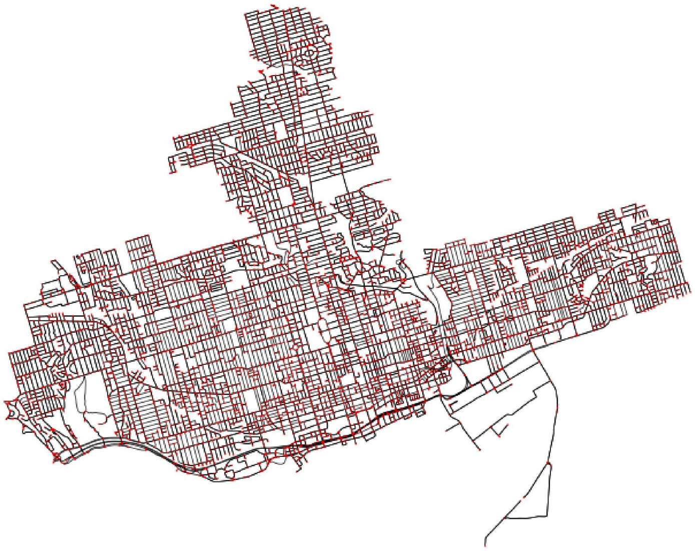
Your Text Answer

The heatmap suggests potential imbalances with certain FSAs having uniformly longer distances to hospitals, but the dense color overlap makes detailed insights difficult.

Q2: Visualizing Health Network Fairness

Q2a

```
## you code here ##
place_name = "Toronto, Ontario, Canada"
network_type = "drive"

graph = ox.graph_from_place(place_name, network_type=network_type)

nodes, edges = ox.graph_to_gdfs(graph, nodes=True, edges=True)

fig, ax = ox.plot_graph(graph, node_size=1, node_color='red',
                        edge_linewidth=0.5, edge_color='black', bgcolor='white')

number_of_nodes = len(nodes)
number_of_edges = len(edges)

number_of_nodes, number_of_edges
# the solution might take > 1 min to run
```



```
(5759, 15184)
```

your text answer

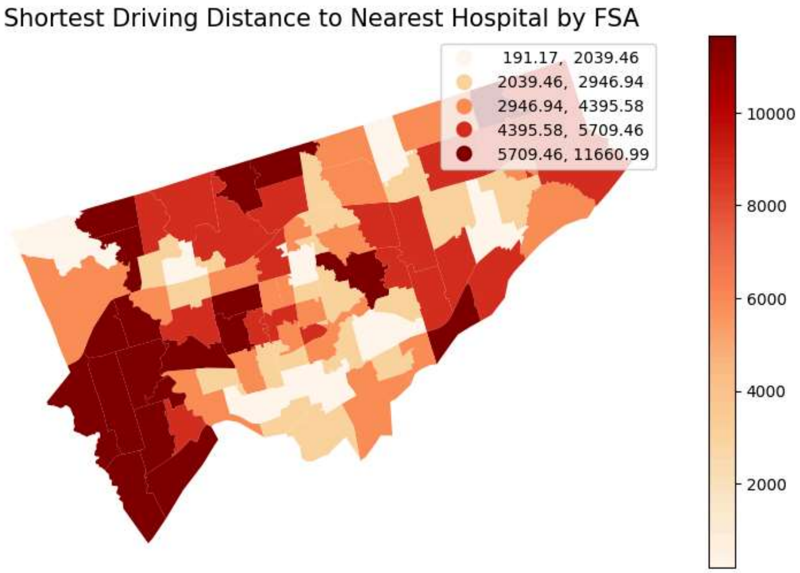
There are 5759 nodes and 15184 edges.

Q2b

```
### DO NOT MODIFY ###
warnings.filterwarnings('ignore')
distance_matrix_by_shortest_path = pd.read_csv('https://raw.githubusercontent.com/MIE223-2024/course-datasets/main/distance_matrix_by_shortest_path.csv', index_col
# create a new pandas series to store the nearest distance
smallest_distance_by_shortest_path = distance_matrix_by_shortest_path.min(axis=1)
# assign the name of the series for future merging
smallest_distance_by_shortest_path.name = 'nearest_hospital'

# obtain all row that is a foward sortation area
toronto_FSA.to_crs(epsg=4326, inplace=True)
toronto_FSA['centroid'] = toronto_FSA['geometry'].apply(lambda x: x.centroid)
# merge the distance series with the FSA shape data
gdf_smallest_distance_by_shortest_path = toronto_FSA.merge(smallest_distance_by_shortest_path, left_on='name', right_index=True).rename(columns={0: 'nearest_hospit
gdf_smallest_distance_by_shortest_path.head()
# your output should be exactly the same as the expected output, if not, re-run given code in Q1
```

	name	geometry	proerpty_type	centroid	nearest_hospital
637	M9R	POLYGON ((-79.56131 43.67478, -79.56249 43.674...	FSA	POINT (-79.55799 43.68778)	6973.215
638	M9V	POLYGON ((-79.57759 43.76205, -79.57829 43.761...	FSA	POINT (-79.59433 43.74274)	1854.019
639	M9W	POLYGON ((-79.53885 43.72937, -79.53884 43.728...	FSA	POINT (-79.58416 43.70983)	2981.682
701	M1B	POLYGON ((-79.24704 43.75374,	FSA	POINT (-79.27000	[illegible]

```
## you code here ##
import mapclassify

gdf_smallest_distance_by_shortest_path['nearest_hospital'] = gdf_smallest_distance_by_shortest_path['nearest_hospital'].astype(float)

fig, ax = plt.subplots(1, 1, figsize=(10, 6))
gdf_smallest_distance_by_shortest_path.plot(column='nearest_hospital',
                                            ax=ax,
                                            legend=True,
                                            cmap='OrRd',
                                            scheme='quantiles')

ax.axis('off')

ax.set_title('Shortest Driving Distance to Nearest Hospital by FSA',
             fontdict={'fontsize': '15', 'fontweight' : '3'})

sm = plt.cm.ScalarMappable(cmap='OrRd',
                           norm=plt.Normalize(vmin=gdf_smallest_distance_by_shortest_path['nearest_hospital'].min(),
                                              vmax=gdf_smallest_distance_by_shortest_path['nearest_hospital'].max()))
#empty array for the data range
sm._A = []
#add the colorbar to the fig
cbar = fig.colorbar(sm)

plt.show()
```



your text answer

The choropleth map shows an imbalance, with some FSAs having significantly longer distances to the nearest hospital, as indicated by the darker areas.

Q2c

```
## DO NOT MODIFY ##
warnings.filterwarnings('ignore')
census_data = pd.read_csv('https://raw.githubusercontent.com/MIE223-2024/course-datasets/main/2016_census.csv').iloc[:, 1:]
census_data.columns = ['name', 'median_income', 'population','visual_minority']
census_data['prec_visual_minority'] = census_data['visual_minority'] / census_data['population']
census_data = toronto_FSA.merge(census_data, on='name')
census_data = census_data[['name','prec_visual_minority','centroid']]
census_data

# your output should be exactly the same as the expected output, if not, re-run given code in Q1
```

	name	prec_visual_minority	centroid
0	M9R	0.544557	POINT (-79.55799 43.68778)
1	M9V	0.814882	POINT (-79.59433 43.74274)
2	M9W	0.689214	POINT (-79.58416 43.70983)
3	M1P	0.737640	POINT (-79.27000 43.76213)
4	M1R	0.564003	POINT (-79.29717 43.74945)

Next Generate code with census_data View recommended plots

```
# empty folium map
nearest_hospital_map = fm.Map(location=[43.7, -79.4], zoom_start=12,
                                  scrollWheelZoom=False, tiles=None,
                                    control_scale=True)
# geo-json file with vector shape of FSA
FSA_json = gdf_smallest_distance_by_shortest_path[['name', 'geometry']].to_json()

## you code here ##
from folium import Choropleth, LayerControl, FeatureGroup, CircleMarker
merged_data = pd.merge(census_data, gdf_smallest_distance_by_shortest_path, on='name')

fm.TileLayer('openstreetmap').add_to(nearest_hospital_map)

Choropleth(
    geo_data=FSA_json,
    name='Hospital Distance',
    data=merged_data,  # This should be the merged DataFrame with 'nearest_hospital' data
    columns=['name', 'nearest_hospital'],
    key_on='feature.properties.name',
    fill_color='OrRd',
    fill_opacity=0.7,
    line_opacity=0.2,
    legend_name='Shortest driving distance to the nearest hospital (meters)',
    bins=[merged_data['nearest_hospital'].quantile(q) for q in [0, 0.25, 0.5, 0.75, 1]],
    reset=True
).add_to(nearest_hospital_map)

circle_feature_group = FeatureGroup(name='Visual Minority Percentage')
for idx, row in census_data.iterrows():
    CircleMarker(
        location=[row['centroid'].y, row['centroid'].x],  # Assuming centroid is a Point object
        radius=row['prec_visual_minority'] * 20,  # Adjust the multiplier for visibility
        color='blue',
        fill=True,
        fill_color='blue',
        fill_opacity=0.6,
        popup=f'Visual Minorities: {row["prec_visual_minority"]:.2%}'
    ).add_to(circle_feature_group)

circle_feature_group.add_to(nearest_hospital_map)

LayerControl().add_to(nearest_hospital_map)

nearest_hospital_map
```

+
−
Bolton
Hill
Markham
Ajax
Pickering
191
2,337
3,873
5,243
11,661
Shortest driving distance to the nearest hospital (meters)