Global Air Quality and Respiratory Health Outcomes

July 1, 2025

[1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

[3]:
```
df = pd.read_csv('../data/air_quality_health_dataset.csv')
print(df.head())
print(df.info())
```

```
          city        date  aqi  pm2_5  pm10   no2    o3  temperature  \
0  Los Angeles  2020-01-01   65   34.0  52.7   2.2  38.5         33.5
1      Beijing  2020-01-02  137   33.7  31.5  36.7  27.5         -1.6
2       London  2020-01-03  266   43.0  59.6  30.4  57.3         36.4
3  Mexico City  2020-01-04  293   33.7  37.9  12.3  42.7         -1.0
4        Delhi  2020-01-05  493   50.3  34.8  31.2  35.6         33.5

   humidity  hospital_admissions population_density  hospital_capacity
0        33                    5              Rural               1337
1        32                    4              Urban               1545
2        25                   10           Suburban               1539
3        67                   10              Urban                552
4        72                    9           Suburban               1631
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 88489 entries, 0 to 88488
Data columns (total 12 columns):
 #   Column               Non-Null Count  Dtype
---  ------               --------------  -----
 0   city                 88489 non-null  object
 1   date                 88489 non-null  object
 2   aqi                  88489 non-null  int64
 3   pm2_5                88489 non-null  float64
 4   pm10                 88489 non-null  float64
 5   no2                  88489 non-null  float64
 6   o3                   88489 non-null  float64
 7   temperature          88489 non-null  float64
 8   humidity             88489 non-null  int64
 9   hospital_admissions  88489 non-null  int64
 10  population_density   88489 non-null  object
 11  hospital_capacity    88489 non-null  int64
```

```
dtypes: float64(5), int64(4), object(3)
memory usage: 8.1+ MB
None
```

[5]:

```
# Missing values are checked for each column
print("Missing values:\n", df.isna().sum())
```

```
Missing values:
 city                   0
date                   0
aqi                    0
pm2_5                  0
pm10                   0
no2                    0
o3                     0
temperature            0
humidity               0
hospital_admissions    0
population_density     0
hospital_capacity      0
dtype: int64
```

[7]:

```
# Convert the 'date' column to datetime format
df['date'] = pd.to_datetime(df['date'])
```

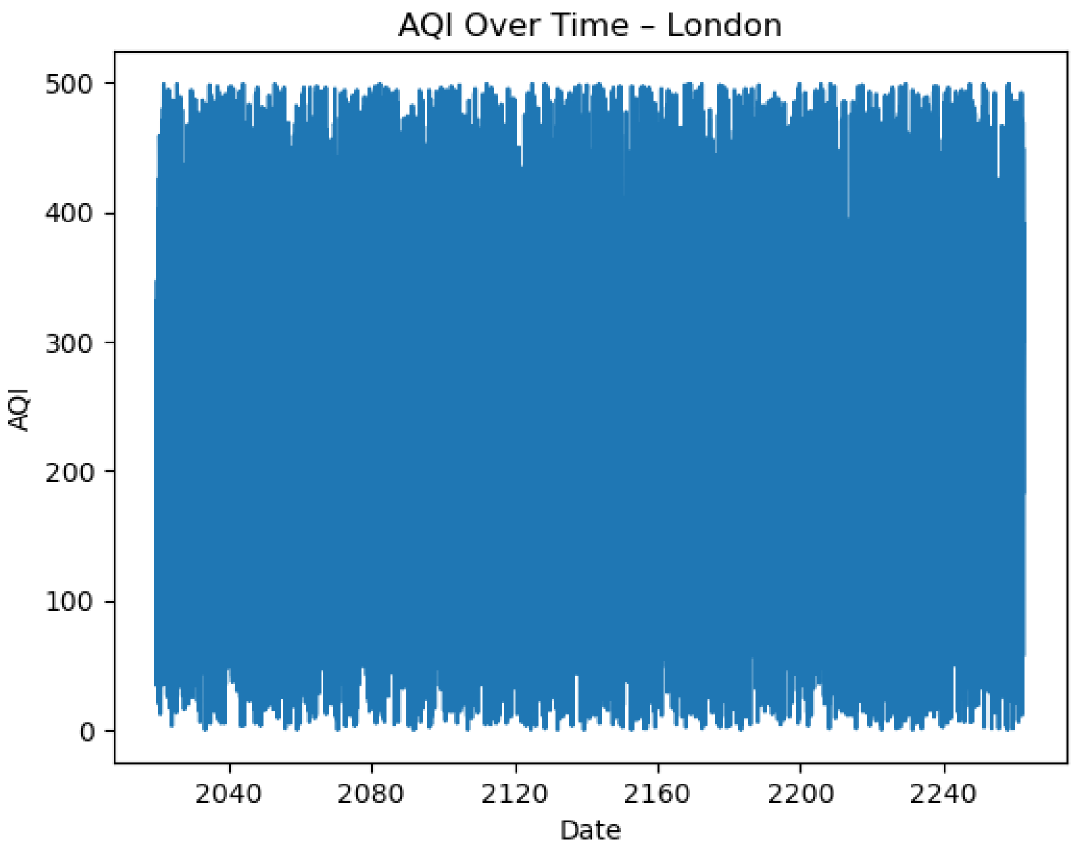
[15]:

```
# Top 10 days with the highest PM2.5 levels
top_pm25 = df.nlargest(10, 'pm2_5')[['city', 'date', 'pm2_5']]
print(top_pm25)
```

```
              city       date  pm2_5
52628        Delhi 2164-02-03  109.9
43181        Delhi 2138-03-24  108.7
31482        Cairo 2106-03-13  105.2
5164   Mexico City 2034-02-20  103.8
75840        Delhi 2227-08-24   96.3
43350        Delhi 2138-09-09   95.9
10471  Mexico City 2048-09-01   94.7
40433        Delhi 2130-09-14   94.1
57637        Delhi 2177-10-21   93.4
77990        Delhi 2233-07-13   92.9
```

[17]:

```
#Line plot of Air Quality Index (AQI) in London
la = df[df['city']=='London']
plt.plot(la['date'], la['aqi'])
plt.title('AQI Over Time - London')
plt.ylabel('AQI')
plt.xlabel('Date')
plt.show()
```

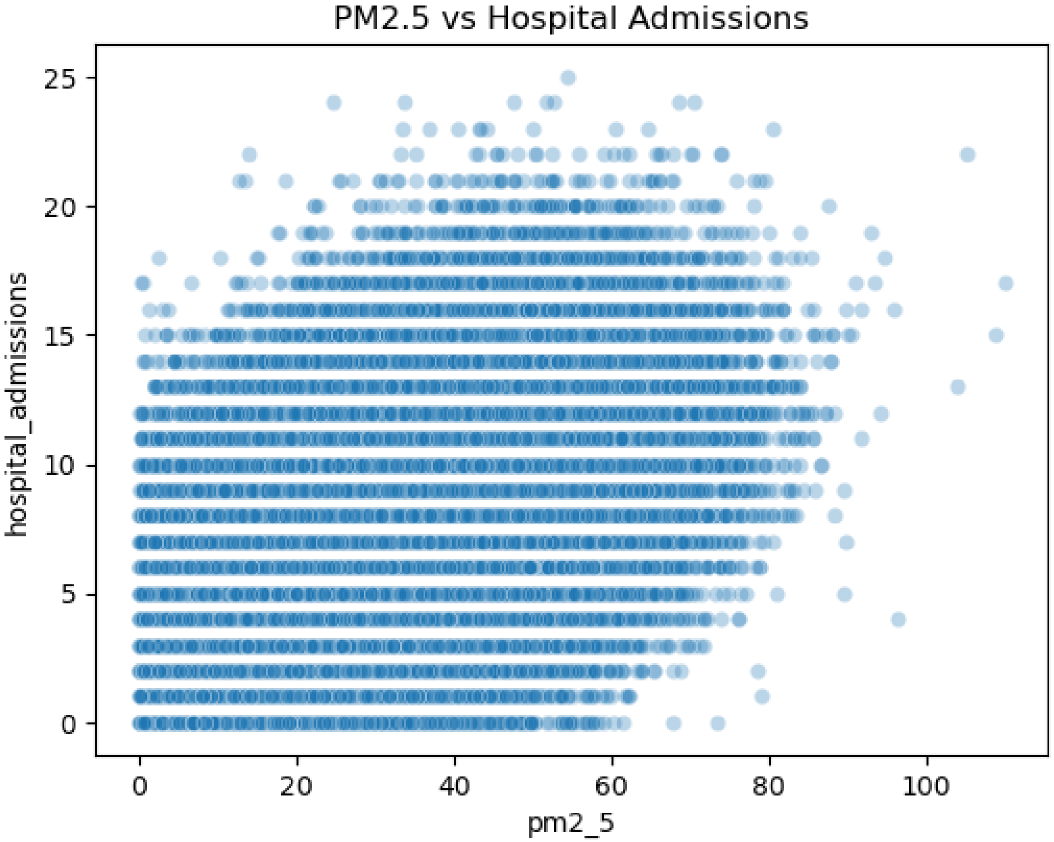


```
[35]: # Average hospital admissions per city (Top 10 cities)
      df.groupby('city')['hospital_admissions'].mean().sort_values(ascending=False).
       ↪head(10)
```

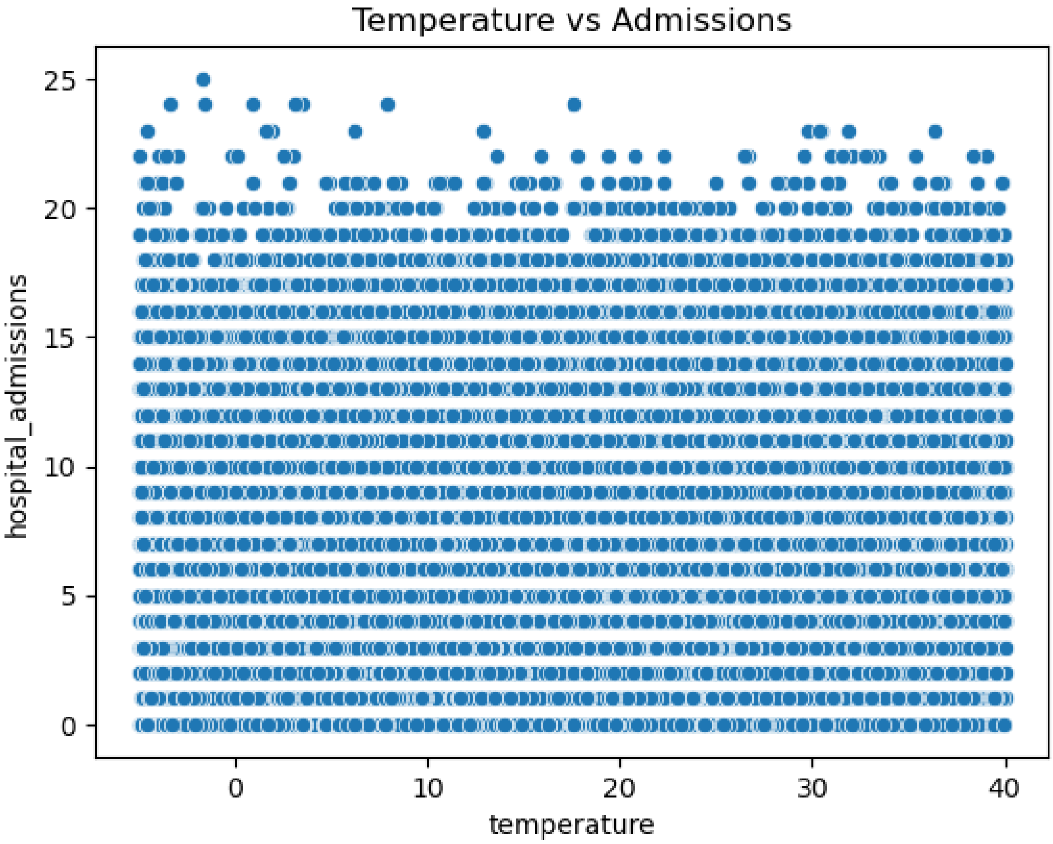
```
[35]: city
      Cairo            8.108519
      Beijing          8.096039
      London           8.057409
      Delhi            8.044323
      Tokyo            8.028469
      Los Angeles      8.021215
      Mexico City      8.007550
      São Paulo        7.952517
      Name: hospital_admissions, dtype: float64
```

[37]:

```
# Scatter plot showing the relationship between PM2.5 levels and hospital␣
 ↪admissions
sns.scatterplot(data=df, x='pm2_5', y='hospital_admissions', alpha=0.3)
plt.title('PM2.5 vs Hospital Admissions')
plt.show()
```



[41]:
```
# Scatter plot showing the relationship between temperature and hospital␣
↪admissions
sns.scatterplot(data=df, x='temperature', y='hospital_admissions')
plt.title('Temperature vs Admissions')
plt.show()
```

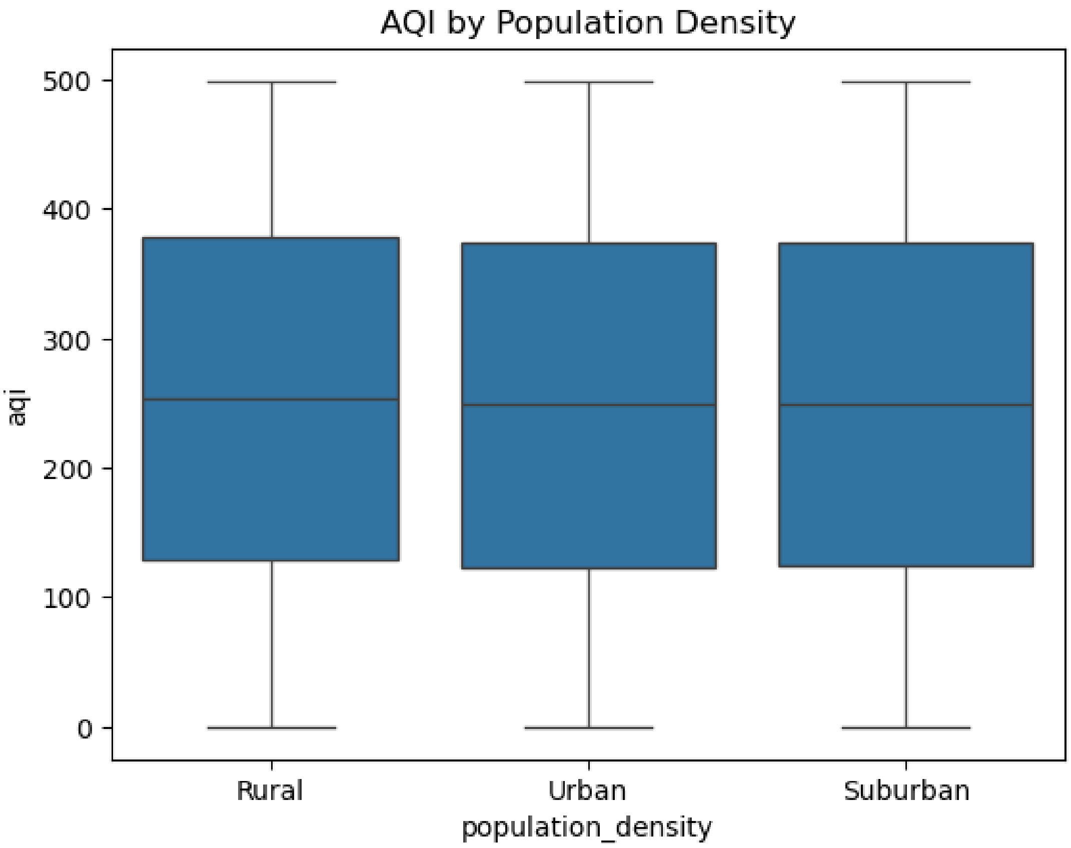


[43]:
```
# Average Air Quality Index (AQI) by population density
df.groupby('population_density')['aqi'].mean()
```

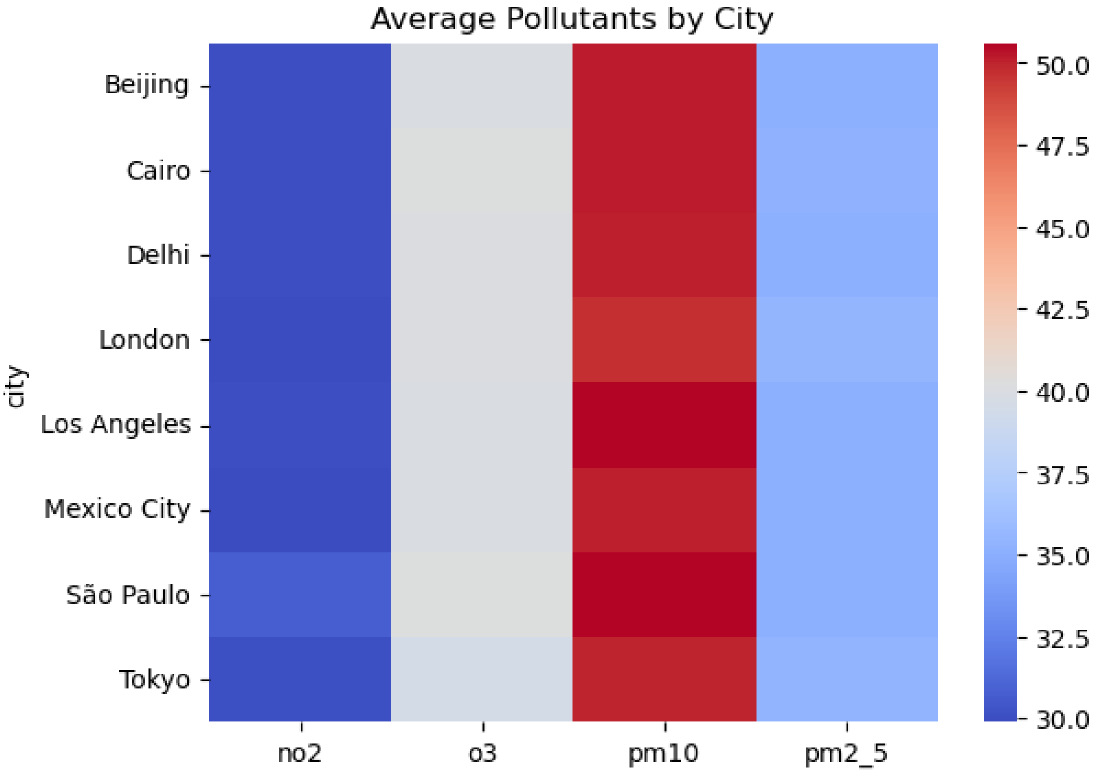
[43]:
```
population_density
Rural       252.397079
Suburban    248.999131
Urban       249.052207
Name: aqi, dtype: float64
```

[45]:

```
# Boxplot of AQI levels by population density
sns.boxplot(data=df, x='population_density', y='aqi')
plt.title('AQI by Population Density')
plt.show()
```



[49]:
```
# Heatmap showing average pollution levels (PM2.5, PM10, NO2, O3) by city

pollutants = df.pivot_table(index='city', values=['pm2_5','pm10','no2','o3'],␣
 ↪aggfunc='mean')
sns.heatmap(pollutants, cmap='coolwarm')
plt.title('Average Pollutants by City')
plt.show()
```



[61]:
```
# Top cities with the highest total hospital admissions
df.groupby('city')['hospital_admissions'].sum().nlargest(10)
```

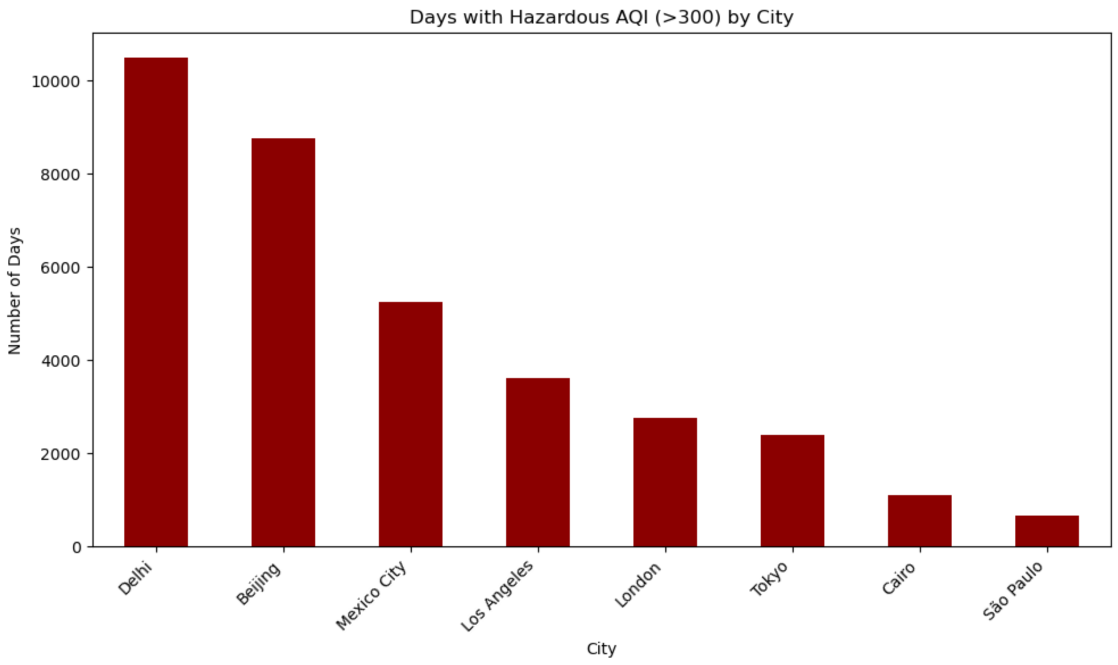
[61]:
```
city
Delhi          212893
Beijing        178631
Mexico City    107117
Los Angeles     72215
London          56281
Tokyo           49351
Cairo           21893
```

```
São Paulo       13901
Name: hospital_admissions, dtype: int64
```

[105]:

```
#City Comparison of Extreme Pollution Days
# Count days with AQI > 300 (Hazardous) by city

hazardous_days = df[df['aqi'] > 300].groupby('city').size().
 ↪sort_values(ascending=False)
print("Days with Hazardous AQI (>300) by City:")
print(hazardous_days)
plt.figure(figsize=(10, 6))
hazardous_days.plot(kind='bar', color='darkred')
plt.title('Days with Hazardous AQI (>300) by City')
plt.xlabel('City')
plt.ylabel('Number of Days')
plt.xticks(rotation=45, ha='right')
plt.tight_layout()
plt.show()
```

```
Days with Hazardous AQI (>300) by City:
city
Delhi          10492
Beijing         8752
Mexico City     5250
Los Angeles     3617
London          2771
Tokyo           2402
Cairo           1101
São Paulo        676
dtype: int64
```



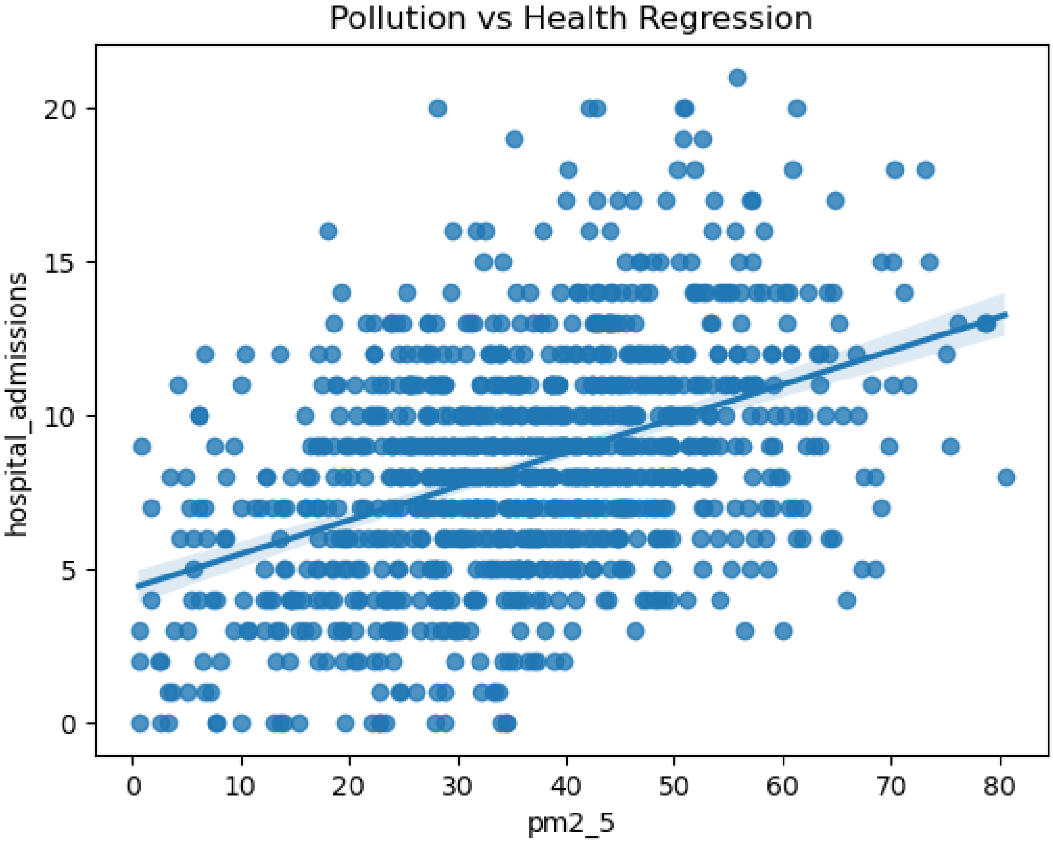
[71]:

```
# Annual average AQI over the years
mask = (df['date']>='2020-01-01')&(df['date']<'2021-01-01')
df[mask].groupby('city')['aqi'].mean()
```

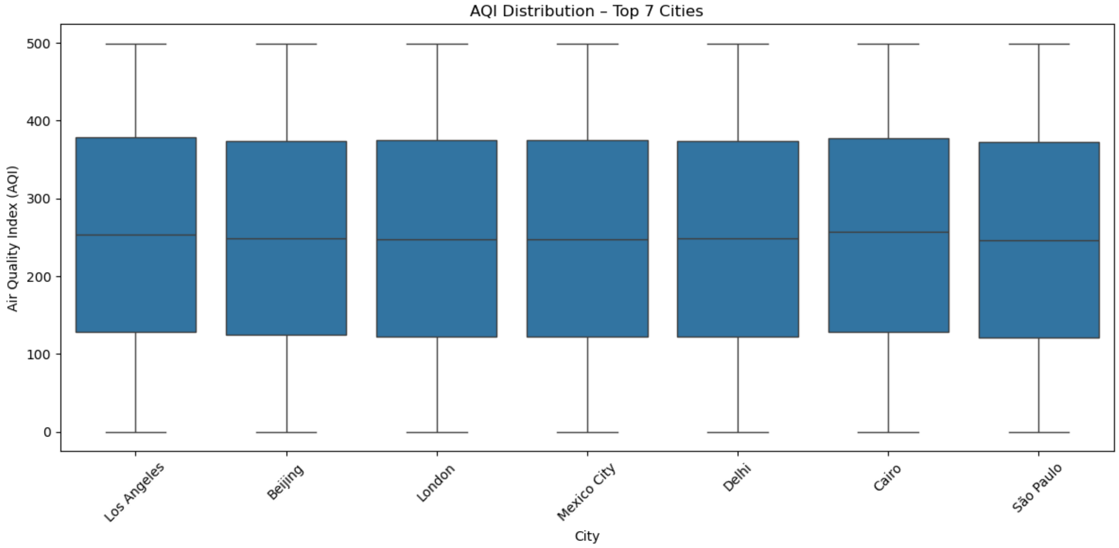
[71]:

```
city
Beijing          273.400000
Cairo            236.916667
Delhi            245.412281
London           221.064516
Los Angeles      268.189189
Mexico City      249.177419
São Paulo        392.000000
Tokyo            237.458333
Name: aqi, dtype: float64
```

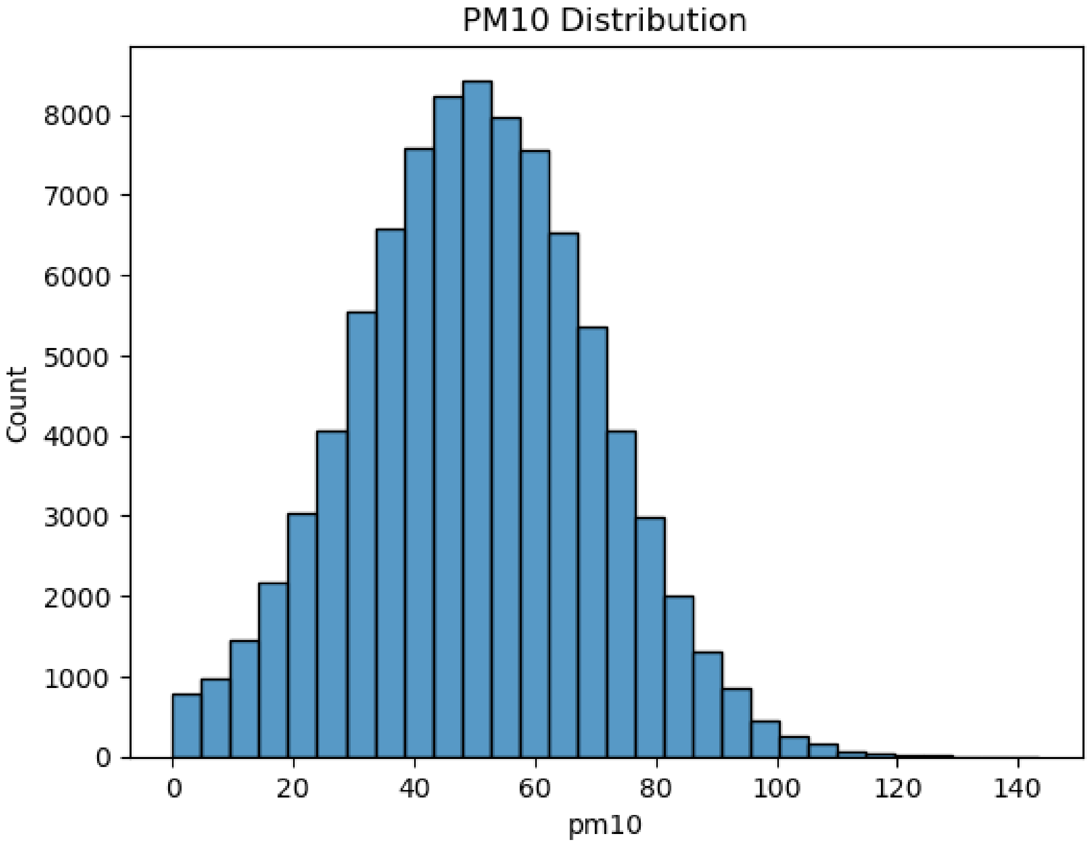
[85]:
```
#Simple Linear Regression Analysis: Relationship between PM2.5 and Hospital␣
↪Admissions
sns.regplot(x='pm2_5', y='hospital_admissions', data=df.sample(1000))
plt.title('Pollution vs Health Regression')
plt.show()
```



[95]:
```
# 18. AQI Distribution for the Top 7 Most Polluted Cities
top7 = df.groupby('city')['aqi'].mean().nlargest(7).index

plt.figure(figsize=(12, 6))
sns.boxplot(data=df[df['city'].isin(top7)], x='city', y='aqi')
plt.title('AQI Distribution - Top 7 Cities')
plt.xticks(rotation=45)
plt.ylabel('Air Quality Index (AQI)')
plt.xlabel('City')
plt.tight_layout()
plt.show()
```

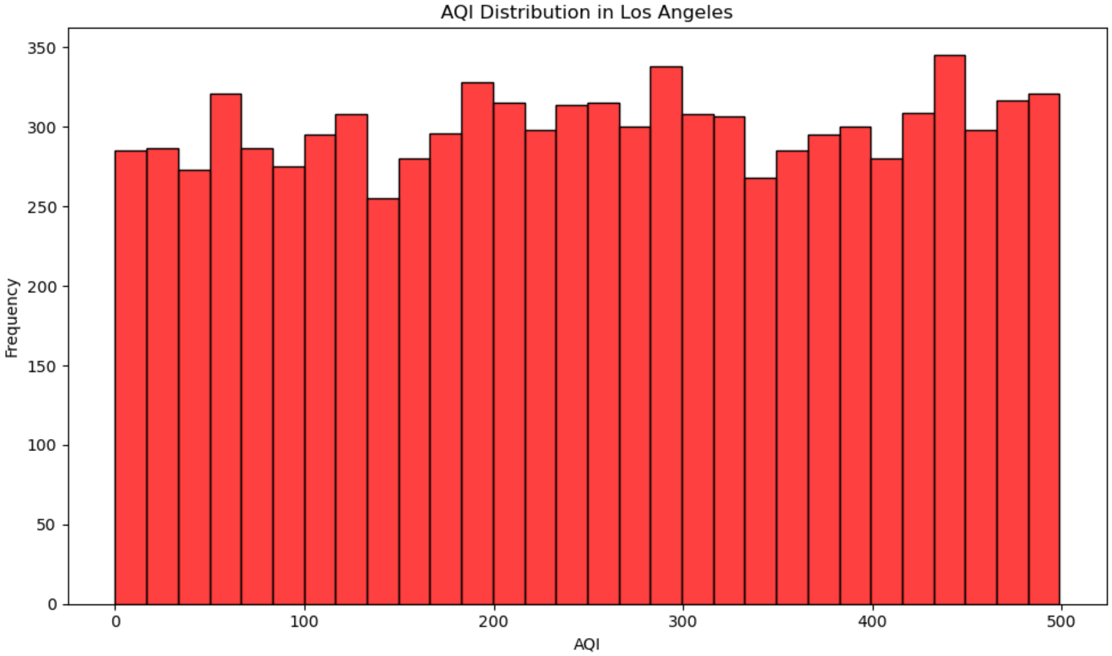


[93]:
```
sns.histplot(df['pm10'], bins=30)
plt.title('PM10 Distribution')
plt.show()
```



[103]:

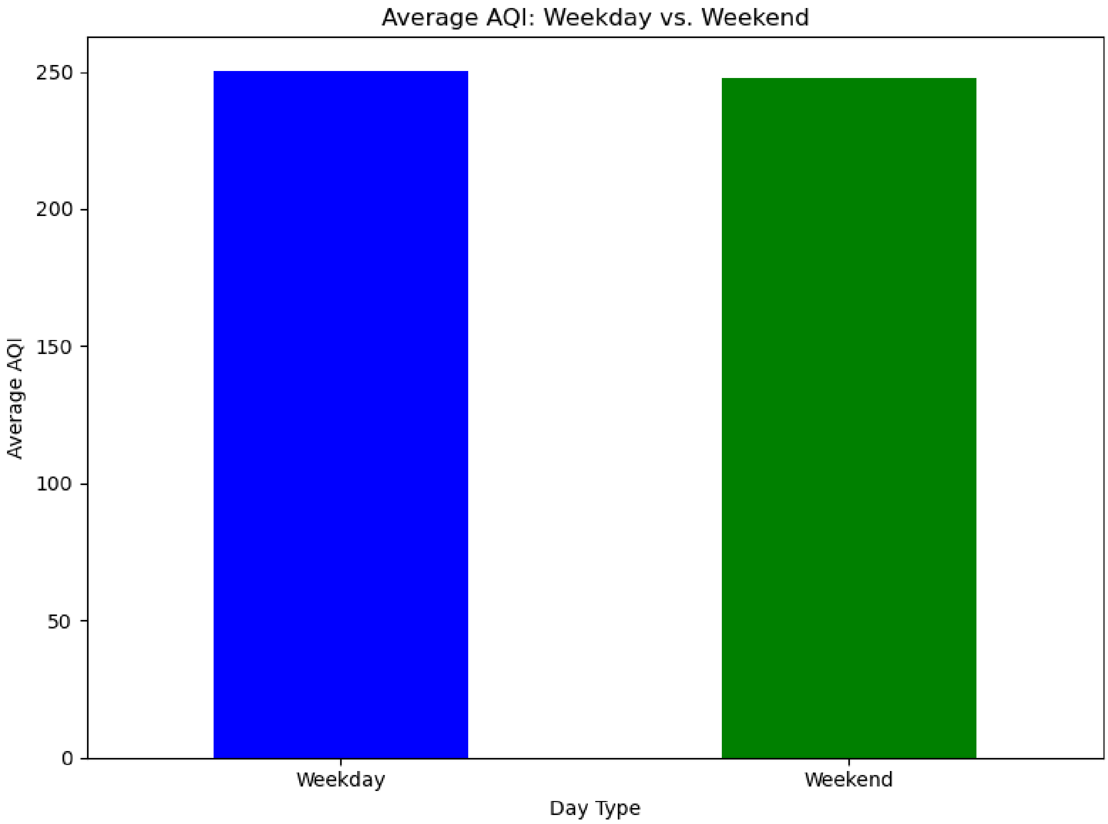
```
# City-Specific AQI Histogram
# Plot AQI distribution for top polluted city
top_city = df.groupby('city')['aqi'].mean().idxmax()
plt.figure(figsize=(10, 6))
sns.histplot(df[df['city'] == top_city]['aqi'], bins=30, color='red')
plt.title(f'AQI Distribution in {top_city}')
plt.xlabel('AQI')
plt.ylabel('Frequency')
plt.tight_layout()
plt.show()
```



[99]:

```
# Weekend vs. Weekday AQI Comparison
# Compare AQI on weekends vs. weekdays
df['day_of_week'] = df['date'].dt.dayofweek
df['is_weekend'] = df['day_of_week'].isin([5, 6])
aqi_weekend = df.groupby('is_weekend')['aqi'].mean()
print("Average AQI: Weekday vs. Weekend:")
print(aqi_weekend)
plt.figure(figsize=(8, 6))
aqi_weekend.plot(kind='bar', color=['blue', 'green'])
plt.title('Average AQI: Weekday vs. Weekend')
plt.xlabel('Day Type')
plt.ylabel('Average AQI')
plt.xticks([0, 1], ['Weekday', 'Weekend'], rotation=0)
plt.tight_layout()
plt.show()
```

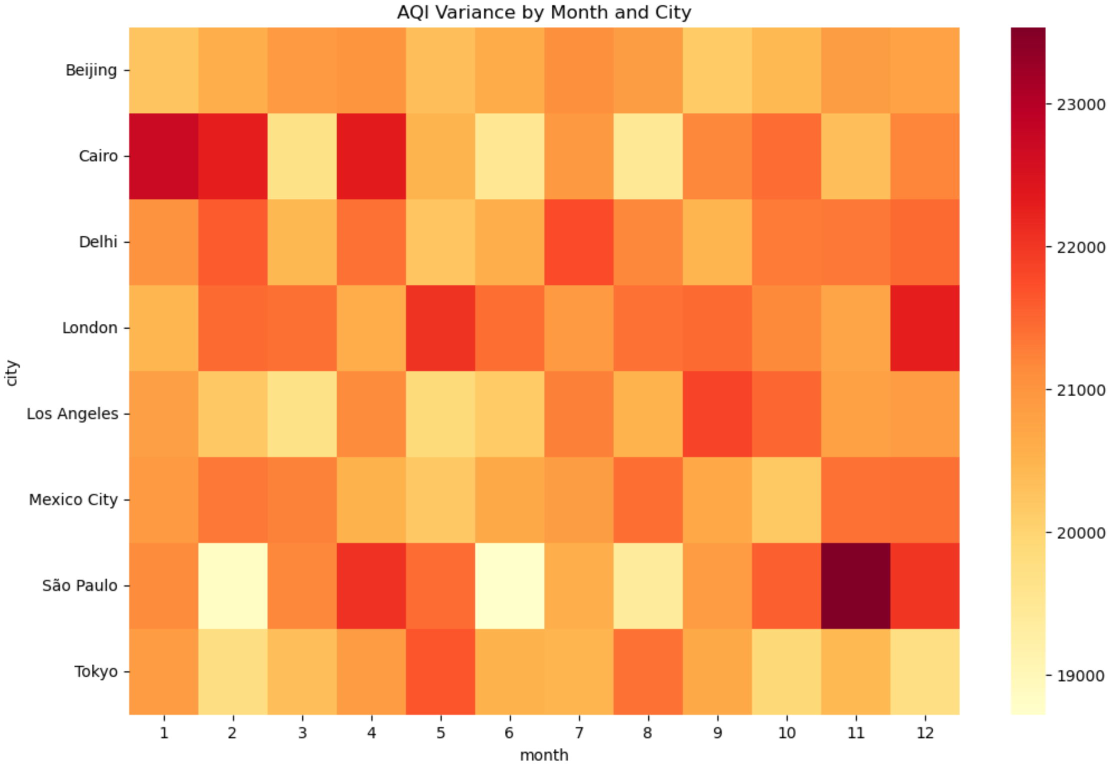
```
Average AQI: Weekday vs. Weekend:
is_weekend
False    250.043002
True     247.688078
Name: aqi, dtype: float64
```



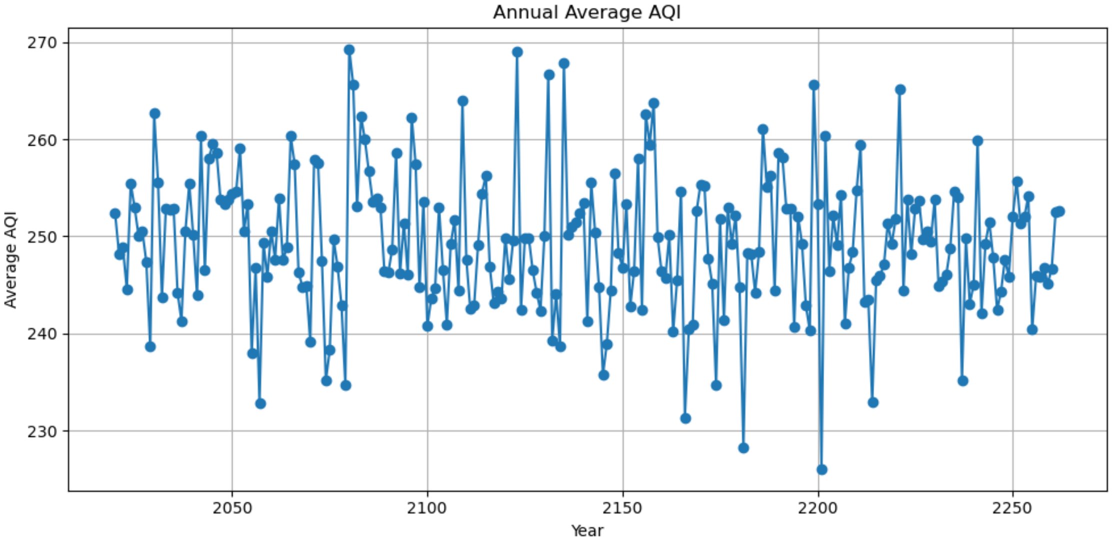
[109]:

```
#Monthly AQI Variance by City
# Calculate variance of AQI by month for each city
df['month'] = df['date'].dt.month
aqi_variance = df.groupby(['city', 'month'])['aqi'].var().unstack()
print("AQI Variance by Month and City:")
print(aqi_variance)
plt.figure(figsize=(12, 8))
sns.heatmap(aqi_variance, cmap='YlOrRd')
plt.title('AQI Variance by Month and City')
plt.show()
```

```
AQI Variance by Month and City:
month                   1             2             3             4   \
city
Beijing      20251.681782  20576.396850  20909.597959  21001.512997
Cairo        22705.849318  22288.054296  19675.014705  22323.321760
Delhi        21026.724436  21608.593142  20438.884101  21371.467676
London       20459.647485  21444.243397  21388.372484  20603.003784
Los Angeles  20834.124699  20175.640740  19664.042579  21125.159225
Mexico City  20906.085357  21322.747489  21224.460180  20530.157560
São Paulo    21133.356530  18837.132799  21166.645705  22055.874986
Tokyo        20889.843681  19752.248083  20345.702500  20886.261658

month                   5             6             7             8   \
city
Beijing      20349.831404  20626.295799  21085.438105  20878.264081
Cairo        20485.494110  19504.547400  20930.691502  19477.923988
Delhi        20235.484214  20564.806929  21780.744638  21177.805578
London       22037.544638  21421.969065  20908.783240  21374.595598
Los Angeles  19881.123054  20140.608000  21245.291729  20514.335777
Mexico City  20175.782638  20670.814945  20870.601782  21409.540250
São Paulo    21425.295260  18717.854806  20586.918321  19386.432206
Tokyo        21668.044243  20540.277919  20484.143195  21378.548921

month                   9             10            11            12
city
Beijing      20140.346190  20424.515405  20870.025037  20775.460928
Cairo        21169.391964  21433.884077  20334.508889  21192.104096
Delhi        20481.948432  21308.092310  21318.203511  21453.581290
London       21444.010012  21158.324686  20722.905136  22270.714671
Los Angeles  21848.777871  21487.742809  20803.065800  20896.395207
Mexico City  20688.794599  20184.762181  21369.139185  21387.439433
São Paulo    20895.014631  21557.394465  23530.107178  22013.838936
Tokyo        20659.706269  19910.498150  20412.535430  19739.822663
```


AQI Variance by Month and City
city
Beijing
Cairo
Delhi
London
Los Angeles
Mexico City
São Paulo
Tokyo
month
1
2
3
4
5
6
7
8
9
10
11
12
23000
22000
21000
20000
19000

[67]:
```
# Annual average AQI over the years
annual_avg_aqi = df.groupby(df['date'].dt.year)['aqi'].mean()

plt.figure(figsize=(10, 5))
annual_avg_aqi.plot(marker='o')
plt.title('Annual Average AQI')
plt.xlabel('Year')
plt.ylabel('Average AQI')
plt.grid(True)
plt.tight_layout()
plt.show()
```



[73]:

```
sns.
 ↪heatmap(df[['aqi','pm2_5','pm10','no2','o3','temperature','hospital_admissions']].
 ↪corr(), annot=True)
plt.title('Correlation Matrix')
plt.show()
```