Spatiotemporal Analysis of the Environmental Driver PM2.5 on Respiratory Health: Emergency Room Visits for Asthma and COPD

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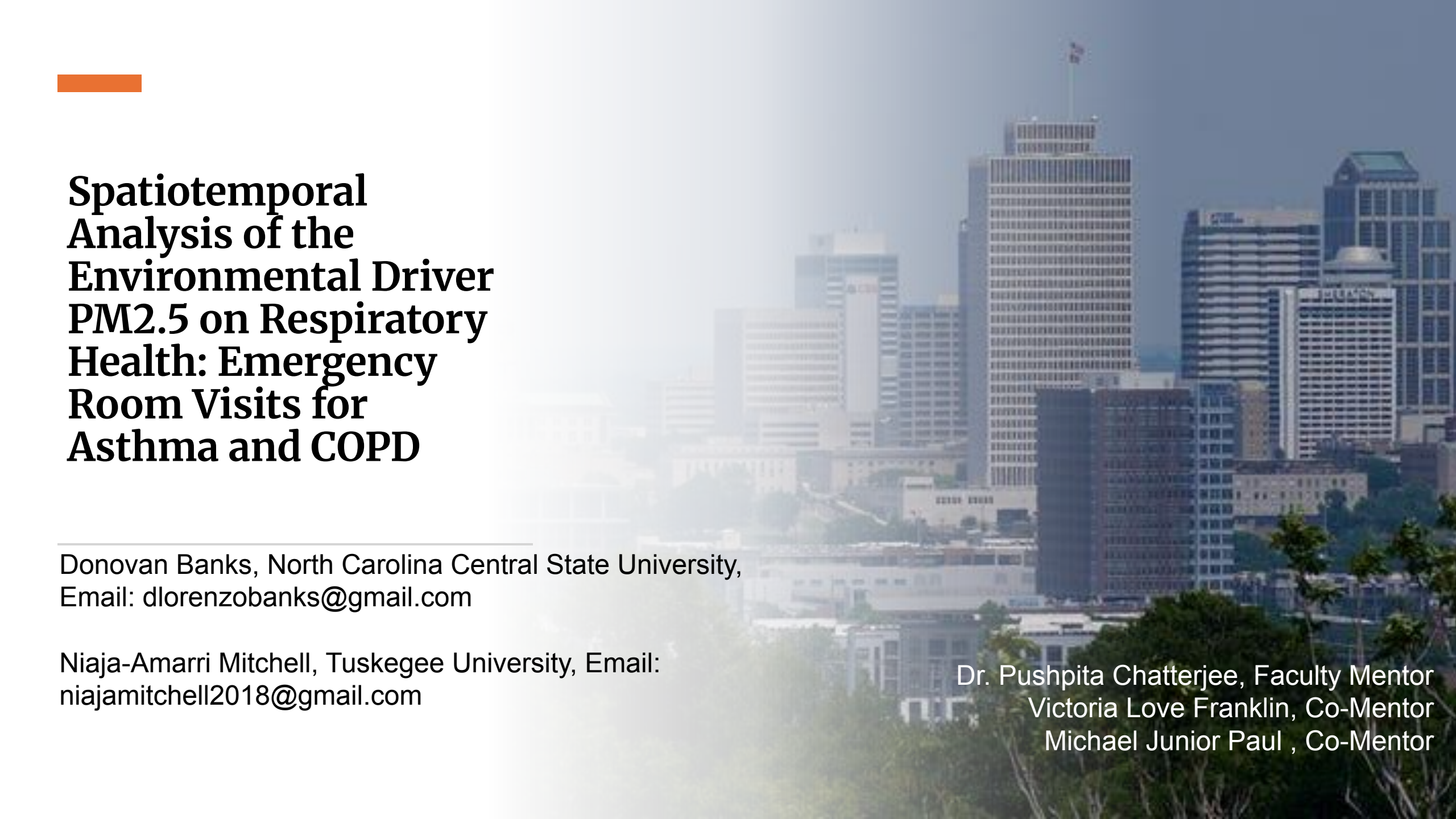


BACKGROUND

- Respiratory Illnesses Remain A Critical Public Health Concern In The United States, Disproportionately Affecting Vulnerable Populations, Including Children Under 18, Adults Over 65, And Communities Of Color, According To The American Lung Association.
- In Tennessee's Nashville-Murfreesboro-Franklin Metropolitan Area, Encompassing Davidson, Maury, And Sumner Counties, Persistent Air Quality Challenges Have Raised Concerns About The Health Impacts Of Fine Particulate Matter ($PM_{2.5}$) Pollution.
- This Study Investigates The Spatiotemporal Relationships Between $PM_{2.5}$ Concentrations And Emergency Room (ER) Visits For Asthma And Chronic Obstructive Pulmonary Disease (COPD) Across The Three Counties. Rising $PM_{2.5}$ Levels In Davidson County Show Strong Associations With Increased Respiratory-related ER Visits, Pointing To The Potential Health Consequences Of Urbanization, Industrial Activity, And Seasonal Pollution Peaks.

American Lung Association Score Card

Figure 1: Davidson County

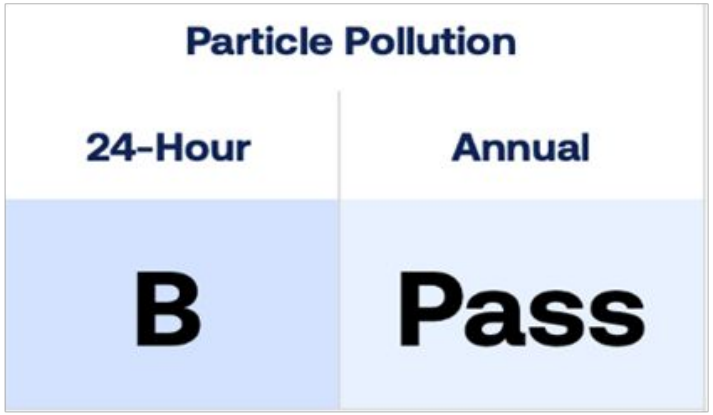


Figure 2: Maury County

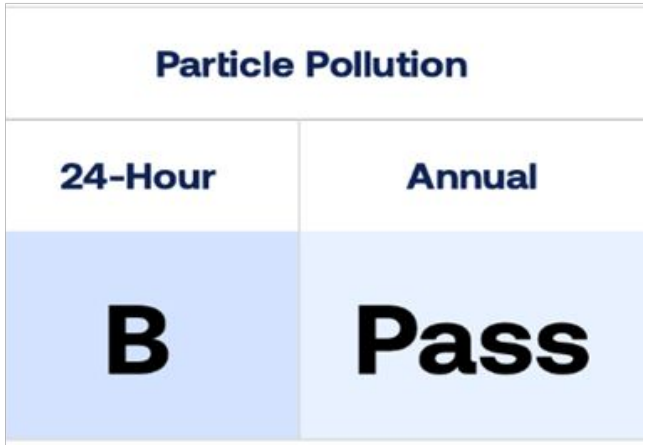


Figure 3: Sumner County

MATERIALS

- **Data Sources:** EPA Air Quality System (AQS): $PM_{2.5}$ daily concentration data for the year 2020. National Environmental Public Health Tracking Network: Emergency Department (ED) visits for asthma and COPD, stratified by county.

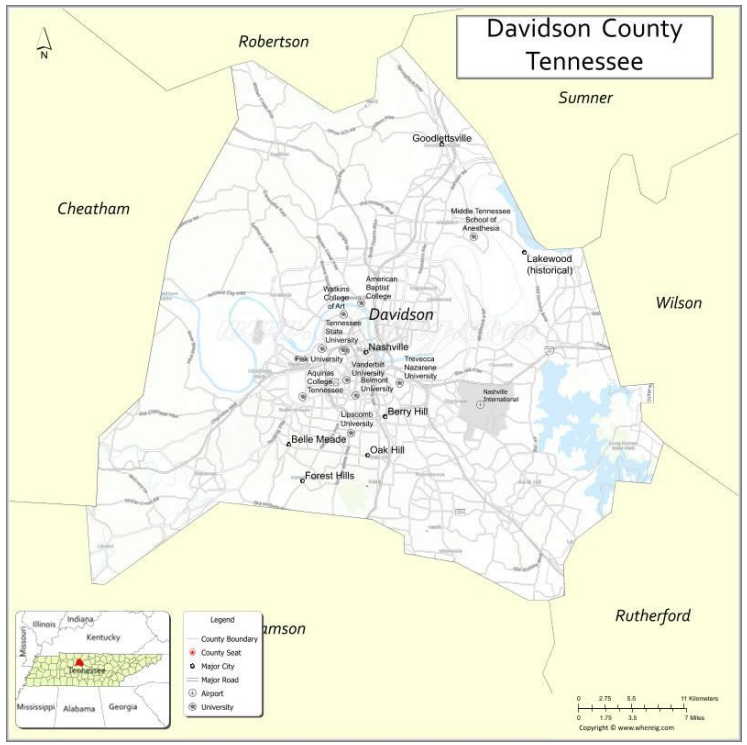
- **Analysis:** Correlate $PM_{2.5}$ concentrations with rates of asthma and COPD ED visits. Identify vulnerable populations based on geographic, health, and demographic patterns.

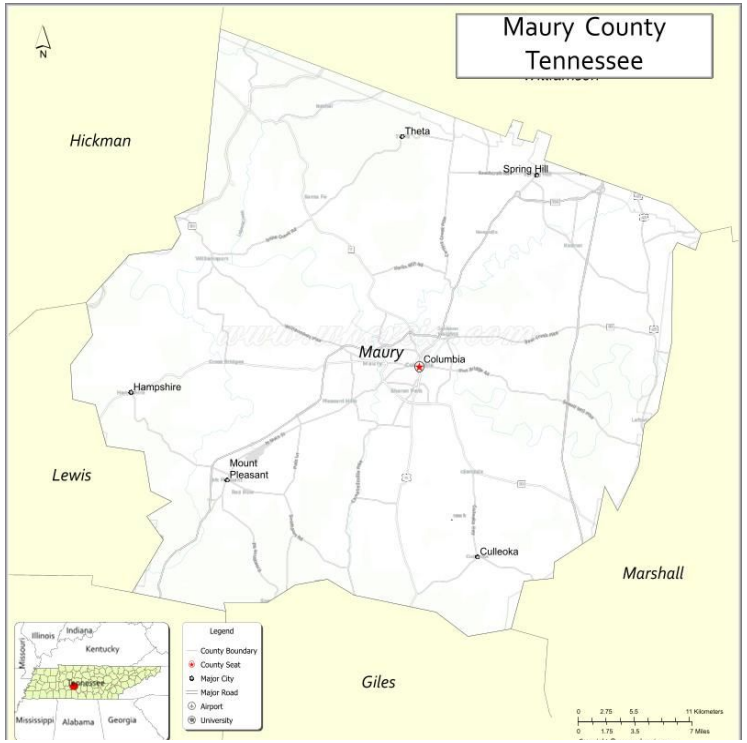
METHODOLOGY

- **Pre-processing Data:** We downloaded $PM_{2.5}$ data from the EPA Air Quality System (AQS) and pre-processed it in Python using Google Colab. Key steps included: Importing Libraries: We utilized pandas, matplotlib, and seaborn for the purpose of data handling and visualization. Feature Selection: We ensured the retention of pertinent columns, including Date, PM2.5, AQI, Site ID, and County.

- **Methods:** We applied Correlation Analysis: Pearson coefficients to assess relationships between $PM_{2.5}$, health outcomes (e.g., asthma, COPD), and SDOH. Regression Modeling: Used MLR and Random Forest to model pollution–health outcome associations.

COUNTIES OF FOCUS





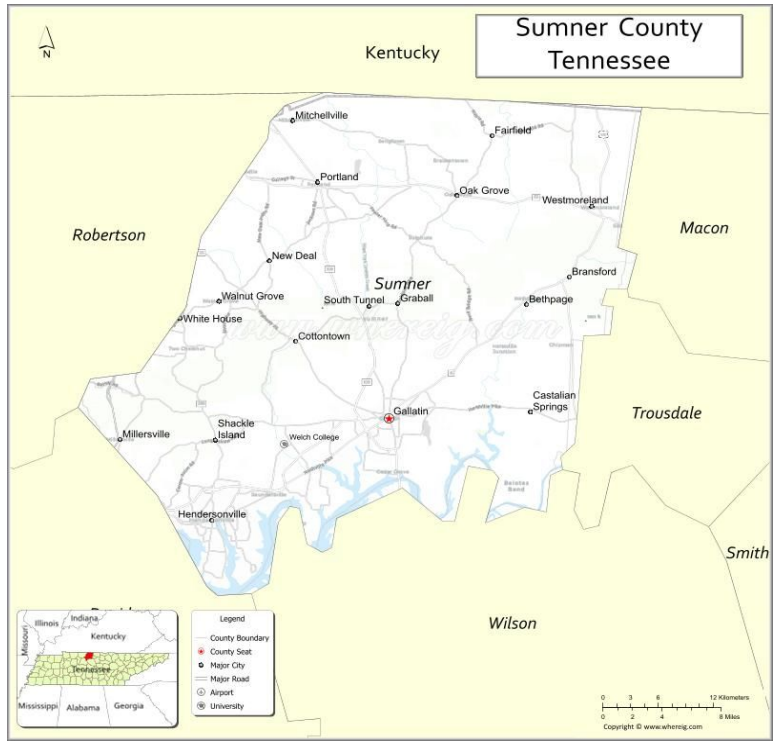


Figure 4: Average Monthly PM2.5 - 2020

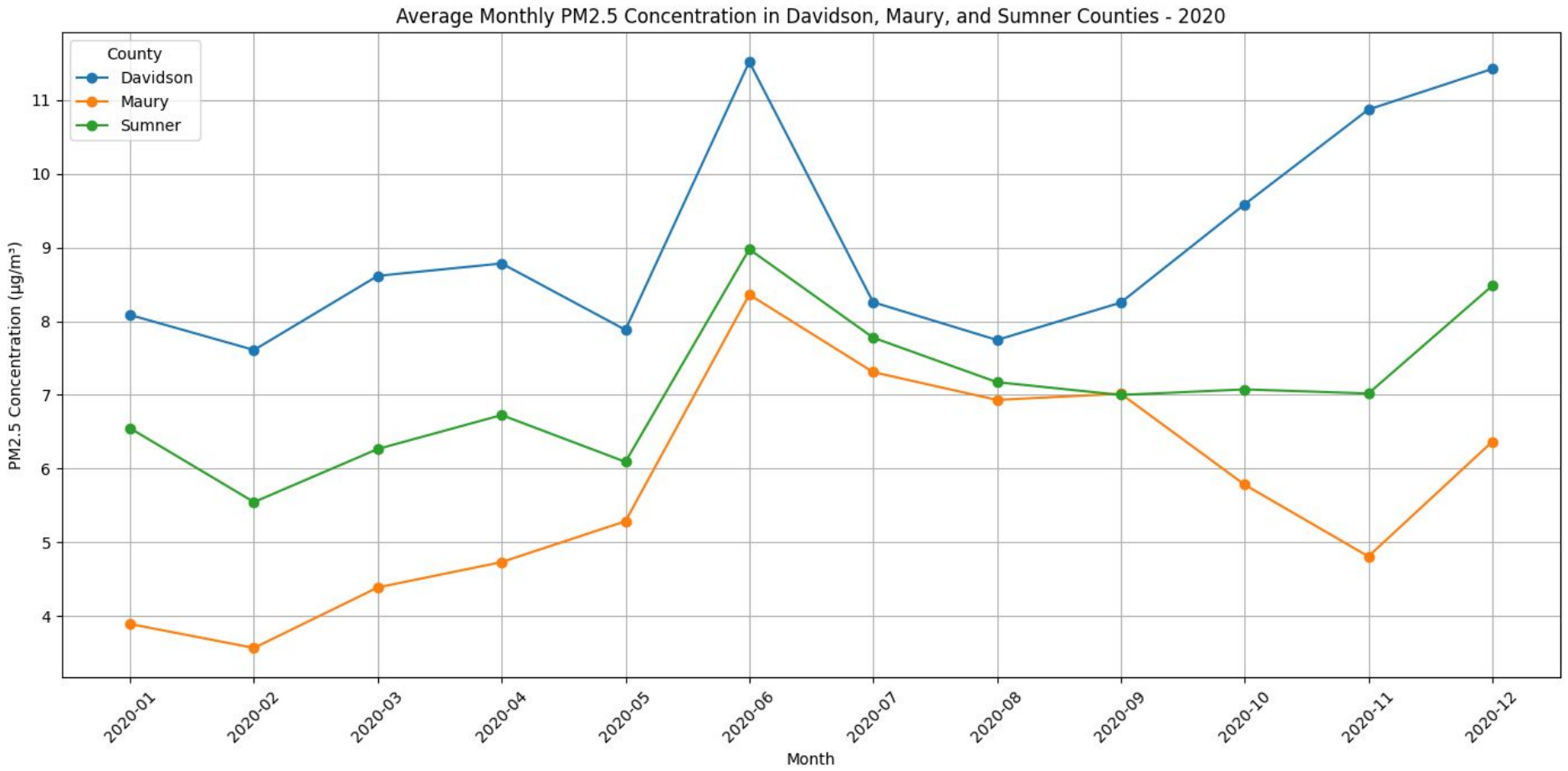


Figure 5: Average Monthly AQI - 2020

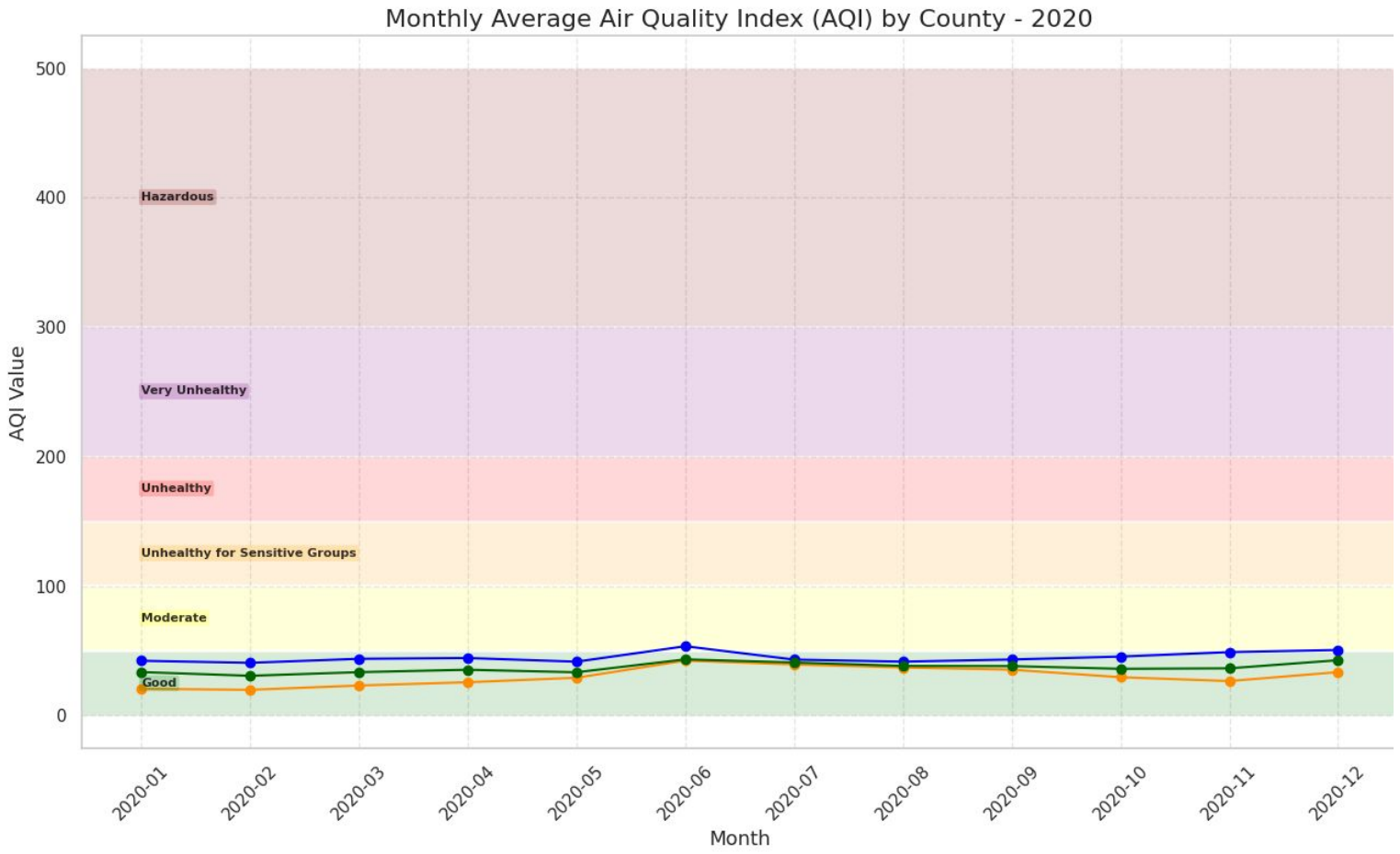


Figure 6: Correlation Matrix PM2.5 vs ER Visits - 2020

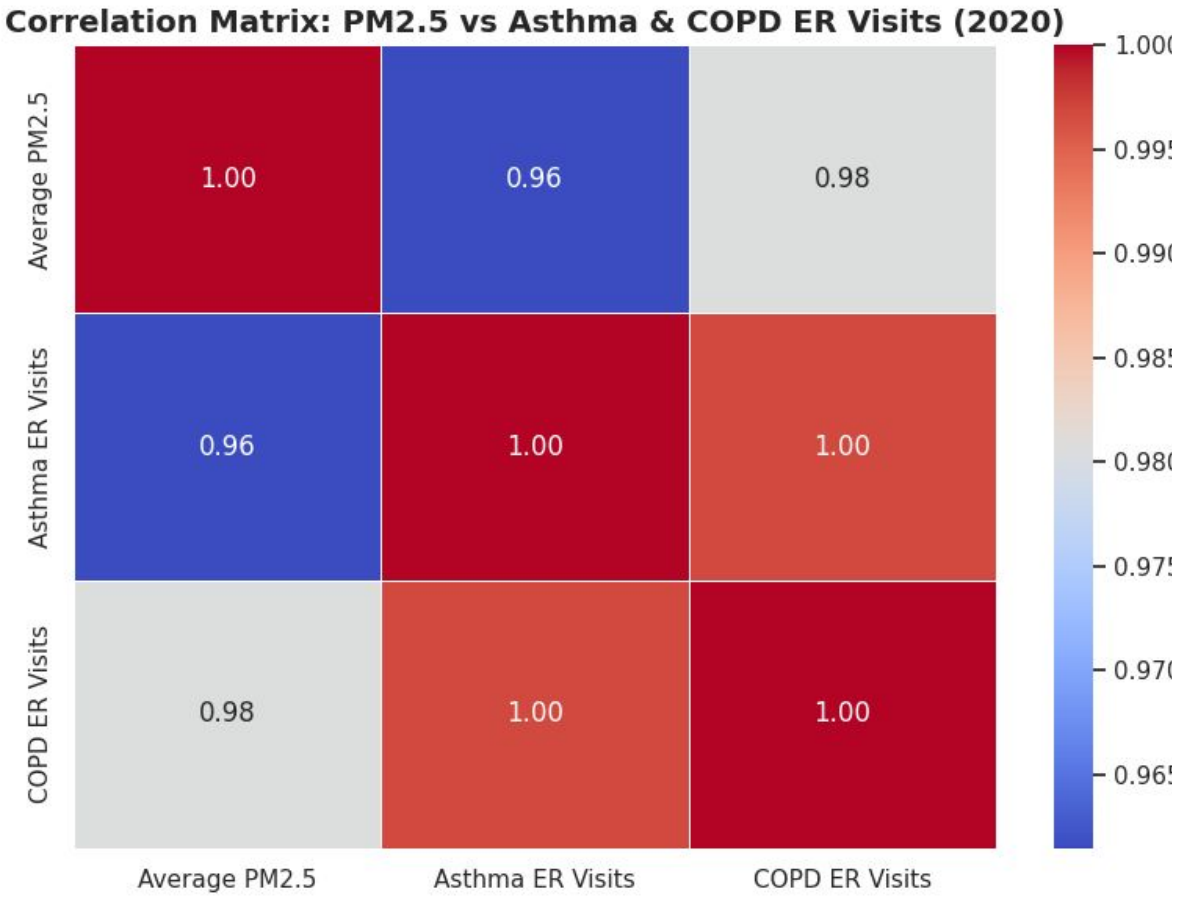


Table 1: PM2.5 vs Asthma & COPD ER Visits Heat Matrix Results (2020)

Variables	Average PM2.5	Asthma ER Visits	COPD ER Visits
Average PM2.5	1.00	0.96	0.98
Asthma ER Visits	0.96	1.00	1.00
COPD ER Visits	0.98	1.00	1.00

Correlation Matrix Key Findings:

❑**Strong Positive Correlations**

- PM2.5 is **strongly correlated with COPD ER visits** (r = 0.98).
- PM2.5 is **strongly correlated with Asthma ER visits** (r = 0.96).
- Asthma and COPD ER visits have a **perfect correlation** (r = 1.00), suggesting they increase together, potentially due to shared environmental triggers.

❑**Environmental Health Implication**

- The data suggests a **clear association between higher PM2.5 pollution and increased respiratory-related ER visits**, indicating PM2.5 is a key environmental risk factor.

Figure 7: Annual ER Visits - 2020

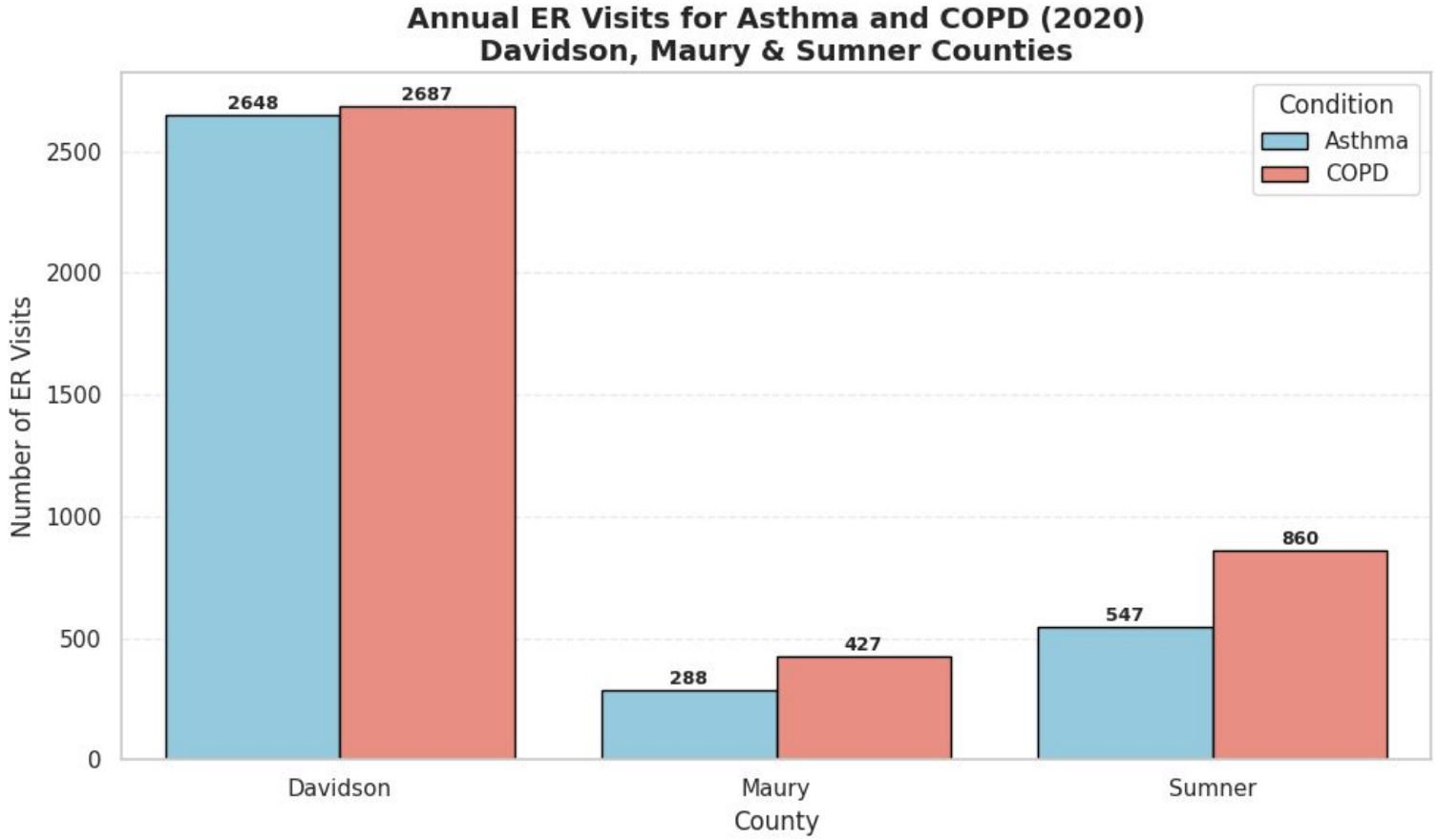
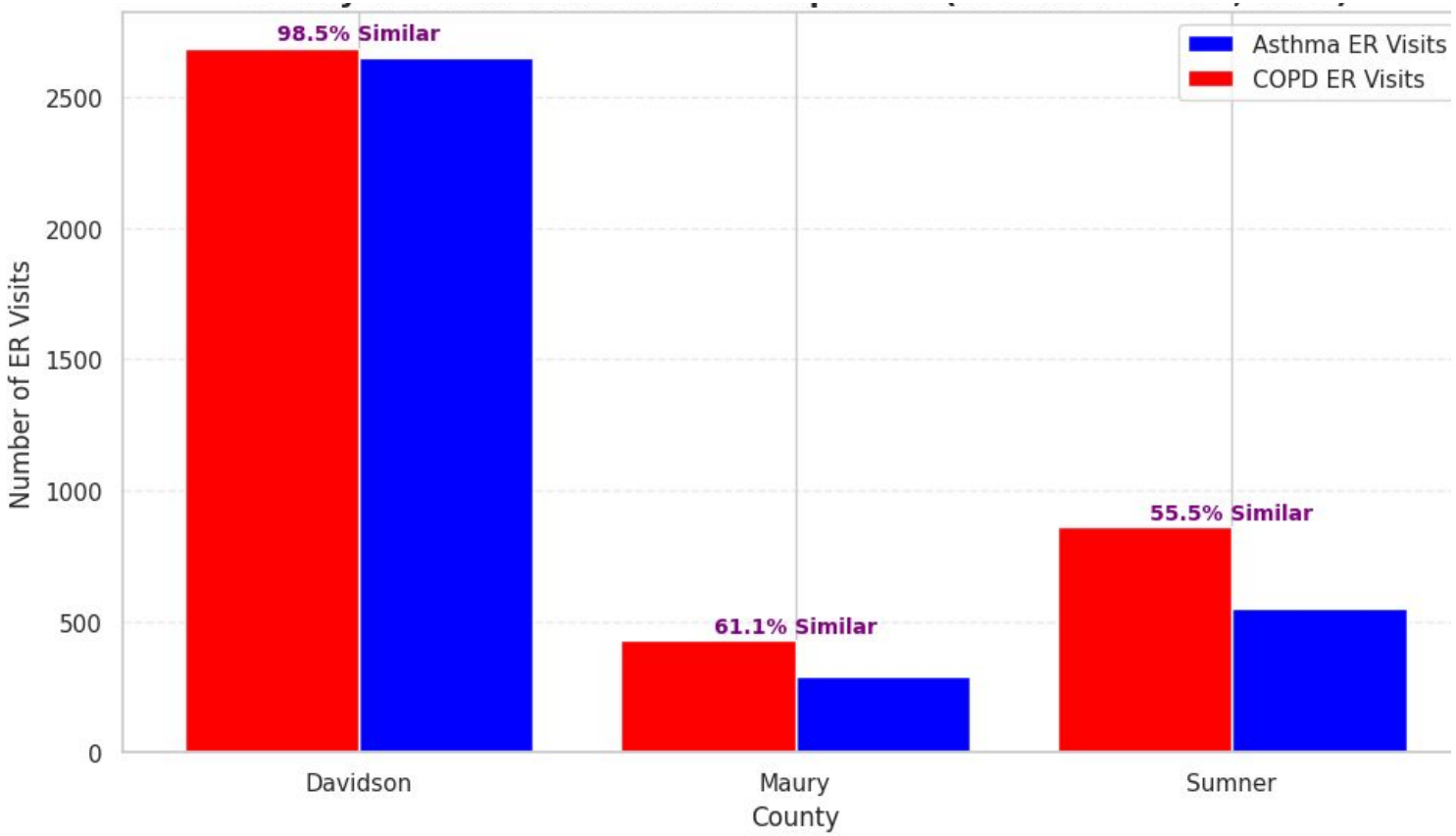


Figure 8: Asthma & COPD ER Visits Correlation



DISCUSSION

The data analysis revealed a moderate positive correlation between PM2.5 levels and emergency room visits for both asthma and COPD across the three studied counties. Davidson, Maury, and Sumner.

Davidson County, with the largest population, exhibited the highest number of ER visits, suggesting that greater urbanization and industrial activity may contribute to elevated exposure and exacerbation of respiratory conditions.

PM2.5 levels in all counties generally remained below the annual EPA threshold; however, seasonal peaks were observed, particularly in Davidson, correlating with increased ER visits during those times.

Rising urban development and climate change may worsen air quality, potentially increasing the frequency and severity of respiratory illnesses. Integrating environmental data with healthcare planning could play a critical role in reducing ER visits and improving overall respiratory health outcomes in affected populations.

County	Sumner	Maury	Davidson
Total Population:	**207,994**	**110,760**	**712,334**
Children Under 18:	47,358	25,217	145,337
Adults 65 & Over:	35,517	19,670	95,020
Pediatric Asthma:	4,612	2,456	14,155
Adult Asthma:	17,649	9,387	62,304
COPD:	16,416	8,691	50,749
People of Color:	41,623	25,548	323,504

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