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In this issue...

Impact of Air Quality on COVID-19-Associated Hospitalizations, New Haven County, October 2022 – April 2023

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Background

Air quality has important implications for public health. Exposure to air pollution, including fine particulate matter less than 2.5 microns in diameter (PM2.5), has been linked to respiratory disease. PM2.5, a toxic mixture of solids and liquids suspended in air, can be derived from natural (e.g., wildfires) as well as man-made sources (e.g., vehicle exhaust). PM2.5 can irritate the respiratory tract, exacerbate underlying respiratory conditions, and may increase susceptibility to respiratory infections like COVID-19 (1). The Environmental Protection Agency (EPA), in collaboration with state and local agencies, monitors six types of air pollutants including particle pollution at over 4,000 monitoring stations, with most reporting data daily.

COVID-19 is a respiratory disease caused by infection with SARS-CoV-2 virus. Anyone can be infected with SARS-CoV-2, but certain risk factors such as increasing age, underlying medical conditions, and lack of vaccination are known to be associated with more severe disease. Recent research has also shown a relationship between air pollution and COVID-19 (2). This analysis aimed to investigate whether particle pollution, as measured by PM2.5, was associated with incidence of COVID-19 associated hospitalizations in Connecticut during the 2022–23 respiratory virus season.

Methods

The PM2.5 data came from the EPA's Air Quality System (AQS), a repository of ambient air quality data. These data are publicly accessible through AirNow.[1] In Connecticut, the Department of Energy and Environmental Protection (DEEP) measures air pollutants at 14 stations throughout the state. This analysis used PM2.5 data from two monitoring sites in New Haven County, Connecticut: Meadow and Bank Streets in Waterbury and Criscuolo Park in New Haven. Using the maximum PM2.5 monitor measurement for each site by calendar day, we calculated a previous 5-day rolling average PM2.5 value for the entire study period. PM2.5 was divided into three categories: low (0–<9 $\mu g/m^3$), medium (9–<15 $\mu g/m^3$) and high (15+ $\mu g/m^3$3) (Figure 1).

COVID-19-associated hospitalization data came from COVID-NET, a CDC-sponsored, population-based surveillance system. COVID-NET cases used in this analysis were defined as a positive SARS-CoV-2 test ≤14 days prior or ≤3 days after hospital admission in a resident of New Haven County during the regular respiratory virus season (October 2022–April 2023). Data on each case-patient were collected by medical record review and included demographic information, underlying conditions, interventions, test results and outcomes. COVID-19-testing was clinician-driven or based on each hospital's testing practices. We used COVID-NET data to capture severe COVID-19-associated disease.

Each COVID-NET case was geocoded and linked to their census tract of residence. The study sample was limited to case-patients who lived in a census tract completely within 15 kilometers of either the Waterbury or New Haven monitoring site (Figure 2). Each COVID-associated hospitalization was assigned an average PM2.5 value based on daily maximum data from the closest monitoring site during the 5-day period prior to their hospital admission.

For the COVID-19-associated hospitalization incidence by PM2.5 category calculations, population data came from Census 2020 for census tracts located completely within 15 kilometers of each monitoring site. Incidence calculations used a weighted denominator based on the proportion of days in the study period in each category (low/medium/high) of particle pollution. The 95% confidence intervals were calculated via Poisson regression.

All analyses were performed using ArcMap, version 10.8.1 and SAS, version 9.4.

[1] https://www.airnow.gov/

Impact of Air Quality on COVID-19-Associated Hospitalizations, New Haven County, October 2022 – April 2023 (continued)

Results

During October 2022–April 2023, there were 1,918 COVID-associated hospitalizations among residents of New Haven County that lived within 15 kilometers of a Waterbury or New Haven EPA monitoring site. The majority of case-patients were aged 65+ years, and the overall incidence rate was 373.0 hospitalizations per 100,000 people (Table 1).

Particle pollution was categorized as mostly low in New Haven County with 71.2% of the 212 days in the study period having 5-day average PM2.5 values <9 μg/m³. About 26% of the study period was at the medium level of PM2.5 exposure (between 9–<15 μg/m³) and only 2.4% was high (above 15 μg/m³).

Incidence of COVID-19-associated hospitalization increased as PM2.5 increased (Figure 3). Of the 1,918 total hospitalizations, 1,229 (64.1%) had low 5-day average PM2.5 exposure, corresponding to an incidence rate of 333.6 per 100,000 (95% CI: 315.5–352.8). The hospitalization incidence rate increased to 411.9 per 100,000 for medium PM2.5 exposure (95% CI: 379.8–446.7), and 860.6 per 100,000 at the highest PM2.5 exposure (95% CI: 711.4–1041.1) (Table 1). Across all age groups (except 5–19), in both males and females, and among non-Hispanic White, non-Hispanic Black, non-Hispanic Asian and Pacific Islander, and Hispanic populations, a similar pattern was observed (Figure 3). A sensitivity analysis using narrower buffers (5 and 10 km) found similar results.

Discussion

We have illustrated the association of particle pollution with severe COVID-19 in south central Connecticut. Although particle pollution largely remained low to moderate during the study period, this analysis still found evidence that higher PM2.5 was associated with higher COVID-19 hospitalization rates in New Haven County. According to the EPA categories, PM2.5 does not reach 'Unhealthy for Sensitive Groups' until daily levels of 35.5 μg/m³ or more. However, this analysis suggests that PM2.5 may have serious health effects at levels much lower than that. Meanwhile, the EPA recently strengthened their standards by revising the breakpoint between healthy and moderate PM2.5 down (from 12 to 9 μg/m³). This analysis indicates risk is increased at low levels of PM2.5. Further review of breakpoints is necessary to best capture unhealthy exposures.

This analysis is subject to several limitations. First, ambient air quality readings do not necessarily correspond to personal exposure level and do not consider indoor air quality. Second, this study does not capture individual risk factors such as medical conditions that may increase sensitivity to PM2.5 or increase severity of SARS-CoV-2 infections. Finally, we restricted the study period to the traditional respiratory virus season of October through April, when SARS-CoV-2 transmission was frequent. These findings may not be generalizable to periods with less community transmission. Future analyses using additional years of data may allow for adjustment of individual confounders and stratification by calendar time to address these limitations.

Particle pollution is tracked by the Air Quality Index, this system is used to inform the public of current, real-time conditions. Sensitive and at-risk populations should utilize this resource to monitor local air quality for unhealthy levels of pollution and take proper precautions (limit outdoor activity, decrease any strenuous activity outside or wear a mask).

This study contributes to the growing body of research demonstrating that particle pollution can lead to increased morbidity. Climate change is likely to worsen air quality, including PM2.5. It will be important to continue to monitor the relationship between air quality and severe respiratory disease.

Figure 1: Classification of PM2.5 Exposure Levels

5-Day Average PM2.5 Concentration (μg/m³)	Exposure Level	Reasoning
0 – <9	Low	Within threshold for updated (Feb. 2024) EPA National Ambient Air Quality Standards for Particulate Matter [1]
9 – <15	Medium	Exceeding updated EPA National Ambient Air Quality Standards for Particulate Matter (9.0 μg/m³) [1]
15 or greater (study max. = 19.2)	High	Exceeding annual WHO recommended exposure (fewer than 3-4 days with 24-hour averages exceeding 15 μg/m³) [2]

[1] EPA Guidelines: https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm

[2] WHO Guidelines: https://www.who.int/publications/m/item/who-ambient-air-quality-database-(update-2023)

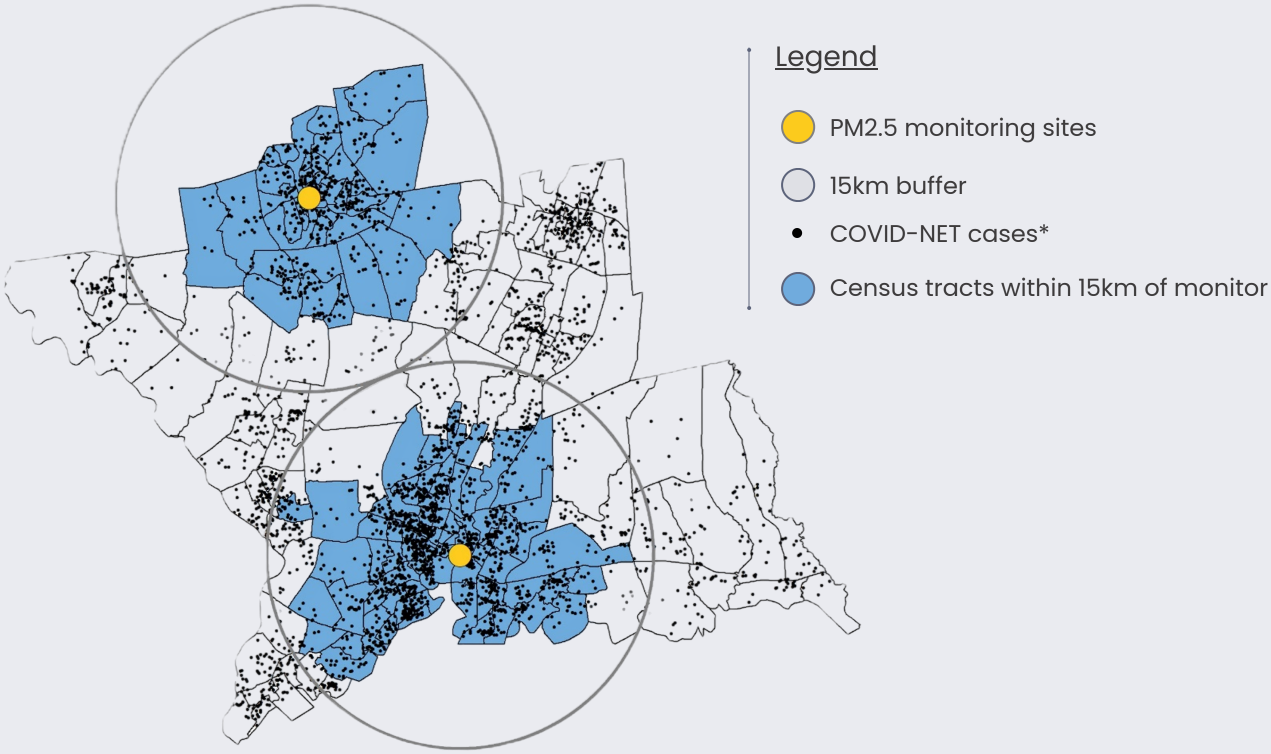
Table 1: Demographics of COVID-19 Hospitalizations, New Haven County, October 2022–April 2023

	COVID-19 Hospitalizations n (%)	Incidence (per 100,000 population)
All	1,918 (100)	373.01
Sex		
Male	865 (45.1)	346.28
Female	1,053 (54.9)	386.50
Age group		
0-4	40 (2.1)	146.47
5-19	36 (1.9)	36.94
20-49	328 (17.1)	155.28
50-64	367 (19.1)	359.66
65+	1,147 (59.8)	1,362.17
Race/Ethnicity		
White, Non-Hispanic	1,101 (57.4)	430.27
Black, Non-Hispanic	416 (21.7)	442.18
Hispanic	328 (17.1)	233.62
Asian American & Pacific Islander	27 (1.4)	110.67
Other Race, Non-Hispanic	8 (0.4)	--
Unknown race or ethnicity	38 (2.0)	--
PM2.5 Exposure		
Low: 0–<9	1,229 (64.1)	333.62
Medium: 9–<15	583 (30.4)	411.90
High: 15 or greater	106 (5.5)	860.60

Notes:
1. Column percent may not total 100 due to rounding.
2. Rates for "Other Race, Non-Hispanic" and "Unknown race or ethnicity" cannot be calculated due to unknown population denominator.

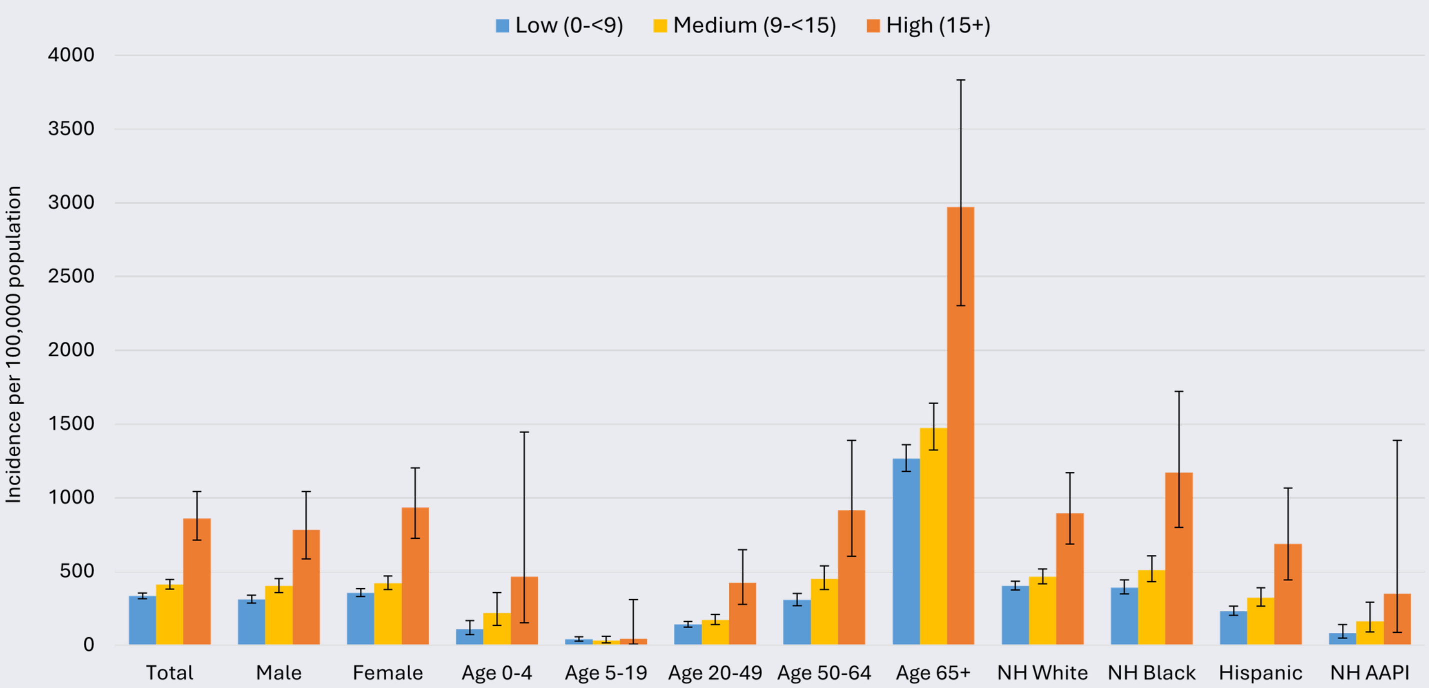
Impact of Air Quality on COVID-19-Associated Hospitalizations, New Haven County, October 2022 – April 2023 (continued)

Figure 2: PM2.5 Monitoring Sites in New Haven County with 15km Buffer



*Points have been modified to protect patient privacy.

Figure 3: COVID-19 Hospitalization Incidence by 5-day PM2.5 Average, New Haven County, October 2022–April 2023



Impact of Air Quality on COVID-19-Associated Hospitalizations, New Haven County, October 2022 – April 2023 *(continued)*

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