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A 2-YEAR FOLLOW UP ON PM2.5 EXPOSURE AND COVID-19 MORBIDITY AND MORTALITY

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Abstract

Introduction: A previous study was conducted to examine the relationship between poor air quality in the form of PM2.5 exposure and COVID-19 morbidity and mortality in Yakima County, Washington (USA). Results showed there was a significant correlation ($p<0.05$) between PM2.5 exposure and COVID-19 hospitalization and mortality in the 12-day lag analysis, however it was not clear if this association remains consistent over time. The purpose of this study was to analyze a second year of PM2.5 exposure and COVID-19 morbidity and mortality in a population significantly impacted by poor air quality (PM2.5) and high COVID-19 morbidity to determine whether the findings of the previous study could be confirmed. **Methods**: A 12-day lag analysis correlating PM2.5 levels and county-level COVID-19 case counts, hospitalization, and mortality was conducted using Pearson correlation between the period of February 1, 2021 and December 20, 2021 in Yakima, County, Washington, USA. **Results**: PM2.5 was found to be significantly correlated ($p<.011$) to COVID-19 morbidity ($r = 0.38$), hospitalization ($r = 0.41$), and mortality ($r = 0.18$). **Discussion**: This study expands upon and confirm previous preliminary findings examining the association between poor air quality exposure and negative COVID-19 outcomes. Populations exposed to long-term PM2.5 may need additional safeguards from COVID-19 as they may have a higher risk of infection, hospitalization, and mortality.

Keywords: PM 2.5. Air Quality. COVID-19.

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1 Introduction

The emergence of COVID-19 has presented a variety of public health challenges, not only due to the nature of the disease and associated illnesses, but also due to the exacerbation of previously existing public health issues. One such issue is poor air quality exposure and the associated hospitalizations and deaths related to particulate matter exposure in both the acute and long terms (WU et al., 2020). Both COVID-19 and poor air quality exposure present risks to lung and cardiovascular health and it is posited that there are several overlapping health consequences to these two exposures (WU, et al, 2020; FIREBAUGH et al., 2021). The present study aims to advance the literature on the correlation between exposure to poor air quality in the form of particulate matter (PM 2.5) to rates of COVID-19 morbidity and mortality. A previously conducted study by Firebaugh et al. provided a baseline analysis that demonstrated the correlation of PM2.5 exposure to COVID-19 morbidity and mortality in Central Washington State (FIREBAUGH et al., 2021). However, it is unclear if that association is consistent over time, as the COVID-19 pandemic enters its third year. Therefore, the purpose of this analysis is to determine if the correlation among these variables is still present in the ongoing years since COVID-19 emerged.

Yakima, Washington is an area characterized by persistent poor air quality as measured by 24-hour period PM2.5 concentrations as well as the number of days in which levels of PM2.5 levels reach unhealthy levels (FIREBAUGH, 2020; AMERICAN LUNG ASSOCIATION, 2021). While several studies have demonstrated that there is a connection between PM 2.5 or poor air quality exposure either at the global or US National level, or urban environments, data regarding rural areas such as Yakima, Washington are lacking (BOWE et. al., 2021; ZHOU et al., 2021; TRAVAGLIO et al., 2021). Yakima, Washington is uniquely different than the areas previously investigated in larger population-based studies. It is an area that experiences geographic, environmental, and socioeconomic health disparities (WASHINGTON STATE DEPARTMENT OF HEALTH, 2017). Yakima, Washington is considered a rural county and has a different chemical composure of particulate matter than urban areas, which are characterized by industrial activities.

Summer (June-September) in Yakima County is typically dry with average daily high temperatures ranging from 78°F to 88°F. Climatological data from the National Oceanic and Atmospheric Administration (NOAA) indicates higher than average temperatures (78°F to 96°F) were recorded June through September 2021, including a June 29th record breaking high of 113°F followed by 27 days >90°F with trace precipitation in July (NCEI, 2021). Air quality was directly impacted in August and September by the 2021 Schneider Springs fire which burned over 107,322 acres of timber and brush in Northwest Yakima County according to InciWeb (2021). Yakima County recorded PM2.5 Daily AQI values > 100 (unhealthy for sensitive groups) on 11 days and AQI values >150 (unhealthy) on 15 days during the wildfire incident time according to the U.S. Environmental Protection Agency (EPA, 2022).

Yakima, Washington experiences high levels of particulate matter due to seasonal forest fires, farming activity, and wood-burning for heat (FIREBAUGH et al., 2022). Mendy et al. (2021) found that areas with long-term exposures to high levels of PM2.5 were significantly associated with COVID-19 hospitalization rates, even when controlling for socioeconomic status. The study asserted that areas with high exposures to PM2.5 might need more stringent or increased efforts to control exposure to COVID-19 in order to prevent the increased risk of COVID-19 morbidity and mortality (MENDY et al., 2021).

It is important to establish the association of PM2.5 exposure and COVID-19 morbidity and mortality in unique geographically rural regions and populations such as Yakima, Washington. One study conducted by Páez-Osuna, Valencia-Castañeda and Rebolledo (2021) aimed to examine the link between COVID-19 mortality and PM2.5 emissions in rural and medium-size municipalities considering population density, dust events, and wind speed. However, the study lacked access to PM2.5 monitors to assess 24-hour PM2.5 levels, which limited the analysis. The present study aims to reproduce and expand a previously conducted study that resulted in preliminary findings.

2 Methods

A time-lag correlation was conducted using the same methods of analysis previously conducted year one study (FIREBAUGH et al., 2021). Descriptive and statistical correlational analyses were performed on the publicly available data of 24-hour daily average PM 2.5 counts and daily counts of COVID-19 hospitalizations, cases, and mortality rates in Yakima County, Washington. As further research on this topic has emerged, both 12 and 14-day lags appear to be the most frequently used intervals of time between exposures and hospitalizations. The present study performed a 12-day lag as was conducted in the previous study that found significant correlations (FIREBAUGH et al., 2021).

Data Collection: COVID-19 daily and total running confirmed cases and confirmed mortality rates were made publicly available on the Washington State Department of Health (USA) and Yakima County Health District's COVID-19 dashboard. Although the data were publicly available, for both COVID-19 rates, hepatizations, and mortality and the 24-hour PM2.5 levels in Yakima County, Washington, members of the County Health District and regional representatives from the Washington State

Department of Ecology were consulted to obtain accurate counts for the respective measures between the dates of February 1, 2021-December 20, 2021, which expanded the date range from the previously conducted study for a total number of data points (n=323). The Washington State Department of Ecology Collects and Reports 24-hour daily average readings of PM2.5 in Yakima County Washington (WASHINGTON SMOKE INFORMATION, 2020). The Washington State Department of Ecology regularly calibrates the particle collectors to EPA standards and of the four collectors stationed in the county, the one with the most reliable data (defined as the least amount of missing daily counts) was used for this analysis.

Data Analysis: Descriptive data on the number of total daily cases of COVID-19, daily hospitalizations and daily mortality rates in Yakima County, Washington were available. To measure air quality, the 24-hour average PM2.5 measure from the validated particle collectors were used as it is considered more reliable than a 24-hour max reading. The range of PM2.5 readings, along with the number of unhealthy days during this period of investigation were reported. Unhealthy days of air quality are defined by the EPA (2021) as having a 24-hour average of PM2.5 ppm concentration of 50 or over as leaving the healthy designation. A 12-day lag analysis using a Pearson correlation was conducted between exposure (PM 2.5) and outcome (COVID-19 new cases: days 1-12) to determine whether exposure to PM2.5 was significantly associated with new cases of COVID-19. This study had no research directly related to human subjects, only publicly available data and was exempt from institutional review board (IRB)/Human Subjects review at Central Washington University.

3 Results

During the period of observation, PM2.5 levels ranged from 1-102.9, with a mean of 10.8, (SD=□11.4). The number of days with concentrations over the EPA designated level of 50 PM2.5 ppm concentration of 50 or over was six days. The daily case counts of COVID-19 ranged from 1-329, with an average of 66 cases per day (SD=□61.8). The daily hospitalization rate ranged from 0-14, with an average of 3.3, (SD=□3.0). The daily mortality rate from COVID-19 in Yakima County was less than 1 (.79, SD=□1.0) with a range of 0-5 deaths per day. In the Pearson correlation, PM2.5 was found to be significantly correlated ($p<.011$) to COVID-19 morbidity ($r = .38$), hospitalization ($r = 0.41$), and mortality ($r = 0.18$) 12-day lag counts.

4 Discussion

This follow-up study demonstrated higher correlation coefficients for all outcome variables (daily case counts, daily hospitalizations, and daily mortality rates) in association with daily PM2.5 levels in Yakima, Washington, than were found in the preliminary study. In fact, in the initial shorter-range study, PM2.5 was not found to be significantly associated with daily mortality rates, yet this follow-up analysis revealed a small, yet significant association between daily PM2.5 levels and daily mortality rates.

A study conducted by Zhou et al., (2021) examined the excess of COVID-19 cases and deaths due to fine particulate matter exposure during the 2020 wildfires in the Western United States, which included Yakima County, Washington. The study examined the 2020 wildfire season in a similar effort to the previous study by Firebaugh et al., (2021), however, the Zhou study included 92 counties on the West coast while the original Firebaugh et al., study only focused on Yakima County, Washington. In addition, the Zhou study examined the fire season period from 15th of March to 16th of December 2020 and the Firebaugh study March 1, 2020-October 15, 2020. The Yakima County only study used data supplied by the Washington State Department of Ecology local air quality monitors. The Zhou study focused on daily increases in PM2.5 levels on wildfire days whereas the Firebaugh study focused on levels of daily levels of PM2.5 regardless of source. However, the studies used different type of analyses, the Firebaugh study used a simplified correlation analysis, and the Zhou study employed a more complex multistep model factoring in covariates such as temperature, humidity, etc. (FIREBAUGH et al., 2021). In the Zhou study, an analysis of 10-point increases in PM2.5 levels in their measure of wildfire days were not found to have a significant positive effect on COVID-19 outcomes in Yakima County. It would be interesting to know if a follow-up study using their methodology would yield repeated results if a second year follow up analysis occurred.

A strength of this study is the confirmation of previous findings, by expanding data points and duration of the original analysis. In addition, the raw data was verified by the agencies issuing the publicly available data sets for validity and guidance on use. However, the study was limited by the simple methods of analysis performed. Due to the limited patient information associated with case counts, confounding variables at the individual level could not be controlled for in the analyses.

This study adds to the growing body of literature demonstrating the dangers of acute and long-term poor air quality exposure in the era of COVID-19 infection and reinfection. Populations living in areas with persistent poor air quality in the form of PM2.5 exposure should mitigate the risks of both PM2.5 and COVID-19 exposure to prevent the compounded impacts of these co-exposures. This study has added a unique perspective, that of rural areas with persistently poor air quality, which are distinct from urban air pollution areas.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

C. Mace Firebaugh: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Writing, Proofreading, Validation, Y. Barios: Data curation, Formal analysis, Methodology, Writing, Proofreading, Validation, T. Beeson: Project administration, Writing, Proofreading, D. Rich: Writing, Proofreading, A. Wojtyna: Proofreading.

DECLARATION OF INTEREST

The authors disclose that they have no known competing financial interests or personal relationships that could have appeared to influence the study reported in this manuscript.

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REFERENCES

AMERICAN LUNG ASSOCIATION (ALA). State of the Air. American Lung Association, Chicago, 2021. Available from: https://www.lung.org/getmedia/17c6cb6c-8a38-42a7-a3b0-6744011da370/sota-2021.pdf. Accessed on: 21 may 2022

BOWE, B.; XIE, Y.; GIBSON, A.K.; CAI, M.; VAN DONKELAAR, A.; MARTIN, R.V.; BURNETT, R.; AL-ALY, Z. Ambient fine particulate matter air pollution and the risk of hospitalization among COVID-19 positive individuals: Cohort study. Environment international, London, v. 154, art. 106564, 2021. Available from: https://doi.org/10.1016/j.envint.2021.106564. Accessed on: 15 jul. 2022.

EPA. Air data - Daily air quality tracker. United States Environmental Protection Agency. 2022. Available from: https://www.epa.gov/outdoor-air-quality-data/air-data-daily-air-quality-tracker. Accessed on: 20 jul. 2022.

FIREBAUGH C.M.; BEESON, T.; MORGAN, S.; WOJTYNA, A.; LASCANO H.; MADLEM, M. Mental distress associated with air quality vulnerability during COVID-19. European Journal of Environment and Public Health, London, v. 6, n. 1, art. em0103, 2022. Available from: https://doi.org/10.21601/ejeph/11674.

FIREBAUGH, C.M.; BEESON, T.; WOJTYNA, A.; ARBOLEDA, R. Increased PM2. 5 levels associated with increased incidence of COVID-19: The Washington wildfires of 2020. Environmental Smoke, João Pessoa, v. 4, n. 2, p. 49-53, 2021. Available from: https://doi.org/10.32435/envsmoke.20214249-53.

FIREBAUGH, C.M., BEESON, T.; WOJTYNA, A.; BRAVO, L.; EVERSON, T.; JOHNSON, J.; SALDANA A. A community case study on geographic, environmental, and social health disparities in COVID-19 disease: Yakima, Washington. Open Journal of Preventive Medicine, v. 10, n. 11, p. 288-297, 2020. Available from: https://doi.org/10.4236/ojpm.2020.1011021.

INCIWEB. Schneider Springs, 2021. Available from: https://inciweb.nwcg.gov/incident/7775/. Accessed on: 21 May 2022

MENDY, A.; WU, X.; KELLER, J.L.; FASSLER C.S.; APEWORKIN, S.; MERSHA, T.B.; XIE, C.; PINNEY, S.M. Air pollution and the pandemic: Long-term PM2. 5 exposure and disease severity in COVID-19 patients. Respirology, Nedlands, v. 26, n. 12, p. 1181-1187, 2021. Available from: https://doi.org/10.1111/resp.14140.

NCEI (National Centers for Environmental Information). 2021. Local climatological data -Yakima County. Available from: https://www.ncei.noaa.gov/pub/orders/IPS/IPS-D1A62DFC-6A40-41F5-9699-7822FD8E19BE.pdf. Accessed on: 21 may 2022.

PAEZ-OSUNA, F.; VALENCIA-CASTENADA, G.; REBOLLEDO, U. A. The link between COVID-19 mortality and PM2. 5 emissions in rural and medium-size municipalities considering population density, dust events, and wind speed. Chemosphere, Oxford, v. 286, art. 131634, 2022. https://doi.org/10.1016/j.chemosphere.2021.131634

TRAVIGLIO, M.; YU, Y.; POPOVIC, R.; SELLEY, L.; LEAL, N.S.; MARTINS, L.M. Links between air pollution and COVID-19 in England. Environmental pollution, Essex, v. 268, art. 115859, 2021. Available from: https://doi.org/10.1016/j.envpol.2020.115859.

WASHINGTON SMOKE INFORMATION. Smoky siege: A look back at the smoke storm of 2020. 2020. Available from: https://wasmoke.blogspot.com/2020/09/smoky-siege-look-back-at-smoke-storm-of.html. Accessed on: 21 May 2022.

WASHINGTON STATE DEPARTMENT OF HEALTH. Yakima Community Health Needs Assessment. 2017. Available on: https://www.yakimamemorial.org/pdf/about/community-hna-2019.pdf. Accessed on: 21 May 2022.

WU, X., NETHERY, R.C.; SABATH, M.B.; BRAUN, D.; DOMINICI, F. Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis. Science advances, Washington, v. 6, n. 45, art. eabd4049, 2020. Available from: https://doi.org/10.1126/sciadv.abd4049.

ZHOU, X.; JOSEY, K.; KAMMEREDINE, L.; CAINE, M.C.; LIU, T.; MICKLEY, L.J.; COOPER, M.; DOMINICI, F. Excess of COVID-19 cases and deaths due to fine particulate matter exposure during the 2020 wildfires in the United States. Science advances, Washington, v. 7, n. 33, art. eabi8789, 2021. Available from: https://doi.org/10.1126/sciadv.abi8789.