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Research Brief

COVID-19 Stay-at-home Orders and Secondhand Smoke in Public Housing

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Abstract

Introduction: To better understand the inequitable impact of the pandemic by examining associations between stay-at-home orders and indoor smoking in public housing, measured by ambient particulate matter ($PM_{2.5}$), a marker for secondhand smoke (SHS).

Methods: $PM_{2.5}$ was measured in six public housing buildings in Norfolk, VA from 2018 – 2022. Multi-level regression was used to compare the seven-week period of the Virginia stay-at-home order in 2020 with that period in other years.

Results: Indoor $PM_{2.5}$ was 10.29 μg/m^3 higher in 2020 (95% CI [8.51, 12.07]) relative to the same period in 2019, a 72% increase. While $PM_{2.5}$ improved in 2021 and 2022, it remained elevated relative to 2019.

Conclusions: Stay-at-home orders likely led to increased indoor SHS in public housing. In light of evidence linking air pollutants, including SHS, with COVID-19, these results also provide further evidence of the disproportionate impact of the pandemic on socioeconomically disadvantaged communities. This consequence of the pandemic response is unlikely to be isolated and calls for a critical examination of the COVID-19 experience to avoid similar policy failures in future public health crises.

Introduction

Public housing residents, compared to the general public, are more likely to smoke and nonsmoking residents are disproportionately exposed to chronic secondhand smoke (SHS), contributing to persistent health disparities.[1] In response, the U.S. Department of Housing and Urban Development (HUD) adopted a federal rule in 2018 requiring Public Housing Authorities (PHAs) to ban smoking in all indoor areas of public housing, and within 25ft of PHA buildings.[2] PHA officials have reported challenges implementing the rule, including ensuring resident adherence,[3] which may deter the potential health impacts of the rule, particularly on reducing health disparities.[4,5] The situation has broader implications for preventive interventions in challenged communities with limited autonomy, including homeless shelters and correctional facilities, where policy effectiveness is undermined by a lack of buy-in and low adherence.

The COVID-19 pandemic has further complicated implementation of the smoke-free housing rule. In the first quarter of 2020, many states issued extended stay-at-home orders in response to the pandemic. These orders have been linked to overall increases in cigarette smoking. For example, in an analysis of U.S. tax data, Asare et al. found that cigarette sales increased by 14% during the pandemic, relative to pre-COVID-19 trends.[6]

Consideration of cigarette smoking and SHS is important because they are significant risk factors for several major respiratory diseases including COPD, interstitial lung disease, and asthma that are also linked to poorer COVID-19 outcomes. Furthermore, current smoking and SHS exposure have been independently linked to higher COVID-19 mortality.[7] On a population level, several studies have also shown a link between COVID-19 and outdoor air pollution.[8–10] Particulate matter at the 2.5 micron threshold ($PM_{2.5}$), a common measure of air pollution also used as a marker of SHS, has been implicated as a potential carrier of SARS-CoV-2, the virus that causes COVID-19.[11]

This study examined variation in ambient indoor $PM_{2.5}$ in public housing communities subject to COVID-19 stay-at-home orders. The modeling procedure compared the period of the Virginia order to the same time-period two-years prior and post the stay-at-home order. The implications of stay-at-home orders for health outcomes in vulnerable communities that often have limited control over what happens to them—such as public housing—warranted further study. This assessment has the potential to reduce disparities by suggesting actionable targets of intervention.

Methods

Indoor air quality was monitored in common areas of six multi-unit PHA buildings in Norfolk, VA from 2018 - 2022. The mid-rise apartment buildings were the same across all years and ranged between 47 and 114 units (*M* = 87 units). Monitor placement maximized comparability between buildings (e.g., not in the direct path of HVAC airflow and similar distance from nearby vents). All common areas were interior spaces large enough for residents to congregate. Lobbies or other exits were not used due to the influx of outside air and monitor placement remained constant over the entire period. $PM_{2.5}$ measurements were taken hourly using SidePak AM520 aerosol monitors (TSI, Inc., St. Paul, MN) with a flow rate of 1.7 L/min. A calibration factor of 0.32 was applied to yield measurements appropriate for SHS particles, as used in previous work.[4] $PM_{2.5}$ data, expressed as μg/m^3, were downloaded twice weekly. The monitors were also cleaned and zero-calibrated on this schedule.

Using linear mixed modeling, average daily $PM_{2.5}$ during the period spanning March 23rd to May 9th, 2020—the period of the VA stay-at-home order—was compared for the years 2018, 2019, 2020, 2021, and 2022. Seasonality was accounted for by limiting comparisons to the same period across years. Random site and day effects were modelled using the equation:

$$PM_{ij} = \beta_0 + Building_{0i} + Day_{0j} + \beta_1 Year_{ij} + e_{ij}, \quad \text{for } i = 1, \dots, 6;\ j = 1, \dots, 49.$$

Version 4.1.0 of R was used for analysis.

Results

Mean indoor $PM_{2.5}$ ranged from 1.83 – 108.41 μg/m^3 across the six sites. Mean $PM_{2.5}$ in 2018—before indoor smoking was prohibited—was 17.27 μg/m^3 (Figure 1). Following the introduction of the ban in 2019, mean $PM_{2.5}$ decreased to 14.33 μg/m^3, but peaked in 2020 (24.52 μg/m^3). $PM_{2.5}$ decreased in 2021 (22.68 μg/m^3) and 2022 (22.14 μg/m^3), but not to levels observed before the pandemic. Analysis suggests the stay-at-home order was associated with 72% higher ambient indoor SHS relative to the same period in 2019, corresponding to a $PM_{2.5}$ increase of 10.29 μg/m^3 (95% CI [8.51, 12.07]; see the Appendix for the full model). While indoor air quality did improve in 2021 and 2022 after the stay-at-home order was lifted, $PM_{2.5}$ remained 56.8% and 55.1% higher in 2021 and 2022, respectively, relative to 2019.

Conclusions

The 2020 stay-at-home order was associated with increased ambient indoor SHS, and, by inference, SHS exposure among public housing residents. This is of particular concern because public housing residents entered the pandemic with a higher burden of smoking-related disease.[12,13] While public housing residents have a multitude of other risk factors for poor health outcomes, this finding may contribute to understanding the increased burden and disparate COVID-19 outcomes observed in other studies of socioeconomically disadvantaged localities.[14] For example, increased indoor smoking could have offset potential health benefits related to decreased exposure to outdoor pollution associated with COVID-19 stay-at-home orders and other pandemic-related restrictions.[15]

This study has limitations. $PM_{2.5}$ is a non-specific marker of combustion. However, $PM_{2.5}$ was shown to be a valid measure of tobacco smoke in earlier work conducted in the same locations.[4] While it is unclear whether these findings are generalizable, there is evidence of low adherence with public housing smoke-free policies prior to the pandemic in multiple settings[4,5] and the poorly coordinated COVID-19 pandemic response likely exacerbated factors already contributing to the failure of these policies to live up to their promise of protecting residents from harms associated with SHS. Extreme consequences—eviction, which could mean homelessness for this population—coupled with inconsistent enforcement had already undermined residents' perceived legitimacy of the policies. Active, sustained, and meaningful resident engagement likely was the sole path forward. Unfortunately, the pandemic created additional barriers to policy enforcement (e.g., property managers working offsite).

With adequate resources and careful planning, HUD and local housing authorities could have supported public-housing residents with adherence to smoke-free rules or smoking cessation assistance during the stay-at-home phase of the COVID-19 pandemic. However, these efforts likely would have meant starting from a deficit, limited by the lack of trust and buy-in needed to engage residents to determine how best to support them. Further, while the reasons for persistently elevated levels of SHS exposure are not clear, these findings call for ongoing investigation and coordinated future interventions to prevent widening of the health disparities experienced by public housing residents and other socioeconomically marginalized groups.

Ensuring equitable responses to future public health crises will require a critical examination of the COVID-19 experience for marginalized groups. These findings suggest a crucial lesson: failing to understand how the deficiencies of the COVID-19 response were driven by, and even reinforced, pre-pandemic disparities will impede efforts to equitably respond to future public health crises. It is naïve to think this unintended consequence of COVID-19 is an isolated phenomenon. To do better in the future, policymakers must anticipate how emergency measures have the potential to cause harm in the presence of existing inequity. Authentic engagement of marginalized communities put in place before the next public health emergency is a necessary first step in this process.

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Credit Author Statement

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References

1. Levy DE, Rigotti NA, Winickoff JP. Tobacco Smoke Exposure in a Sample of Boston Public Housing Residents. *Am J Prev Med*. 2013;44(1):63-66. doi:10.1016/j.amepre.2012.09.048

2. U.S. Department of Housing and Urban Development. FR-5597-F-03, –Instituting Smoke-Free Public Housing‖, 81 FR 87430. Published online December 5, 2016.

3. Wray JA, Sheehan BE, Rees VW, Cooper D, Morgan E, Plunk AD. A Qualitative Study of Unfairness and Distrust in Smoke-free Housing. *Am J Health Behav*. 2021;45(5):798-809. doi:10.5993/AJHB.45.5.1

4. Plunk AD, Rees VW, Jeng A, Wray JA, Grucza RA. Increases in Secondhand Smoke After Going Smoke-Free: An Assessment of the Impact of a Mandated Smoke-Free Housing Policy. *Nicotine Tob Res*. 2020;22(12):2254-2256. doi:10.1093/ntr/ntaa040

5. Thorpe LE, Anastasiou E, Wyka K, et al. Evaluation of Secondhand Smoke Exposure in New York City Public Housing After Implementation of the 2018 Federal Smoke-Free Housing Policy. *JAMA Netw Open*. 2020;3(11):e2024385. doi:10.1001/jamanetworkopen.2020.24385

6. Asare S, Majmundar A, Islami F, et al. Changes in Cigarette Sales in the United States During the COVID-19 Pandemic. *Ann Intern Med*. 2022;175(1):141-143. doi:10.7326/M21-3350

7. Hou H, Li Y, Zhang P, et al. Smoking Is Independently Associated With an Increased Risk for COVID-19 Mortality: A Systematic Review and Meta-analysis Based on Adjusted Effect Estimates. *Nicotine Tob Res Off J Soc Res Nicotine Tob*. 2021;23(11):1947-1951. doi:10.1093/ntr/ntab112

8. Wu X, Nethery RC, Sabath MB, Braun D, Dominici F. Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis. *Sci Adv*. 2020;6(45):eabd4049. doi:10.1126/sciadv.abd4049

9. Ali SM, Malik F, Anjum MS, et al. Exploring the linkage between PM2.5 levels and COVID-19 spread and its implications for socio-economic circles. *Environ Res*. 2021;193:110421. doi:10.1016/j.envres.2020.110421

10. Czwojdzińska M, Terpińska M, Kuźniarski A, Płaczkowska S, Piwowar A. Exposure to PM2.5 and PM10 and COVID-19 infection rates and mortality: A one-year observational study in Poland. *Biomed J*. 2021;44(6, Supplement 1):S25-S36. doi:10.1016/j.bj.2021.11.006

11. Nor NSM, Yip CW, Ibrahim N, et al. Particulate matter (PM2.5) as a potential SARS-CoV-2 carrier. *Sci Rep*. 2021;11(1):2508. doi:10.1038/s41598-021-81935-9

12. Yim B, Howland RE, Culp GM, Zhilkova A, Barbot O, Tsao TY. Disparities in Preventable Hospitalizations Among Public Housing Developments. *Am J Prev Med.* 2019;56(2):187-195. doi:10.1016/j.amepre.2018.08.019

13. Helms VE, King BA, Ashley PJ. Cigarette smoking and adverse health outcomes among adults receiving federal housing assistance. *Preventive Medicine*. 2017;99:171-177. doi:10.1016/j.ypmed.2017.02.001

14. Krieger N, Waterman PD, Chen JT. COVID-19 and Overall Mortality Inequities in the Surge in Death Rates by Zip Code Characteristics: Massachusetts, January 1 to May 19, 2020. *Am J Public Health*. 2020;110(12):1850-1852. doi:10.2105/AJPH.2020.305913

15. Hammer MS, van Donkelaar A, Martin RV, et al. Effects of COVID-19 lockdowns on fine particulate matter concentrations. *Sci Adv*. 2021;7(26):eabg7670. doi:10.1126/sciadv.abg7670

Figure Title

Figure. Mean daily indoor $PM_{2.5}$ for the period of the 2020 Virginia stay-at-home order, March 23rd through May 9th, for the years 2018 – 2022.

Figure Legend

Mean $PM_{2.5}$ measured in the common areas of six Norfolk, VA mid-rise public housing buildings is shown.