

RESEARCH BRIEF

Air Pollution and Risk of Violence in School Settings Among Minnesota Children

PURPOSE OF THE STUDY

In this project, we examined administrative data of Minnesota residents from early childhood through adulthood to understand individual and environmental factors that lead to perpetration of crime. This brief presents findings from a study examining the impact of air pollution on the risk of violence among children using data on school disciplinary referrals.

BACKGROUND & PURPOSE

Violence is now the leading cause of death for children in the United States, with death by firearms surpassing motor vehicle crashes for the first time in decades (Goldstick et al., 2022). The recent changes in childhood mortality attributable to violence underscores the need for greater attention to the underlying mechanisms that may increase the likelihood of children becoming victims of violence, and how early life exposure to the built and natural environments may increase the risk of children becoming perpetrators of violence as they emerge into adulthood.

While drivers of violence are multifaceted and involve both socioeconomic and political mechanisms, there is growing research evaluating the contribution of environmental exposures, including heavy metals and air pollution on violent activities (Beckwith et al., 2021; Higney et al., 2022). Previous work has found associations between heavy metals (i.e. lead) and risk of criminal activity and aggression in children (Beckwith et al., 2021; Yildiz et al., 2023); however, far less research has focused on the impacts of ambient air pollution on violent behavior in children despite a growing body of work demonstrating associations between air pollution and violence in adult populations (Berman et al., 2019; Burkhardt et al., 2019).

Ambient air pollution is a harmful environmental exposure which acts as a toxin and promotes inflammatory responses in the body that may cascade into subsequent neuroinflammation (Calderón-Garcidueñas et al., 2008; Block & Calderón-Garcidueñas, 2009). Further examination of air pollution-associated neurological effects in children should be considered a public health priority because children are particularly vulnerable to adverse health effects from ambient air pollution due to smaller physiques, higher rates of respiration, and developing organ systems (Legot et al., 2012; Garcia et al., 2021).

The research question for this study was:

- 1. To what degree does exposure to air pollution at school environments increase the risk of violence among children?**



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VIOLENCE IS NOW THE LEADING CAUSE OF DEATH FOR CHILDREN IN THE UNITED STATES, WITH DEATH BY FIREARMS SURPASSING MOTOR VEHICLE CRASHES FOR THE FIRST TIME IN DECADES (GOLDSTICK ET AL., 2022).

METHODS

To investigate the impact of ambient air pollution on the frequency of school violence, we integrated data on violence-related disciplinary referrals from the Minnesota Department of Education and air pollution data from the Center for Air, Climate, and Energy Solutions (CACES) through Minn-Link.

FINDINGS

Carbon monoxide, a relatively understudied pollutant that can impact cognitive functions, had the greatest impact on school-level violence among Minnesota children.

Violence-related disciplinary referrals were obtained for schools in the Minnesota Department of Education's Disciplinary Incident Reporting System (DIRS) during the 2008-2009 to 2011-2012 school years (831,002 unique students), with data aggregated to the school level.

We assessed three different pollutants: fine particulate matter (PM_{2.5}), nitrogen dioxide (NO₂), and carbon monoxide (CO). PM_{2.5} is composed of solid and liquid particles emitted into the atmosphere from vehicles, industrial activities, and natural processes including wildfires (Thangavel et al., 2022). NO₂ is a gaseous pollutant formed as a byproduct of combustion with vehicle engines and power plants serving as major sources (United States Environmental Protection Agency, 2022). CO is a colorless, odorless, and tasteless gas with sources including vehicles, gas appliances and industrial activities such as metal processing and chemical manufacturing (Texas Commission on Environmental Quality, 2022; United States Environmental Protection Agency, 2019).

Pollutant concentrations at each school location were obtained using data from the CACES 2010 air pollution models. For each pollutant, we created quartile categories of exposure and compared the risk of violence to the lowest quartile of pollution exposure using statistical models. We examined these associations in all schools, and for urban and rural schools specifically, using pollutant quartiles specific to those populations.

Violence in Rural and Urban Schools in Minnesota

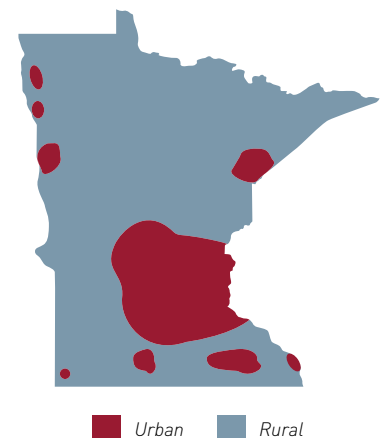
Our study included 2,681 schools of which 1,671 were urban and 1,010 were rural schools (Figure 1). A total of 3,492,049 students were enrolled in these schools during the study period and 831,002 were identified in the DIRS system as having a disciplinary referral for a violent event. More than 70% of students who committed violent events were enrolled in urban schools, and urban schools also had higher levels of pollution compared to rural schools (Figure 2). Urban schools had greater rates of violence (1,999.10 violent events per 100,000 students per school year) compared to rural schools (1,411.97 violent events per 100,000 students per school year).

Associations Between Air Pollution and School Violence

Associations between air pollution and violence are presented in Figure 3. For the overall student population, the 4th quartile – or highest level – of CO exposure had the largest association with violent event rates. The highest level of CO exposure was associated with an increase of 779.10 violent events per 100,000 students per school year, 95% CI: (546.68, 1011.52). The fourth quartiles of NO₂ and PM_{2.5} had the second and third largest incidence rate differences (IRD) respectively (Figure 3). Compared to the 4th quartile IRD estimates for NO₂ and PM_{2.5}, the 4th quartile of CO exposure had a 19.5% and 35% greater increase in the incidence of violence in the total population respectively.

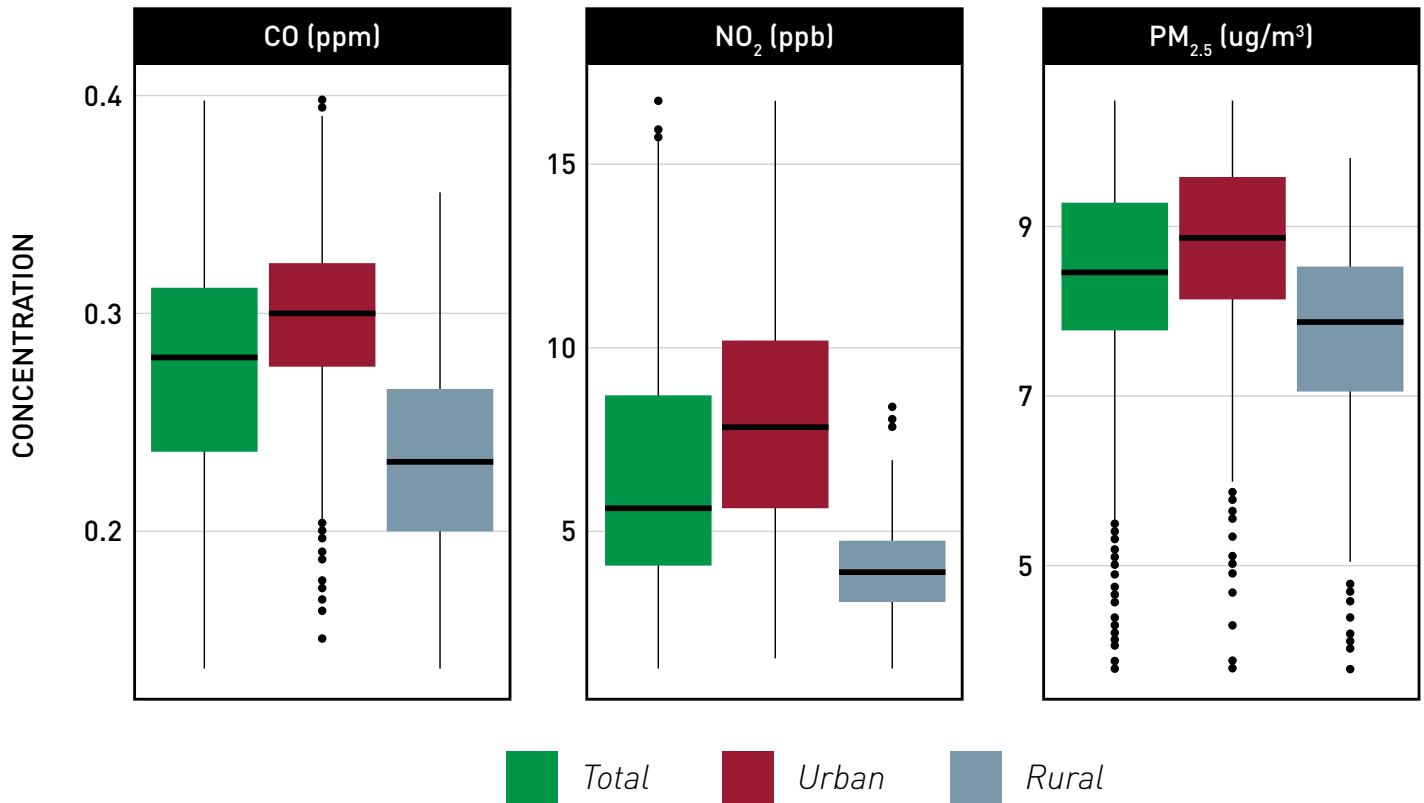
Stratification by urban and rural status of schools found the 4th quartile of NO₂ exposure was associated with the greatest change in the incidence of violence in urban schools with an IRD: 1,315.21 violent events, 95% CI: (911.81, 1,718.61) per 100,000 students per school year (Figure 2). In rural schools, CO was the only pollutant that increased the risk of violence, and it was the 3rd quartile of CO exposure that conferred the greatest risk, IRD: 477.72 violent events, 95% CI: (206.63, 748.82) per 100,000 students per school year (Figure 3).

Figure 1. Locations of Schools in Minnesota (2008-2009 to 2011-2012) Stratified by Urban and Rural Status



FOR THE OVERALL STUDENT POPULATION, THE 4TH QUARTILE – OR HIGHEST LEVEL – OF CO EXPOSURE HAD THE LARGEST ASSOCIATION WITH VIOLENT EVENT RATES. THE HIGHEST LEVEL OF CO EXPOSURE WAS ASSOCIATED WITH AN INCREASE OF 779.10 VIOLENT EVENTS PER 100,000 STUDENTS PER SCHOOL YEAR, 95% CI: (546.68, 1011.52).

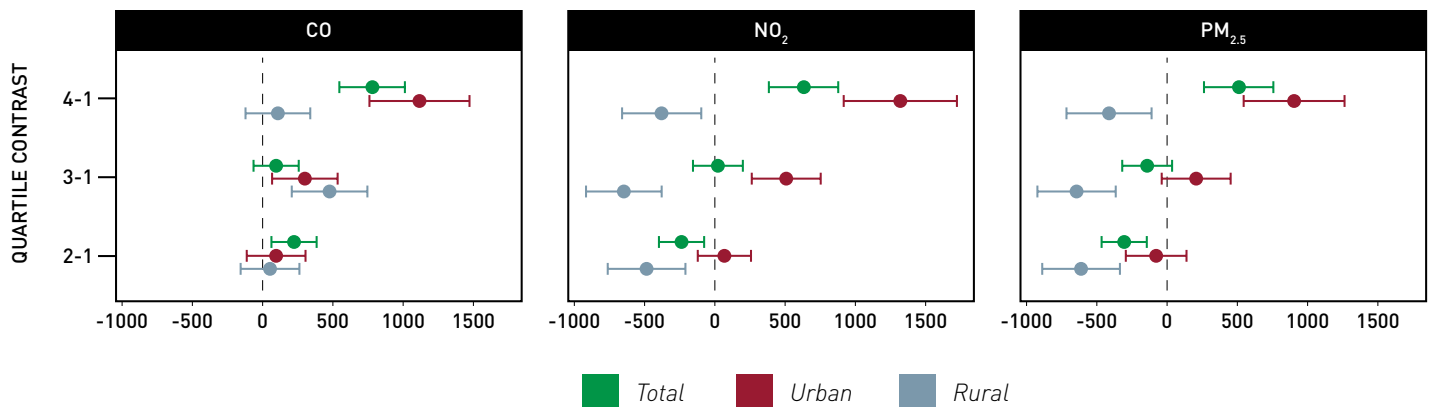
Figure 2. Air Pollution Concentrations Around Schools Stratified by Urban and Rural Status



Note. ppm = parts per million | ppb = parts per billion | ug/m³ = micrograms per cubic meter

URBAN SCHOOLS HAD HIGHER RATES OF VIOLENCE (1,999.10 VIOLENT EVENTS PER 100,000 STUDENTS PER SCHOOL YEAR) COMPARED TO RURAL SCHOOLS (1,411.97 VIOLENT EVENTS PER 100,000 STUDENTS PER SCHOOL YEAR).

Figure 3. Incidence Rate Differences (IRD) Describing the Association Between Air Pollution Concentrations with Violent Events Per 100,000 Students Per School Year



Note. Comparisons made between schools in the lowest pollutant quartile (e.g. 1st quartile) and other quartiles of pollution. Pollutant quartiles were drawn within the total, urban, and rural schools respectively.

Conclusion

Environmental pollution is often overlooked in studies of behavior and violence. Yet, as our results indicated, high levels of ambient air pollution may be associated with a relatively large increase in the frequency of school violence, which can significantly impact the physical, mental, and emotional health of children. Within the population of Minnesota children, we found that CO, an understudied pollutant that can have severe neurological effects in humans, had the largest associations with the incidence of school violence. However, when stratifying schools by urban and rural status, we found violence in urban schools was most associated with nitrogen dioxide and rural schools were most impacted by carbon monoxide. These subtleties in risk are essential to consider because these pollutants come from different sources and affect the body in different ways. It is not surprising that urban schools were most affected by NO₂ as vehicle emissions are a primary source for this pollutant. Commuting patterns in the Twin Cities 7-county metropolitan area may be contributing to high levels of NO₂ in urban areas and subsequent increases of violence in urban schools. Rural areas have been historically understudied in public health research of air pollution due to low population sizes and sparsity of air monitors in rural settings. It is imperative to invest more time and resources into studying violence and health disparities in rural communities so they do not fall behind urban areas in achieving meaningful progress in reducing environmental pollution and school violence. Reductions in air pollution are important not only to improve children's health and reduce school violence, but also to prevent children from future involvement in violent activities as they emerge into adulthood. Addressing upstream effects and early life exposure to environmental hazards is essential to reducing the public health burden of violence in society.

LIMITATIONS

This analysis was a cross-sectional, ecologic study at the school level; therefore, we cannot infer how pollution impacts risk of violent behavior for individual students. We can only speak to school-level community risks and population-level associations.

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