



The Polluted Life Near the Highway

A Review of National Scholarship and a Louisville Case Study

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Roadways are a ubiquitous feature of life in the United States, being used by most Americans for most trips. Much of American society, including the jobs, housing, schools, and recreational centers in metropolitan areas, is clustered in neighborhoods close to highways. But life near roads—while convenient from a transportation perspective—has a major downside: constant exposure to air and noise pollution produced by the cars, trucks, and motorcycles that drive by all times of the day and night.

In this report, we summarize research on the effects of exposure to air and noise pollution. We organize scholarly evidence that shows that people living, working, and learning within 150 to 300 meters (about 500 to 1,000 feet) of highways are disproportionately subject to dirty air and loud ambient noise. This, in turn, causes health problems, including lung disease, stroke, and premature birth. Roadways also tend to reduce the property values of nearby residences. In the United States, a disproportionate share of people of color and people with low incomes live near highways. Limiting exposure to highways could help extend life expectancy, improve quality of life, and increase social equity.

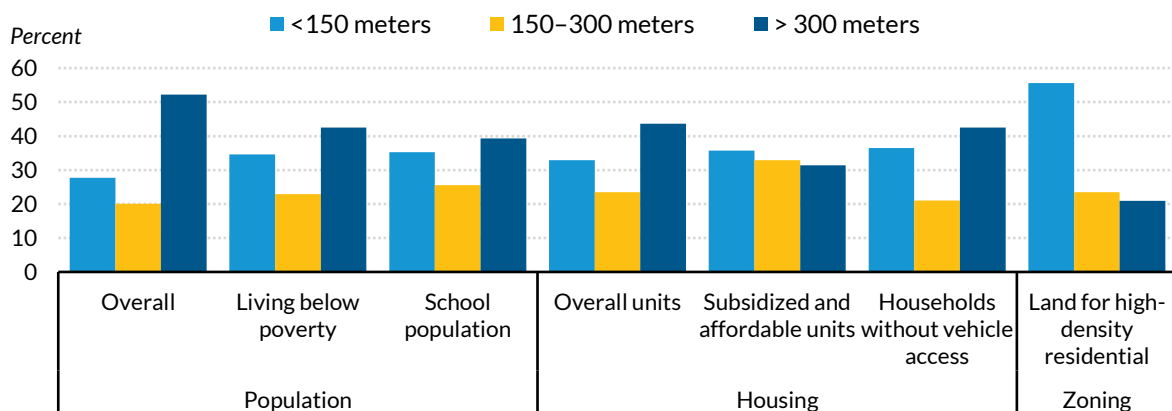
Using Louisville, Kentucky, as a case study, we examine life near highways. About 13 percent of the area's residents live within 300 meters of federally designated Interstates—and almost 50 percent live within that distance of arterials, which are high-speed roads with at least four lanes. This overwhelming exposure of Louisvillians to highways is, to some degree, unremarkable: the reliance of most Americans on car travel means they often need to be near principal roadways. Yet it is also a damning indictment of local, state, and federal transportation and land-use planning. Current and past initiatives prioritized car access and higher densities along highways over communities built around walking, biking, and transit use—neighborhoods with minimal exposure to highway pollution.

People of different races and ethnicities are equally likely to live and work near Louisville’s highways—a sign that exposure to roadway pollution is not racially differentiated. Exposure, however, is differentiated on the basis of class: We find that people with incomes below the federal poverty level and households receiving food stamps are exposed to roadway pollutants at higher rates than the population overall. Households with no car access are also much more likely to live near highways than those with cars, meaning they are disproportionately exposed to the pollution produced by others.

Renters, especially the residents of federally subsidized housing, are also more likely than homeowners to live near highways. This suggests that public investments in housing have been located to the detriment of residents, in terms of pollution exposure. Children, who may be especially vulnerable to the negative health impacts caused by air and noise pollution, are affected, too. About 60 percent of all public schools are located within 300 meters of arterials, and almost one-third of elementary students attend school within 150 meters of such roads.

Commercial and single-family residential buildings permitted over the past decade in Louisville are located predominately in neighborhoods with less exposure to highway pollutants. But multi-family housing continues to be constructed at a high rate near highways. This discrepancy is a consequence of zoning that promotes higher-density development along major roadways rather than in neighborhoods of primarily single-family homes. Land-use planning that continues to encourage this concentration of high-density housing may be bad for residents’ health. And the degree to which residents breathe and hear pollution depends on where transportation agencies build and expand roads, whether roadways are designed to minimize polluting effects, and whether public and private authorities offer alternative transportation options to reduce dependence on automobiles. Our findings are summarized in figure 1.

FIGURE 1
In Louisville, People Experiencing Poverty or Living in Subsidized Housing, Households Without Vehicles, and Areas Zoned for High Densities Are Disproportionately Concentrated Near Highways
Local characteristics, by distance from arterials



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Source: Authors’ calculations based on 2022 geospatial data from LOJIC, Louisville Open GeoSpatial Data; 2015–19 five-year American Community Survey.

New federal grants provided by the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act allow policymakers to leverage transportation expenditures to fund pollution barriers or less-polluting roadway designs. Local land-use regulations, including rules allowing construction near highways, could be reformed to encourage less building in polluted areas. Local governments can think imaginatively about developing future neighborhoods—and redeveloping current communities—into places where residents do not depend on cars and therefore are less likely to be exposed to their pollution.

In Louisville, significant steps have already been taken to address these concerns. Collaborations between local and regional entities, including the Mayor’s Office of Advanced Planning and Sustainability and the Air Pollution Control District (APCD), have established an expansive air quality monitoring network, promoted renewable energy alternatives, and worked to develop planning mechanisms that promote environmental justice and reduced air pollution exposure. As a result of their work—combined with broader improvements in US air quality standards—the Metro has seen declining levels of ground-level ozone, fine particle pollution, and sulfur dioxide over the past few decades.¹ Our findings should strengthen their ability to continue these efforts.

Methods

We conducted our research as part of a broader initiative with the Louisville Metro Office of Planning and Design Services. In accordance with the goals of Louisville Metro’s Plan 2040 for greater social and racial equity,² the office is undertaking an equity review of its land development code, the rules that regulate zoning across most of the region. This paper provides evidence that can inform potential zoning changes related to highway adjacency.

Key Questions

We focus our brief on three primary questions:

- What does research tell us about the effects of living and working near highways, and how do those effects change as distance from those roads increases?
- How does living near highways look in Louisville? Does that exposure vary by population subgroup?
- Are there opportunities to leverage infrastructure investments or policy changes to diminish the effects of life near highways in Louisville and other US jurisdictions?

Data

We investigated our key questions using three primary methods. First, we conducted a national review of research literature evaluating the influence of living, working, and attending school near highways on public health outcomes. We organized findings based on our internal coding of key information.

Second, we identified the degree to which residents of Louisville—a city potentially representing conditions nationally—experience those effects across home, work, and school. We also disaggregated resident data into several categories, including race and ethnicity, age, and income. This allowed us to specify whether certain groups in the broader population are disproportionately exposed to pollution.

Third, we highlighted policies that have been or are being implemented through federal, state, and local initiatives to address the negative effects of roadway pollution.

Louisville operates politically as a merged entity with Jefferson County, creating Louisville Metro. The political leadership that oversees Metro’s Office of Planning and Design Services includes a Metro-wide elected mayor and 26 Metro councilors elected by ward. Though several incorporated cities within Jefferson County manage their own land-use policies, these must adhere to the standards in Plan 2040; we therefore analyze the whole county in our case study. To avoid confusion, we use “Louisville” and “Metro” to describe the county overall. According to 2016–20 American Community Survey data, Louisville was home to about 780,000 residents; about 65 percent of residents were non-Hispanic white, 20 percent were Black, 3 percent were Asian, and 7 percent were Hispanic. Less than 3 percent of the Metro’s workers commuted by walking, biking, or taking transit; about 9 percent of households had no car available.

We collected publicly available data on jurisdictional boundaries, zoning policies, and the location of roadways, building permits, and schools as of June 2022 from the Louisville Open GeoSpatial online database maintained by LOJIC, the Louisville–Jefferson County Information Consortium. For the road information, we developed two data sets, one including all arterial roads and another including all federally designated Interstates (which, as far as we know, are the only limited-access roadways in the Metro). Because the roadway data are based on the centerline of each road, we created “buffers” to represent the full roadway. To do so, we assumed that each road includes two lanes in each direction, and that each lane is 12 feet wide. We estimated that the edge of a road extends another 12 feet away from the centerline. The building permit data, which extend as far back as 2010, included information about whether construction was new and whether it was commercial or residential. We classified schools based on whether they included elementary or pre-kindergarten classes (some middle and high schools include elementary schools).

To examine demographic data, we used 2015–19 five-year American Community Survey data at the block group level, downloaded from the National Historical Geographic Information System. For each block group, we collected data on the total population, number of housing units, population by race and ethnicity, population by age range, population by poverty status, median household incomes, per capita incomes, whether households receive food stamps (SNAP), whether members of households have disabilities, household tenure, vehicle availability, median gross rent, and median housing value. We also collected 2019 data from the Census’ Longitudinal Employer-Household Dynamics OnTheMap tool to locate all recorded jobs at the block level throughout the Metro. These data include information about the race, ethnicity, and income of employees. Finally, we collected data from the National Housing Preservation Database, identifying all federally subsidized affordable housing units located within

Louisville as of 2022. We assumed that units classified as either “active” or “inconclusive” are being used as subsidized affordable housing.

To conduct our analysis, we developed geospatial buffers extending from each arterial and Interstate at the following distances from the projected roadway edge: 0–49 meters, 50–99 meters, 100–149 meters, 150–199 meters, 200–249 meters, and 250–300 meters. Other experts have measured impacts up to 500 meters away from roads (EPA 2019), but we determined in our literature review that pollution is most likely to persist within closer boundaries. We, therefore, took a more conservative approach to distances evaluated, and as such our estimates should be treated as a lower bound. We then estimated housing, employment, and school data within each distance as well as within Louisville but further than 300 meters away from an arterial. To evaluate the Census demographic data, we used an areal interpolation method; we calculated the percentage of the area in each block group located within each buffer and adjusted the data proportionally.

Limitations

Our approach has several limitations. First, although we summarize national studies related to the impact of living and working near highways, we do not measure the concentration of air pollution or other public health matters directly. Second, our estimates assume that exposure to roadway-produced pollution extends evenly over a certain distance away from roads. Yet differences in environment, including wind patterns, physical infrastructure such as sound barriers, and living infrastructure such as trees, may also influence exposure to highway pollution. Our analysis also did not take into account the impacts of other non-roadway air and noise pollution sources, such as the Louisville–Muhammad Ali International Airport, which lies firmly within the Metro’s limits and which emits significant noise into the surrounding area.³ (Another airport used for general aviation purposes, Bowman Field, is also located in the Metro.)

Third, our data, especially that produced by the Census, are largely based on conditions that predate the COVID-19 pandemic. The health emergency altered life patterns in several ways, such as by encouraging remote schooling, expanding the share of people working from home, and potentially transforming dwelling patterns. Additional research is necessary to determine the degree to which these changes influenced peoples’ exposure to highway-produced public health impacts.

Finally, future trends could alter how people experience life near highways. The increasing availability of electric vehicles, including both passenger cars and freight trucks, could reduce tailpipe emissions by eliminating some point-source pollution. That said, such vehicles will produce other forms of pollution, such as noise pollution and the release of particulate matter from tire wear, brake wear, and resuspended dust (see the next section). Electric vehicles require charging from a power grid that may run on fossil fuels, which could increase pollution if power demand increases without a concomitant increase in renewable power production. And it may take decades for these vehicles to be deployed at a substantial enough quantity to affect pollution levels. Additional research here, too, is needed to identify changes in such exposure.

Effects of Air and Noise Pollution on Life Near Highways

Considerable evidence confirms that residents living closer to highways are exposed to more hazardous air and noise pollution than the population overall. Likely because of this exposure, highway-adjacent residents are at an increased risk for lung disease, heart problems, and premature birth. Researchers find that these effects are most common within 300 meters (about 1,000 feet) of highways, where pollution considerably exceeds background levels (table 1). In this section, we review scholarship that examines the incidence and effects of highway pollution.

TABLE 1

Evidence on Health Effects of Living or Attending School Near Major Roadways

A review of scholarship on highway exposure

Within 100 meters	Within 200 meters	Within 300 meters
<ul style="list-style-type: none"> ■ For children at schools, exposure to PM_{2.5} and NO_x are 30 percent and 37 percent higher, respectively, than at comparable schools elsewhere^a ■ Increase in acute myocardial infarction of 5 percent^b ■ Higher cardiopulmonary mortality risks of 1.95 percent^c ■ Increased lung cancer risks attributable to NO₂ and PM_{2.5} exposure by 10 units^d 	<ul style="list-style-type: none"> ■ Increase in odds of stroke mortality of 8 percent at 150 meters^e ■ Greater exposure to ultrafine particles, black carbon, NO_x, and CO than those living further away, elevating risks of asthma and reduced lung function^f ■ 1.3 times increased odds of preeclampsia; 1.6 times increased odds of pProm; and 1.4 times increased odds of preterm births^g 	<ul style="list-style-type: none"> ■ Higher concentrations of CO and black carbon^h (Baldauf et al. 2008) ■ Higher likelihood of autism for children of pregnant women during the third trimesterⁱ ■ Increased risks of coronary heart disease^j

Source: Authors' review of scholarship on highway adjacency.

^avan Roosbroeck et al. (2007); ^bTonne et al. (2007); ^cHoek et al. (2002); ^dHystad et al. (2013); ^ePedde, Szpiro, and Adar (2017);

^fBrugge, Durant, and Rioux (2007); ^gYorifuji et al. 2015; ^hBaldauf et al. (2008); ⁱVolk et al. (2011); ^jKan et al. (2008);

Notes: CO = carbon monoxide; NO_x = nitrogen oxides; NO₂ = nitrogen dioxide; PM_{2.5} = particulate matter made of fine inhalable particles, with diameters generally 2.5 micrometers and smaller; pProm = premature rupture of membranes before 37 weeks of pregnancy.

Causes of Highway Pollution

All vehicles that use roadway networks contribute to pollution, affecting human health. The US Department of Transportation (DOT) Bureau of Transportation Statistics conducts an annual breakdown of estimated emissions rates per vehicle type, distinguishing between light-duty vehicles, light-duty trucks, heavy-duty vehicles, and motorcycles.⁴ Of these, heavy-duty vehicles, defined as trucks with more than two axles or four tires, are the largest emitters, contributing 32 percent of all mobile source emissions of nitrogen oxides in 2017 and 25 percent of total US transportation sector carbon dioxide emissions in 2019 (Lattanzio 2022). Tailpipe exhaust in the form of inhalable particulate matter, however, is the source of most vehicular pollution from fossil fuel-powered vehicles. As of 2021, over 95 percent of new passenger vehicles sold in the US were powered at least partly by fossil fuels, and virtually no trucks or other large vehicles—the heaviest polluters—were electrified.⁵

Several studies identify notable pollution contributions from nontailpipe emissions (Denier van der Gon et al. 2013; Habre et al. 2021), including tire wear, brake wear, road wear, and resuspended road dust. These will persist even as electric zero-emission vehicles become more common (Alexandrova, Kaloush, and Allen 2007). Electrification, however, may reduce tailpipe exhaust and pollution from brake wear, provided roadways feature free-flow vehicular movement rather than stop-and-go traffic with heavy braking (Grigoratos and Martini 2015).

Passenger and freight vehicles emit an array of pollutants into the surrounding air, including black carbon, NO_x, and carbon monoxide (Baldauf, Thoma, Hays, et al. 2008; Brugge, Durant, and Rioux 2007). Researchers consistently find elevated concentrations of inhalable particulate matter, specifically PM_{2.5} and PM₁₀ (measures of the size of particles), downwind of highways (Askariyeh et al. 2020), with concentrations not declining to background levels until 100 to 300 meters away from roads (Baldauf, Thoma, Hays, et al. 2008; Pattinson, Longley, and Kingham 2015; Zhu et al. 2002). Nitrogen dioxide levels similarly decay as distance from expressways increases, declining to background levels at 300 meters (Beckerman et al. 2008). Pollution levels are often just as high—if not higher—near arterials as along limited-access Interstates, because Interstates often feature more free-flowing traffic and less braking (Boehmer et al. 2013).

There are, of course, nonroadway air pollution sources⁶ that contribute to overall emissions. These include other mobile sources such as airplanes; stationary sources such as factories, industrial facilities, oil refineries, and power plants; area sources including agriculture, buildings, and fireplaces; and natural sources such as wildfires, wind-blown dust, and volcanoes.

Noise pollution, although often overlooked in research on traffic-related pollution, can also harm those nearby. Pollutive noises are caused by vibrations in vehicle bodies as well as engine operating sounds.⁷ All vehicles emit some noise pollution, although some, such as heavy trucks and those due for maintenance, are more responsible than others (Farooqi et al. 2020). Other sources of nonvehicular noise pollution include commercial, industrial, and community noise (Farooqi et al. 2020). Aircraft, specifically propeller aircraft (Omni and Azimi 2017), and freight shipping (Halliday et al. 2017; Williams et al. 2015) also contribute to harmful noise pollution.

Health Problems Associated with Pollution

Air and noise pollutants are hazardous to human health. People living near highways, particularly congested ones, experience poor lung health, including chronic obstructive pulmonary disease (Peng et al. 2021; Schikowski 2008), lung cancer (Hystad et al. 2013; Pope et al. 1995), asthma (Brugge, Durant, and Rioux 2007; Commodore et al. 2021; Meng 2008), and reduced lung-function growth among young people (Brugge, Durant, and Rioux 2007; Gauderman et al. 2007). Other research shows increased rates of potentially fatal heart problems as a product of air pollution sourced from roadways (Hoek et al. 2002; Kan et al. 2008; Pope et al. 1995; Tonne et al. 2007). Other related health problems include greater incidence of stroke (Pedde 2017) and several pregnancy-related issues, including premature birth and autism among children (Currie and Walker 2009; Pattinson Longley, and Kingham 2015;

Yorifuji et al. 2015). These problems are worse for individuals who are elderly or exhibit other comorbidities (Deryugina et al. 2019; Simoni et al. 2015).

Noise pollution is associated with the development of type 2 diabetes (Thacher 2021), heart problems (Münzel 2020) and declines in fitness (Pyko et al. 2017; Roswall et al. 2017). Spending time near consistent noise sources can lead to frequent activation of the human “fight or flight” response, which can increase stress levels and blood pressure, accelerate heart rates, and weaken vascular and digestive systems over time.⁸ It is also a cause of poor sleep and impaired cognitive performance, including among children (Thompson et al. 2022). These can lead to an increased risk of driving errors and collisions (Basner and McGuire 2018). Reduced cognition can also harm work and school productivity along with physical and mental health, both of which have long-term implications for personal and economic well-being. Pollution can also have psychological effects; one study found that people living further from highways thought less about air pollution than those living closer (Pattinson, Longley, and Kingham 2015).

This multitude of health problems takes a toll on the global population. Researchers estimate that PM_{2.5} and ambient ozone pollution caused by vehicular exhaust could be linked to around 361,000 premature deaths worldwide in 2010 and 385,000 premature deaths in 2015 (Anenberg et al. 2019). One study estimated that 19,800 US deaths were caused by vehicular air pollution in 2017, though this figure declined from 27,700 in 2008 (Choma et al. 2021), indicating that continued efforts to cut emissions could further reduce associated deaths.

Disproportionate Risks for People of Color and Lower-Income Individuals

People of color and individuals with low incomes in the United States are disproportionately affected by both air and noise pollution. This pollution, on the other hand, is disproportionately produced by the activities of white people moving in their cars or powering their homes, resulting in an inequity in both production and exposure to pollution and its effects (Tessum et al. 2019). Air and noise pollution are global problems, but their effects are not distributed evenly. In this section, we describe national findings on these inequities. In our case study of Louisville, we add nuance to this discussion by offering local-level comparisons; we find no racial or ethnic inequities but identify concerning differences in exposure to highway pollution based on economic class.

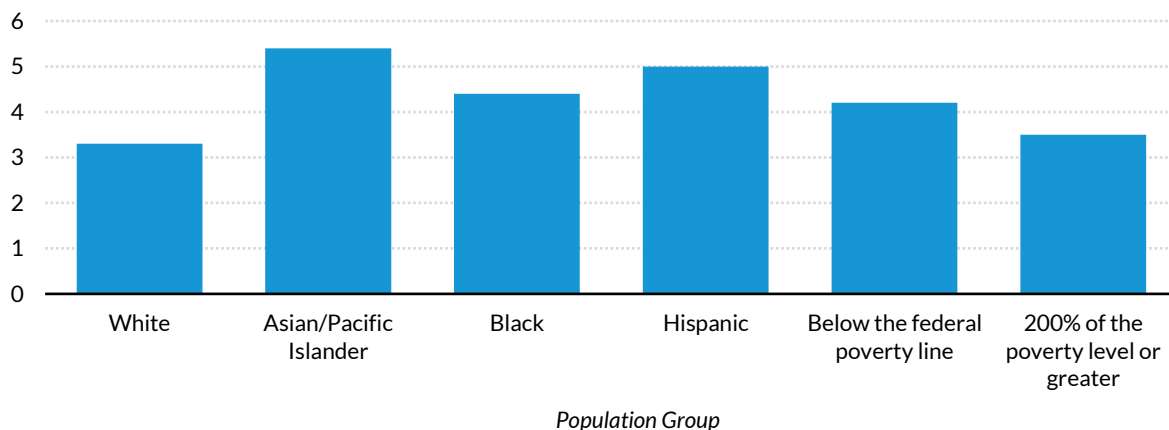
Problems relating to pollution exposure extend to home, work, and school. According to the 2011 Health Disparities and Inequalities Report, a disproportionate share of people of color and individuals below the federal poverty level live within 150 meters of a major highway, compared with white people and individuals who earn 200 percent of the federal poverty level or more (figure 2) (Boehmer et al. 2013). In 2019, the Union of Concerned Scientists modeled vehicular air pollution exposure in several regions. The group’s model found that nonwhite people are exposed to significantly higher levels of PM_{2.5} from vehicles, with Asian American, Black, and Hispanic people exposed to 34, 24, and 23 percent higher levels, respectively, than the US average.⁹ Another study concluded that people of color and individuals with lower incomes are systematically exposed to more nearby traffic (Rosenlieb et al. 2018). A Chicago study concluded that noise pollution from roads and public transportation is higher in

neighborhoods with more residents who have low or moderate incomes, and that these communities may be disproportionately impacted by such exposure (Huang et al. 2021).

FIGURE 2

People of Color and Individuals Experiencing Poverty Are More Likely to Live Near Highways

Percentage of groups living within 150 meters of a highway, United States



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Source: Boehmer (2013).

Notes: Figure should be read as follows: Roughly 5 percent of Hispanic people in the United States live within 150 meters of a major highway. Asian, Black, and white figures are for people of non-Hispanic ethnicities.

Inequities in pollution exposure extend to school trends. One Michigan study found that a larger-than-average percentage of Black, Hispanic, and low-income children attend schools near highways or industrial facilities, putting them at greater risk for neurological and respiratory diseases and contributing to poorer school performance than students attending school further from emissions sources (Kweon et al. 2018).

This greater proximity among people of color and people with low incomes translates to worsened health outcomes. One study found stronger associations between high traffic density in residential neighborhoods and risks of having asthma among individuals living in poverty than those above the federal poverty level (Meng et al. 2008). Many of the health impacts associated with roadway proximity produce racially disparate effects. Studies show that Black and Hispanic children are more likely to experience asthma or asthma symptoms than their white counterparts (Commodore et al. 2021), while Black and Hispanic mothers are at greater risk for adverse birth outcomes caused by air pollution (Gray et al. 2014), highlighting how traffic-produced pollution can worsen health equity.

Indoor Air Pollution

According to some measures, Americans spend around 90 percent of their time indoors, and people can be just as susceptible to air pollution inside as outside.¹⁰ Road-sourced pollution can negatively affect

indoor air quality in offices and residential buildings near highways (González-Martin et al. 2021), especially in older homes (Liang et al. 2021). Indoor air pollution is caused by both external and internal sources, ranging from cleaning materials to central heating and cooling systems,¹¹ but efforts to dilute these internal pollutants through ventilation from outdoor air can actually degrade indoor air quality, particularly in roadway-adjacent buildings.¹² This suggests that being inside near a highway does not necessarily ensure that people are exposed to fewer pollutants.

Values of Property Adjacent to Highways

Public investment in roadways and limited support for public transportation over the past 70 years have supported the creation of a largely automobile-dependent society. In Louisville, for example, almost 90 percent of workers drive to their jobs, according to 2016–20 American Community Survey data. As a result, the road and highway system serves as the key infrastructure for moving people and goods. By connecting people to employment, recreation, and services, highways help vehicle owners access entire regions (Tillema, Van Wee, and Ettema 2010), though they fail to ensure mobility for those who cannot afford to own a car or do not want to. Highways also have relational impacts on the location of residential, commercial, and industrial land uses, all of whose development goes on to influence future roadway construction and peoples' lifestyles.

Yet, because of air and noise pollution, researchers find that highways and the automobiles that move along them have negative impacts beyond health effects. Though the evidence is mixed, some research shows that proximity to roadways reduces property values: noise pollution has a significant negative impact on housing prices, with decreases for each additional decibel generated by highway traffic of 0.3 to 0.8 percent (Allen, Austin and Swaleheen 2015; Nelson 1982; Theebe 2004). Other studies show that proximity to highways can reduce home values by between 4 and 10 percent (Allen, Austin and Swaleheen 2015; Hughes and Sirmans 1992; Nelson 1982; Seo, Golub, and Kuby 2014), although these effects are negligible when homes are adjacent to access ramps (Allen, Austin and Swaleheen 2015; Seo, Golub, and Kuby 2014).

Negative public health impacts and lower property values are just two manifestations of the effects of highway-sourced pollution on sleeping, working, and learning in specific places. Living near roads may also reduce quality of life, increase risk of traffic collisions—for people in cars as well as pedestrians and cyclists—and curtail access to neighborhood features such as open space and retail. In sum, there are many reasons to desire less-intrusive roadway infrastructure. Some policymakers agree; we turn to their actions in the next section.

Policy Approaches to Mitigate Highway Pollution

We identified several ongoing public policy initiatives to reduce the harmful links between highways, pollution, and health impacts. Most are intended to adapt to present conditions. New federal grants incentivize projects that reconnect communities, increase walkability, and make alternative transportation more desirable. State and local governments have simultaneously developed policies

that separate highways from the surrounding environment. Yet, as a whole, US policymakers have largely failed to envision, design, or plan for a transportation system that moves beyond its current automobile dependence—even though a less car- and truck-focused society would be less likely to pollute neighborhoods.

Protection of Neighborhoods near Highways from Pollution

Some recent state and federal programs have shifted focus to reducing highway pollution at the source, which could complement electrification trends and lower long-term roadway emissions. Efforts to use local zoning regulations to limit exposure to highway pollutants are less common.

FEDERAL INITIATIVES

The Interstate highway system connects individuals to work, school, recreation, and other services, yet, as we have seen, exposes millions of Americans to high levels of air and noise pollution. Recognizing the effect of traffic on communities, the US Congress authorized the Congestion Mitigation and Air Quality Improvement Program in 1991. The program allocates funds to transportation projects that reduce regulated emissions, such as particulate matter, specifically through congestion relief efforts.¹³ Funded projects promote fluid traffic movement, from which pollution is less harmful compared with more static conditions (Levy, Buonocore, and Stackelberg 2010), though implementers rarely acknowledge that fluid conditions can induce more vehicular demand, thus causing even more pollution over the long term (Xie et al. 2019).

The highway system has also frequently isolated communities, particularly communities of color, from valuable services (Archer 2020).¹⁴ This includes Louisville: the construction of I-64, I-65, and I-264 in the 1950s and I-265 in the 1970s displaced many inner-city residents or disconnected them from surrounding neighborhoods (Dock 2016). To reverse some of the damage caused by these highway projects, the US Congress funded a new Reconnecting Communities pilot program in the 2021 Infrastructure Investment and Jobs Act.¹⁵ This \$1 billion, five-year program, managed by DOT, provides grants for planning and capital construction for projects in neighborhoods cut off from economic and social opportunity by transportation infrastructure. At least in theory, funds could be used to reduce automobile traffic by converting highways to surface boulevards or capping roadways—if a local or state government is interested in the idea, applies for a grant, and secures federal government support.

Even before the Reconnecting Communities program, cities across the country had begun efforts to replace highways with more accessible boulevards, which can reverse infrastructure-created segregation, unlock parcels of land for redevelopment, reduce exposure to particulate pollution, and create safer routes for pedestrians and cyclists.¹⁶ New York State, for example, released a plan alongside federal officials early in 2022 to demolish the elevated I-81 Interstate running through downtown Syracuse and replace it with a street-level community grid.¹⁷ The Michigan Department of Transportation will use federal funding to replace sections of I-375 in Detroit, whose construction destroyed many Black-owned businesses and homes. Mayor Mike Duggan argues the current project will “improve walkability and reestablish business along the corridor.”¹⁸

Other major federal grants are now available to advance related projects, funded by the Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act (Stacy, Freemark, and Dedert 2022). Some of these opportunities can support transportation infrastructure projects in the same vein as Reconnecting Communities, such as INFRA and RAISE grants, which will collectively fund more than \$3 billion in infrastructure annually.¹⁹ DOT will use RAISE grants for sustainable projects that promote energy efficiency, increase climate resilience, and reduce pollution. Louisville, for example, has applied for a grant to reimagine the 9th Street corridor near downtown with the goal of reducing traffic, improving access to park space, and reducing exposure to pollution.²⁰

The Safe Streets and Roads for All program will dedicate \$5 billion over five years to prevent roadway injuries and deaths.²¹ Grants could support roadway safety treatments, bikeway networks, and safe routes to school, with the net effect of reducing pollution. The Thriving Communities pilot program, a partnership between DOT and the Department of Housing and Urban Development, will provide technical assistance to foster vibrant neighborhoods through transportation access; planning funds could be used for investments that reduce roadside pollution.²² The Inflation Reduction Act also created the Neighborhood Access and Equity Grant program, a \$3 billion initiative that will provide grants to improve walkability, safety, and affordable transportation access through the construction of projects on surface transportation facilities.²³

At present, DOT funds noise abatement measures, which can include traffic management and road design alterations to reduce noise pollution. Barriers are sometimes included in the construction of new highways and occasionally added by state departments of transportation during renovations. DOT allows some federal funds to be used for noise barriers and requires all states to maintain an inventory.²⁴ But states have discretion over these choices; Kentucky state policy, for example, does not fund noise barriers on existing highways unless their construction is included in a related improvement project.²⁵

Scholars and practitioners debate the effectiveness of barriers.²⁶ Some argue that they are worthwhile investments, capable of reducing pollution concentration (Finn et al. 2010; Venkatram et al. 2016). Others note that barriers are more likely to be effective when constructed alongside mature vegetation (Baldauf, Thoma, Khylstov et al. 2008). According to the US Environmental Protection Agency (EPA), this combination can alter airflow, intercept pollution, and reduce noise, while the vegetation can double as a tool to control stormwater runoff.²⁷

Barriers may, in some cases, actually increase sound levels, especially for those living on hills or near freeway openings, and they can block small animals from moving between habitats (Fahy et al. 1995). Opponents instead sometimes advocate for highway pavement alterations that dampen noise, such as adding more porous surfaces to asphalt (Donavan 2013). Several states have experimented with these changes, including Arizona, where the state DOT launched a 10-year research program to explore pavement surface transformation as a permanent solution for noise pollution (Donavan and Scofield 2005). This option, however, has not yet been approved by the Federal Highway Administration as a standard form of noise abatement.

Conventional barriers and pavement alterations may have design flaws, but there is no shortage of alternative designs available. The Federal Highway Administration provides a lengthy design handbook with alternative approaches that vary in cost, material, and aesthetic value (Fleming et al. 2017). Highway engineers have experimented with a design that incorporates pollution-dispersing photocatalytic coatings that reduce nitrous oxide levels by up to 92 percent at peak daylight.²⁸ Huertas and others (2021) conclude that the most cost-effective design is a quarter-ellipse barrier with a height equivalent to 15 percent of the road width. Noise berms are a particularly cost-effective option, as they are constructed in a natural, unsupported condition from earthen materials usually available in surplus on project sites. To determine the most promising approaches, DOT is evaluating the effectiveness of noise barriers implemented by states.²⁹

STATE AND LOCAL POLICIES

In our review of local land-use policies, we found that few local regulations incorporate highway setback standards designed to minimize public exposure to air and noise pollution. A recent study of the proximity of new housing to highways in San Jose found that mitigation efforts among public and private sector stakeholders were both limited and uncoordinated, leading to 45 percent of new housing being near high-traffic roadways (Gabbe, Oxlaj, and Wang 2019). That said, in Louisville, the Metro has implemented 250-foot (about 75-meter) setbacks for residential uses and noise-sensitive community facilities around Interstates in the outer Metro; the Metro discourages such uses—but does not ban them—within 250 feet of Interstates in the inner Metro.³⁰

Some states and federal agencies support highway setback standards for schools. California banned new construction of schools within 500 feet, or roughly 150 meters, of freeways in 2003, with some exceptions.³¹ The EPA, meanwhile, recommends that school districts exercise caution before picking sites near major roads or truck routes, acknowledging that schools built further from highways could increase commute time and thus exposure to pollution (EPA 2015).

Local governments can diminish exposure to roadway pollution in several ways. Hundreds of cities have agreed to embed complete streets principles into their road design standards.³² This generally means implementing pedestrian- and bike-friendly infrastructure on roads previously designed for automobiles, making it feasible for people to travel without driving. Louisville's Complete Streets initiative requires bicycle and pedestrian ways in all new roadway construction and reconstruction projects unless certain conditions are met.³³

Localities can also limit car traffic altogether. During the COVID-19 pandemic, several US cities opened key streets to pedestrian and bicyclist traffic, preventing cars from traveling along them. Such changes likely improved the air quality of surrounding areas while promoting local economic and public safety improvements. In Madrid, Spain, efforts to reduce car traffic and pedestrianize parts of the central city, for example, reduced exposure to particulate pollution (Sánchez et al. 2021). Similarly, in Seoul, South Korea, regeneration of several downtown streets through pedestrianization improved air quality and thus locals' perceptions of quality of life (Kim, Lee, and He 2021).

If integrated with land-use development, low- or no-car zones could significantly reduce local exposure to air and noise pollution. The Vauban neighborhood of Freiburg, Germany, for example, is built with almost no through streets for cars and little parking. Initially developed in the 1990s, Vauban demonstrates the possibilities of development without car dependence. Instead of connections to a major highway, the community is linked to employment and social services centers via electrically powered, pollution-free tramways.³⁴ Barcelona, Spain's superblocks follow a similar model, increasing green space, fostering social cohesion, and reducing noise and emissions by closing streets to vehicles (Burrowes and Schilling 2021).

Reduction of Highway Pollution at the Source

The state and local programs and policies described above emphasize new investment in infrastructure that could reduce air and noise pollution in communities surrounding highways. The other key approach to reducing exposure is to curtail the pollution cars and trucks generate in the first place. The earliest federal action to limit pollution at the source came in 1970, when Congress strengthened the 1963 Clean Air Act. The newly formed EPA was given authority to regulate transportation pollution, which led to cleaner fuels, fewer air pollutants, technological innovation, and better air quality.³⁵ Over the past few decades, standards set by the federal government have been somewhat effective in reducing air pollution exposure, such as from diesel trucks, though such contaminants remain a major concern.³⁶

The Infrastructure Investment and Jobs Act's Carbon Reduction Program will fund \$6.4 billion for states and localities to develop additional pollution-reduction strategies.³⁷ These funds can be spent on projects such as implementing bus rapid transit corridors that reduce carbon dioxide emissions from on-road highway surfaces, facilitating micromobility, improving biking infrastructure, deploying zero-emission vehicles, supporting congestion pricing, and establishing electrification systems to reduce the environmental impacts of freight movement and emissions at port facilities.

Vehicle electrification may encourage emissions reductions at the consumer level. Less than 1 percent of the 250 million vehicles on the road in the US today operate using electric propulsion. Yet, recent trends indicate their use will increase over the coming years, and the Inflation Reduction Act includes tax credits for consumers to purchase them.³⁸ This growth will likely be spurred on due to changing consumer preferences in support of electric vehicle use, improved battery technologies that make these vehicles more affordable and longer in range, and stricter environmental policies curbing the production and sale of gas-powered vehicles (Dia 2019).

President Biden signed an executive order in August 2021 aiming to make "half of all new vehicles sold in 2030 zero-emissions vehicles, including battery electric, plug-in hybrid electric, or fuel cell electric vehicles."³⁹ Although the executive order does not actually require this change to occur, recent estimates indicate that electric vehicles could constitute up to 70 percent of all cars on the road by 2050.⁴⁰ This could drastically reduce carbon dioxide emissions, and associated reductions in PM_{2.5} and ozone formation could save hundreds of lives (Peters et al. 2020). Goals related to electric vehicles are not just in the federal government's jurisdiction: for example, the state of California introduced a landmark regulation in August 2022 that will require all vehicles sold in the state to be either electric or

plug-in hybrids by 2035, and Louisville’s Metro government prioritizes the purchase of electric vehicles.⁴¹

Another proactive way to reduce roadway pollution is to implement structural changes that reduce dependence on cars and other personal and commercial motorized vehicles, even without large-scale neighborhood transformation. The most feasible strategy is to encourage the use of public transportation systems. The 2021 Infrastructure Investment and Jobs Act includes funds that could be used for such projects, including the construction of new rail lines, bus rapid transit corridors, and transit vehicle electrification.⁴² Meanwhile, the federal government has long incentivized its employees to commute to work using public transportation through the transportation subsidy program. Other exemplary policies that have supported efforts to reduce car dependency include Denver’s rebates for the purchase of electric bicycles and Toronto’s electrification of train lines.⁴³

A Louisville Case Study: Exposure to Highway Pollution in Kentucky’s Largest City

In the summer of 2020, the Louisville Metro Office of Planning and Design Services began taking steps to reform the city’s land development code, which regulates how land is used through the zoning text and map. This reform is designed to prioritize social and racial equity, in line with Plan 2040, the comprehensive plan. Both are oriented toward three goals: expanding housing choices, establishing more accessible development procedures, and increasing quality of life by reducing the concentration of environmental hazards near housing.

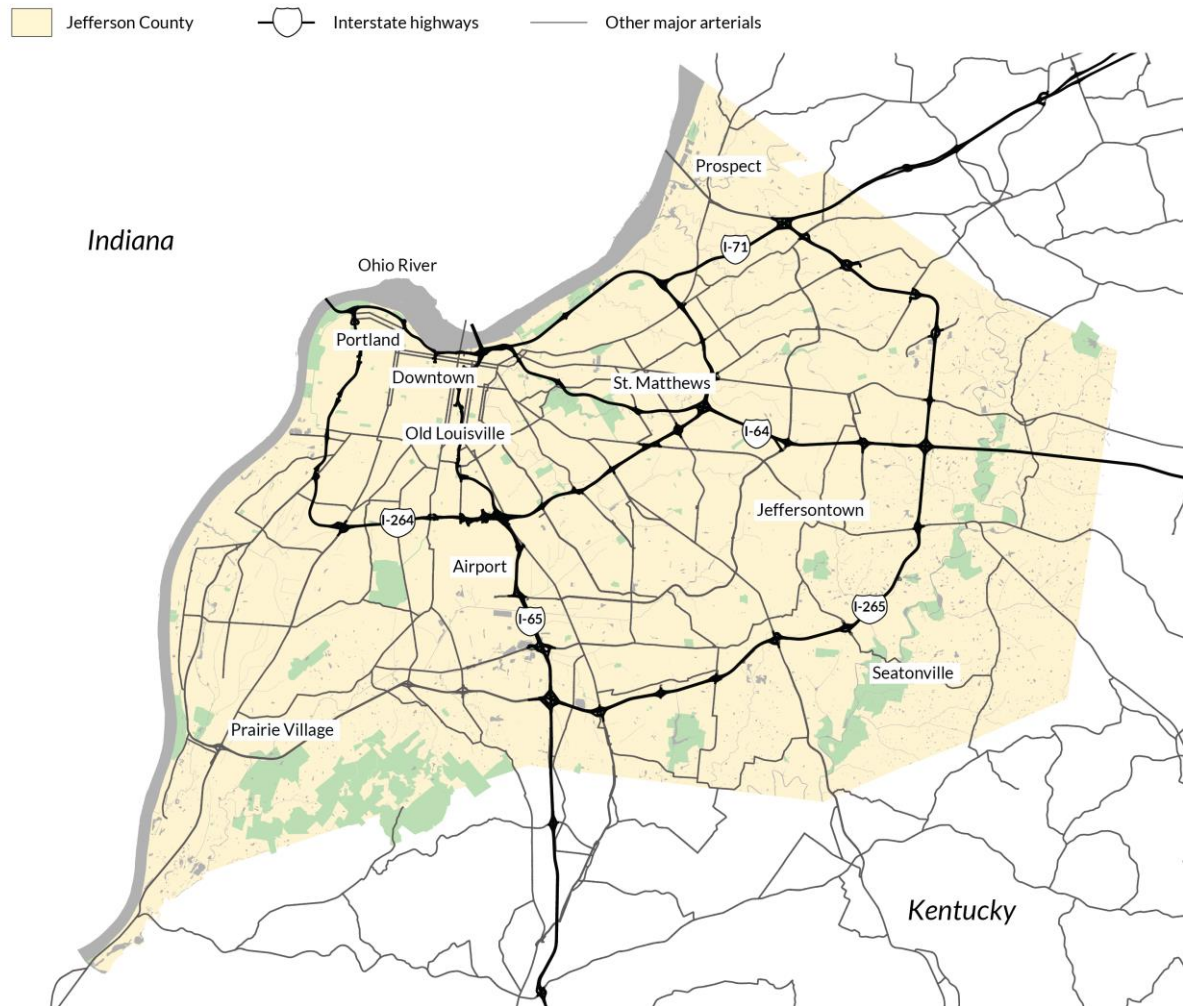
One way Louisville planners are considering addressing each goal during the second phase of the reform is through a proposed code amendment that would review the existing buffer standards for residential development adjacent to highways, make adjustments, and propose new standards as needed. This proposed amendment comes in response to concerns about the dangerous consequences of automobile pollution for public health, specifically, the individuals with low incomes and people of color living in areas with high pollution. This work supplements the work of the Louisville APCD over the past 70 years to implement federal clean air requirements, including through air monitoring (of ambient air, including in near-road conditions) and facility permitting (such as of factories and power plants) to ensure their compliance with those rules. But, as far as we could find, no study has previously identified the degree to which Louisvillians reside, work, or go to school adjacent to highways.

Metro Louisville, like most US cities, features a network of Interstates and arterials (figure 3). The Interstates, which generally have four lanes, are limited-access roads often grade-separated from the regular street system. I-64, I-65, and I-71 run radially from downtown, whereas I-264 and I-265 run in a circumferential pattern. Each Interstate carries tens of thousands of cars a day.⁴⁴ Most of the arterials also have four lanes but are not limited access. These include US highways, state highways, county roads, and some city streets, and each carries several thousand cars a day. We do not include “regular” neighborhood streets, such as those with fewer than four lanes and with less traffic, in our analysis.

FIGURE 3

Louisville– Jefferson County Metro Highways

The Interstate system around Louisville includes a network of radial and circumferential routes linked with arterials.



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Source: Authors' calculations based on 2018 geospatial data from LOJIC, Louisville Open GeoSpatial Data.

Louisvillians' Exposure to Highways and Pollution

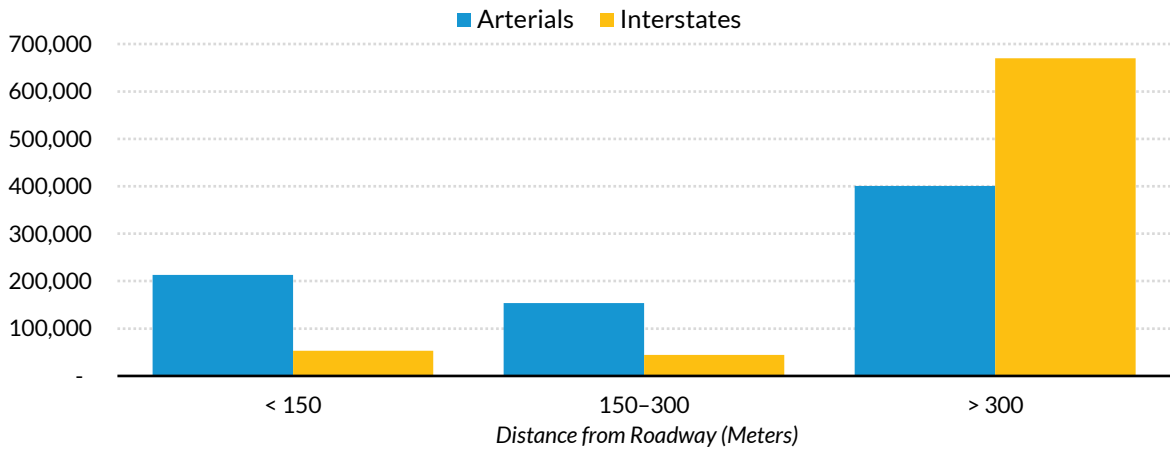
People spend a large share of their time not just at home but also at work and school. Our research explores the frequency of residence, employment, and schooling near highways throughout Louisville. Numerous other studies have examined office and school adjacency to highways as health indicators because of their association with pollution exposure (e.g., Ingle et al. 2005; Kweon et al. 2018; van Roosbroeck et al. 2007). We explore adjacency to Interstates and arterials because pollutant levels can be elevated around both (Boehmer et al. 2013).

Our analysis specifies how exposure to roadway pollution differs by racial, ethnic, and income group. The Metro’s proposed amendment to the land development code seeks to limit the exposure of “the most vulnerable low-income people of color among high concentrations of air pollutants.”⁴⁵ This goal, however, cannot be achieved without a deeper understanding of how individuals experience health and economic stressors caused by highway adjacency.

LIVING NEAR HIGHWAYS

We estimate that nearly half of Louisville’s residents—48 percent—live within 300 meters of at least one arterial, and about 13 percent of residents live within 300 meters of at least one Interstate. Roughly one-third of the Metro’s residents—more than 200,000 residents—live within 150 meters of arterial roads, exposing them to the most dramatic pollution impacts (figure 4).

FIGURE 4
Much of the Louisville Metro Population Lives Near Highways
Number of residents



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Source: Authors’ calculations based on US Census, 2015–19 five-year American Community Survey.

We detail the demographics of Louisvillians living near and far from highways in table 2. We find little differentiation in exposure to highways by race or ethnicity. Black people are somewhat less likely to live near major arterials than white people, but somewhat more likely to live near Interstates; nonetheless, these differences are small. We do not find any evidence that children are more likely to live near Interstates than the population overall, although children are roughly 7 percentage points more likely than all residents to live within 300 meters of arterials. Similarly, adults 65 and older are no more likely to live near Interstates than other Louisvillians, although they are 6 percentage points more likely to live close to arterials.

TABLE 2

Characteristics of Louisville Metro Residents, by Distance from Arterials and Interstates

Percent

	Arterials			Interstates		
	Within 150 meters	150–300 meters	Beyond 300 meters	Within 150 meters	150–300 meters	Beyond 300 meters
Residents	27.7	20.1	52.2	7.0	5.7	87.3
Demographic variables						
White people	33.6	24.9	41.4	7.0	5.8	87.2
Black people	28.8	19.9	51.2	7.3	6.0	86.7
Hispanic people	31.8	23.4	44.7	6.0	4.7	89.3
People under 18	31.1	23.4	45.5	6.7	5.5	87.8
People over 65	30.8	23.0	46.2	6.6	5.7	87.7
Economic indicators						
People with incomes below federal poverty level	34.6	22.9	42.4	8.3	6.5	85.2
Housing units	32.9	23.5	43.6	7.1	5.9	87.0
Households receiving SNAP benefits	35.8	22.5	41.7	8.9	7.0	84.0
Households without vehicle access	36.5	21.0	42.6	9.8	8.0	82.2
Renters	36.2	23.6	40.2	8.6	6.9	84.5
Subsidized affordable housing	35.7	32.9	31.4	8.7	10.4	80.9
Built environment and land use						
Permits, new residential units	15.8	22.7	61.5	1.6	1.7	96.6
Permits, new multi-family units	31.3	29.2	39.6	12.5	0.0	87.5
Permits, new single-family units	14.7	22.2	63.1	0.8	1.9	97.3
Permits, housing additions or renovations	20.5	23.3	56.2	2.6	5.2	92.2
Land with low-density residential zoning ^a	14.9	15.3	69.8	2.7	3.6	93.6
Land with moderate-density residential zoning ^b	42.0	23.5	34.4	6.3	7.1	86.7
Land with high-density residential zoning ^c	55.6	23.5	20.9	15.5	12.4	72.1

Source: Authors' calculations based on 2022 permit data from LOJIC, Louisville Open GeoSpatial Data; US Census, 2015–19 five-year American Community Survey; National Housing Preservation Database; and Louisville Land Development Code.

Notes: All percentages are on the base of Metro totals or subset (e.g., 28.8 percent of all Black Louisvillians live within 150 meters of arterials). Statistics for white and Black people in this chart are for those who are non-Hispanic/non-Latino.

^aLow-density residential zoning is defined as allowing fewer than 10 housing units per acre.

^bModerate-density residential zoning is defined as allowing 10–50 housing units per acre.

^cHigh-density residential zoning is defined as allowing more than 50 housing units per acre.

We do find major differences based on housing tenure. Of renters, 8.6 percent live within 150 meters of Interstates, compared with just 7.1 percent of all housing units. Moreover, 47.1 percent of housing units within 50 meters of an Interstate and 46.8 percent of units within 50 meters of an arterial are rented, compared with 38.2 percent of homes across the Metro as a whole (not shown). This suggests that the housing stock is composed differently based on its adjacency to highways, with renters in a more vulnerable location near roads.

When we examined federally subsidized affordable housing units, we found that they, too, are disproportionately near arterials; almost 70 percent of them are within 300 meters of arterials and almost 20 percent are within 300 meters of Interstates (compared to 56 and 13 percent, respectively,

for all housing units). Of public housing units specifically (not shown), 72 percent are near arterials and 35 percent are near Interstates. 21 percent of public housing units are located within 150 meters of Interstates—far higher than the overall rate. This suggests that government support for subsidized housing has, at least historically, focused on areas where exposure to air pollutants is higher.

New housing permits are less likely to be located within 300 meters of arterials or Interstates than existing housing units (38.5 percent and 3.3 percent, respectively). This trend could lead to less-polluted housing in the Metro for those who will reside in newly constructed homes, but the difference is principally informed by permits for single-family homes. Indeed, permits for multi-family homes (which more often than single-family homes contain rental units) are more likely to be located within 150 meters of Interstates than existing homes (12.5 versus 7.1 percent, respectively) and more likely to be located within 300 meters of arterials (60.5 versus 36.9 percent, respectively). Multi-family homes are more likely to be occupied by people with low incomes and people of color.

These results raise concerns about whether zoning policy encourages the location of more affordable, higher-density housing construction near arterials. We examined the Louisville zoning map to compare land-use policies near and far from arterials, dividing the Metro area into land zoned for low-density (meaning fewer than 10 units per acre), moderate-density (10–50 units per acre), or high-density (more than 50 units per acre) residential use. This comparison shows that 55.6 percent of the Metro’s land zoned for high-density residential use is located within 150 meters of arterials, as is 15.5 percent within 150 meters of Interstates. More than two-thirds of land zoned for low-density residential use, on the other hand, is located more than 300 meters away from arterials (table 2). This means that current zoning policy is concentrating dense housing growth, such as multi-family apartment buildings, in the areas most likely to be exposed to pollution.

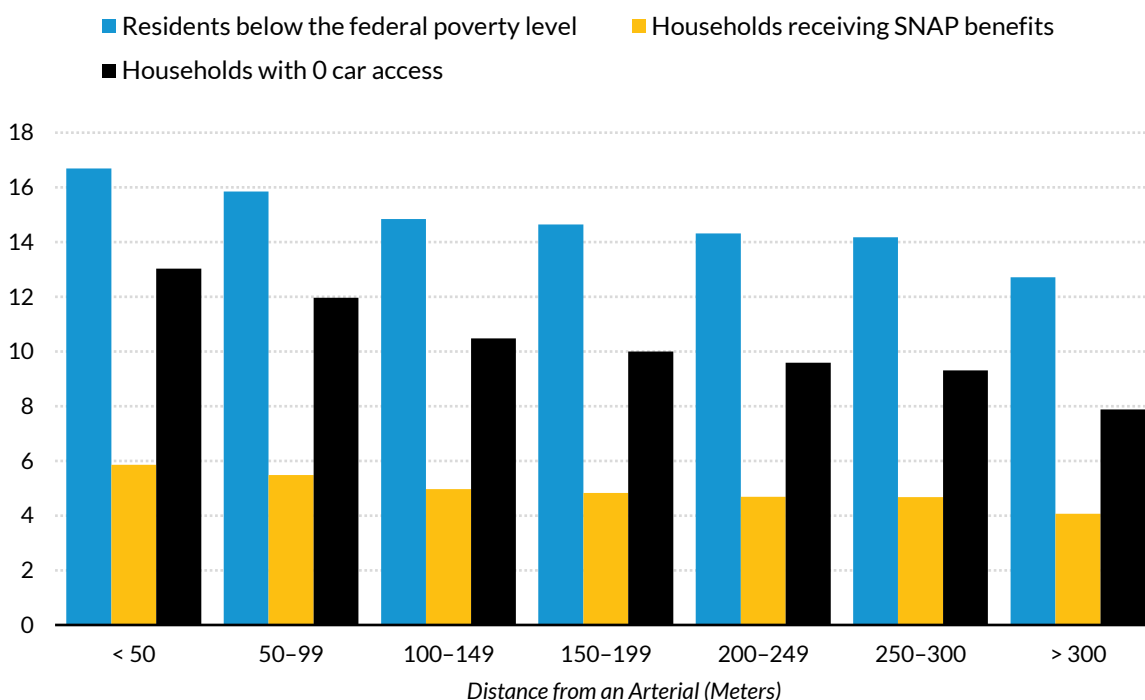
Table 2 also documents links between class and highway adjacency. A significantly higher share of people with incomes below the federal poverty level and households receiving SNAP benefits live near both arterials and Interstates. This may mean that lower housing prices near roads attract Metro residents with lower incomes, or simply that families with low incomes are more likely to live in publicly subsidized affordable housing and the larger multi-family housing units allowed under the zoning code in those areas.

We further illustrate the relationship between attributes of resident economic status and highway adjacency in figure 5, on the basis of distance from arterials. Of residents living within 50 meters of arterials, 16.7 percent have incomes under the federal poverty level, compared with only 12.7 percent of residents living more than 300 meters away from arterials; the trend shows a consistent downward slope. Similarly, of households living within 50 meters of arterials, 5.9 percent receive SNAP benefits, compared with 4.1 percent living more than 300 meters away. These differences are statistically significant ($p < 0.05$), and we identified similar characteristics of residents and households near and far from Interstates.

FIGURE 5

A Higher Share of the Low-Income and Zero-Car Population Lives Close to Arterials

Percentage of total population or households, by economic indicator



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Source: Authors' calculations based on US Census, 2015-19 five-year American Community Survey.

Notes: Figure should be read as follows: Roughly 17 percent of people living within 50 meters of arterials live below the federal poverty level, whereas only about 13 percent of people living more than 300 meters away from such arterials live below the federal poverty level.

Figure 5 also makes evident another concerning trend related to who lives near highways. Whereas 13 percent of residents within 50 meters of arterials have no car access, less than 8 percent of those more than 300 meters away have no car. This relationship between highway proximity and car access shows a consistent downward slope. As noted in table 2, compared with the general population, households without vehicle access disproportionately reside in neighborhoods close to both arterials and Interstates. These residents are breathing in the air and hearing the noise pollution others cause, while being unable to rely on automobiles themselves.

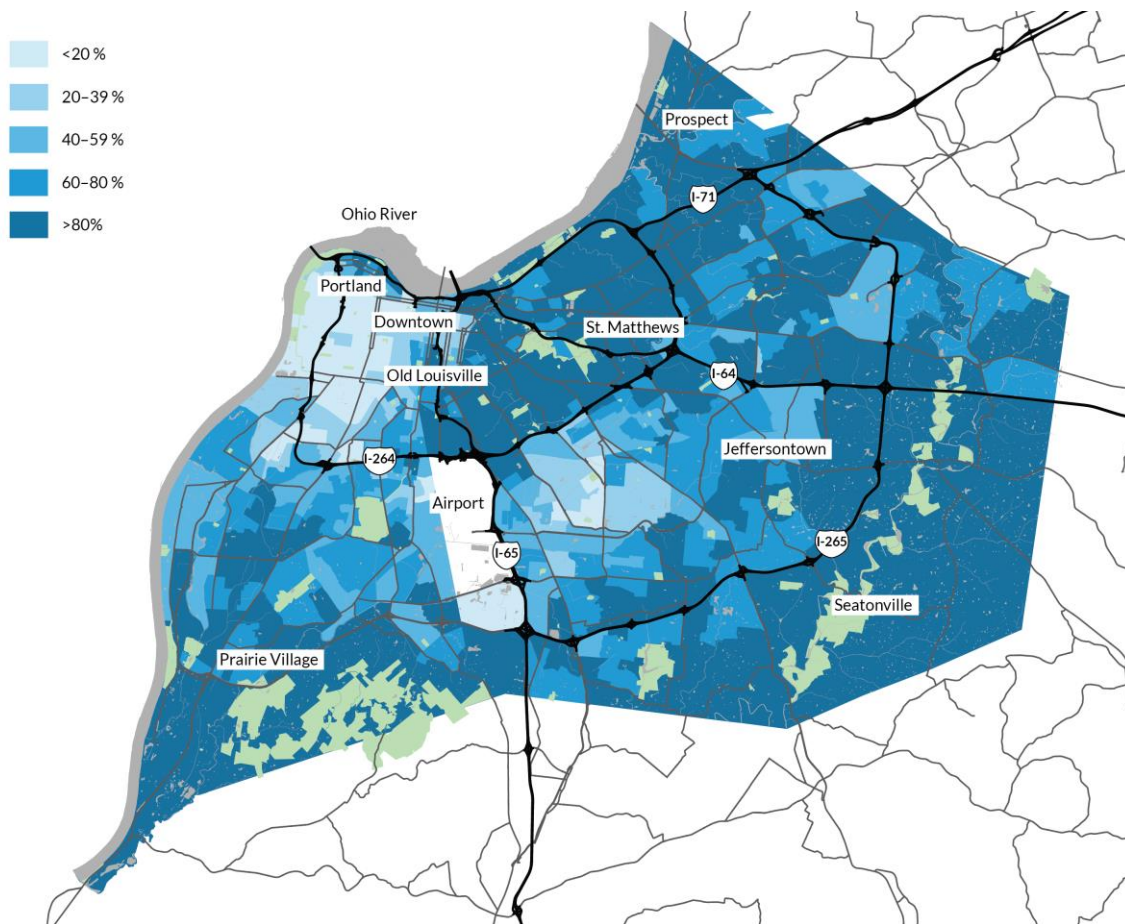
Adjacency to highways also has implications for housing prices. Homes tend to have less market value the closer they are to a highway. We find that the median home value within 50 meters of an arterial (\$177,294) is 4 percent lower than the median home value Metrowide (\$184,667). The disparity is even greater for homes within 50 meters of Interstates, with median home values of \$175,120.

Relatedly, household incomes are negatively associated with proximity to highways. For example, median household incomes in neighborhoods within 50 meters of an arterial and Interstate are \$56,908 and \$58,998, respectively, compared with \$64,374 in the Metro overall (per capita incomes are also

lower adjacent to arterials). All in all, these data strongly indicate that residents with lower incomes are more likely to be exposed to highway pollution than those with higher incomes.

In contrast to the relationship between adjacency to highways and resident class, as noted, we did not find a strong correlation based on racial or ethnic patterns (table 2). In figure 6, we illustrate the location of roadways and the share of each neighborhood that is non-Hispanic white. Louisville has several neighborhoods with low white population shares, such as the Portland community, through which an Interstate (I-264) extends directly. But other neighborhoods, such as those along the eastern portions of I-264 and I-265, have a population that is almost all white. Exposure to arterials and Interstates is not, Louisville-wide, differentiated by race—but differences abound by neighborhood.

FIGURE 6
Arterials and Interstates Traverse Neighborhoods both White and Nonwhite
Share of residents who are non-Hispanic white, by block group



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Source: Authors' calculations based on 2018 geospatial data from LOJIC, Louisville Open GeoSpatial Data; and US Census, 2015–19 American Community Survey.

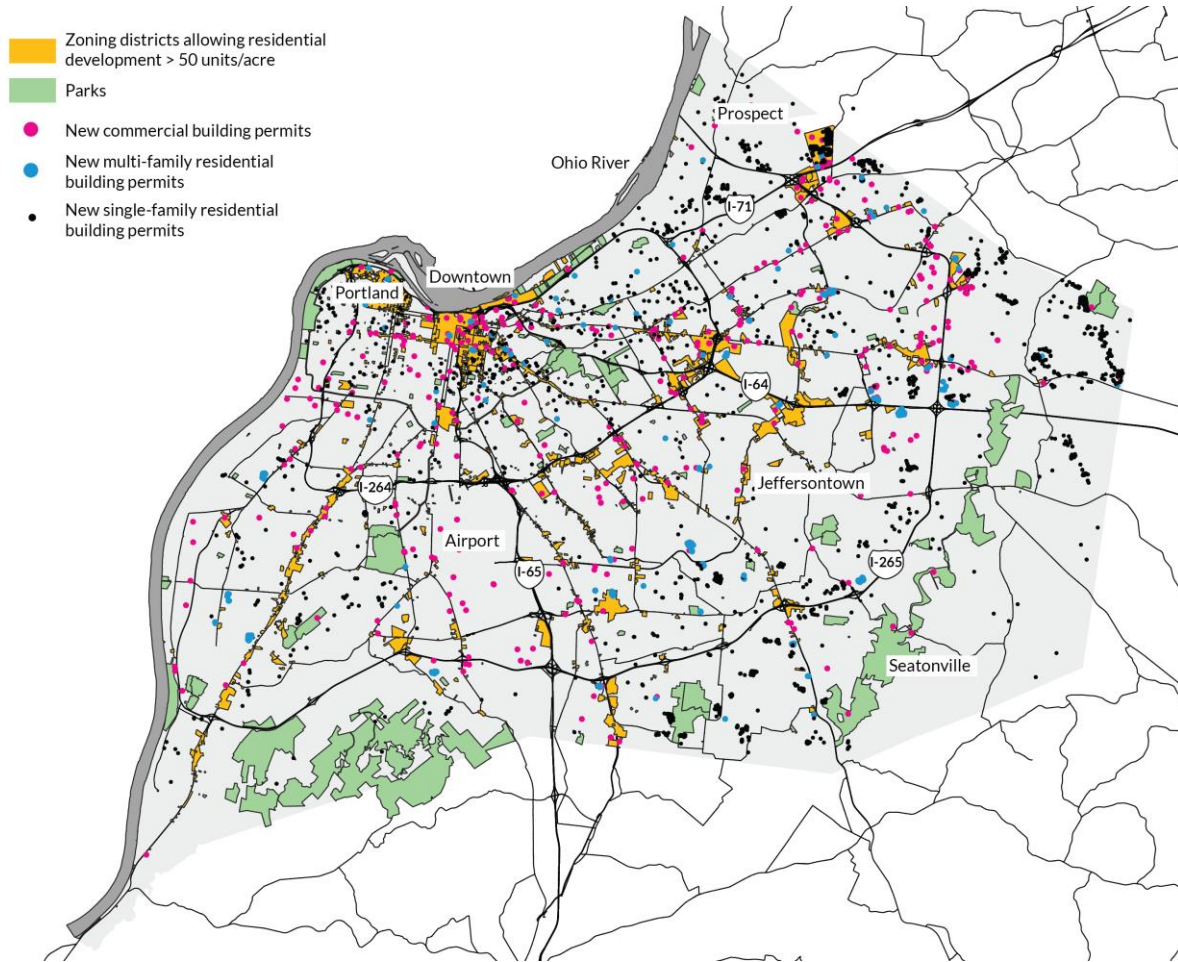
Many of the neighborhoods where people who are non-white predominate, as noted in figure 6, are classified by local officials as environmental justice areas.⁴⁶ These communities have suffered from decades of exposure to toxic pollution from industrial facilities, such as coal power plants. As a result, their adjacency to highways reflects only a portion of their overall exposure to air and noise pollution.

In figure 7, we map high-density zoning districts and new building permits throughout Louisville. Residential permitting for new multi-family construction is clustered in areas along highways and in the zoning districts allowing high-density residential construction (which are themselves clustered along highways). Single-family permitting, on the other hand, is more evenly distributed throughout the Metro, with permitting in many areas far from either arterials or Interstates, where residents are less likely to be exposed to roadway-derived pollution. We also show the location of new commercial building permits, which we explore in more detail in the next section.

FIGURE 7

Recent Building Permits Are Distributed across the City, with Some Concentrations of Multi-family Projects along Highways and in High-Density Zones

Zoning for high-density residential uses and building permits for new construction, 2010–20



URBAN INSTITUTE

Source: Authors' calculations based on 2022 permit data and 2018 geospatial data from LOJIC, Louisville Open GeoSpatial Data.

WORKING NEAR HIGHWAYS

The studies we examined typically use residential location as the standard for exposure to highway-produced pollution, but adults spend a large share of their time at their jobs as well—often eight or more hours a day. As we noted, being indoors does not necessarily prevent exposure to dangerous levels of air and noise pollution (especially considering inadequate ventilation systems), so even indoor jobs near highways could expose employees to health dangers. This risk could apply to retail, health care, education, hospitality, security, and many other jobs. We, therefore, explored the degree to which employment in Louisville is located adjacent to highways.

Table 3 summarizes our findings. Most of the Metro’s jobs are located within 300 meters of arterials, with 44 percent within 150 meters of such roads and 9.5 percent within 150 meters of Interstates in particular. Such employment concentration is a consequence of the convergence of roadways in the downtown area, where most jobs are located. Many jobs are also located along routes connecting the central business district to the rest of the Metro, reflecting land-use policies that promote concentration of employment near highways and the reality that most job holders depend on their automobiles to get to work.

TABLE 3

Louisville Metro Employment and Commercial Permits, by Distance from Arterials and Interstates
Percent

	Arterials			Interstates		
	Within 150 meters	150–300 meters	Beyond 300 meters	Within 150 meters	150–300 meters	Beyond 300 meters
All jobs	44.0	24.0	32.0	9.5	14.8	75.7
Employment at \$1,250/month or less	45.0	26.3	28.7	10.9	9.7	79.5
White job holders	43.4	24.2	32.4	9.5	14.7	75.7
Black job holders	46.1	23.4	30.4	9.4	15.7	74.9
Hispanic job holders	42.4	21.8	35.8	8.0	10.6	81.4
Job holders with less than a high school education	42.4	23.6	34.0	8.7	12.7	78.6
Job holders with a bachelor’s degree or higher	48.8	23.9	27.3	9.8	19.6	70.6
Building permits for new commercial investments	10.3	4.2	66.2	2.1	2.0	95.9

Source: Authors’ calculations based on 2022 permit data from LOJIC, Louisville Open GeoSpatial Data; 2019 employment data from US Census, Longitudinal Employer-Household Dynamics.

Notes: All percentages are on the base of Metro totals or subset (e.g., 42.4 percent of all jobholding Hispanic Louisvillians work within 150 meters of arterials). Statistics for white and Black people in this chart are for those who are non-Hispanic/non-Latino.

As with residential location, we find no strong relationship between the race and the ethnicity of job holders and their workplace location relative to roadways, except that Hispanic employees are more likely to hold jobs further away from highways. We do, however, find contrasting trends with respect to employee earnings and education. On the one hand, employees with low salaries (\$1,250 a month or less) are more likely than job holders overall to work within 150 meters of arterials and Interstates; on the other hand, employees with a bachelor’s degree or higher are *also* more likely to have jobs in those locations. But job holders with less than a high school education are less likely to work near arterials.

We also investigated the location of building permits for new commercial investments (which we mapped in figure 7). We find that few new commercial permits have recently been requested within 300 meters of Interstates, and a disproportionately small share is located within 300 meters of arterials. The implication of this finding is unclear; it may mean future commercial sites do not yet have roads leading

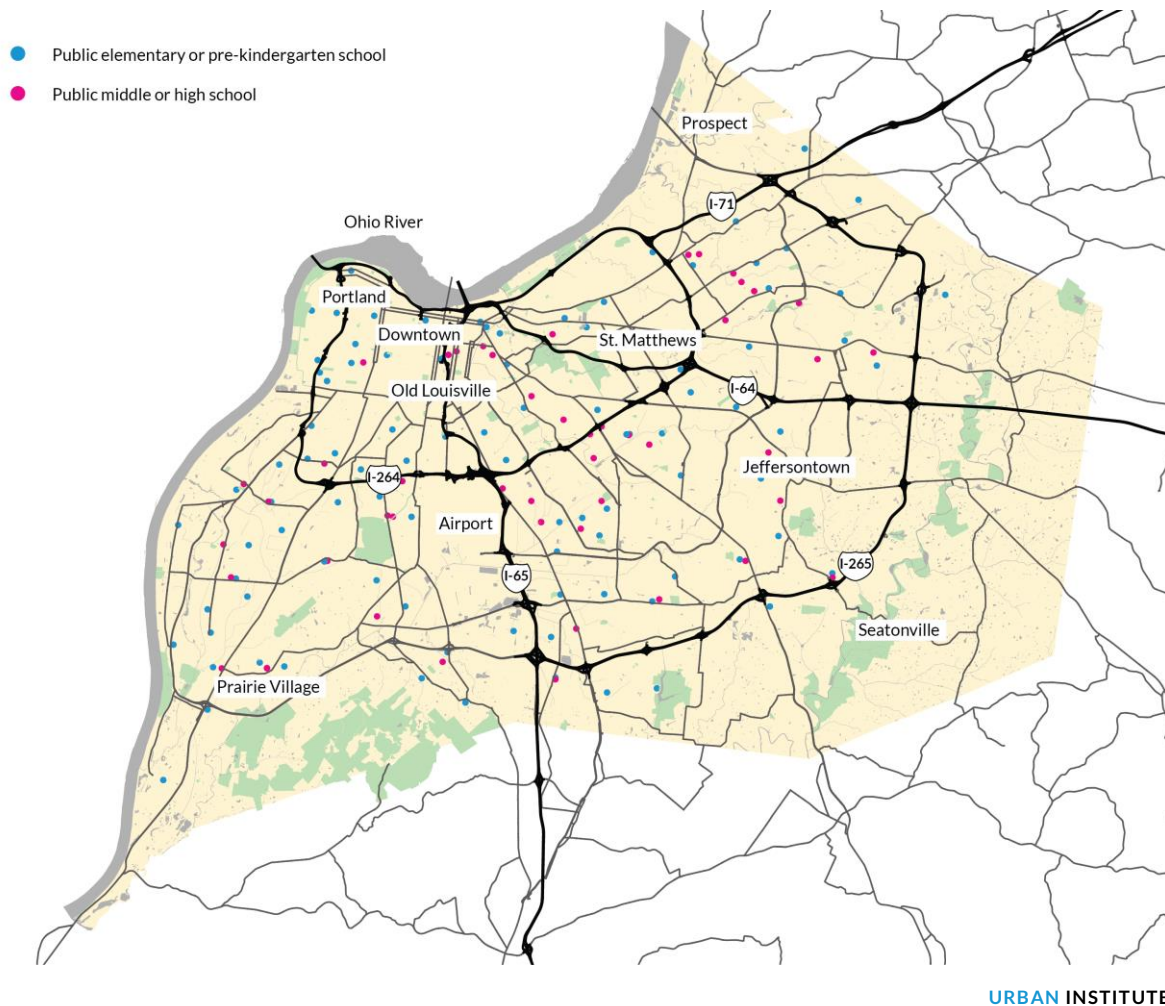
to them. Or it could mean that employment is being concentrated in exurban locations far from downtown, which raises other concerns, such as a lack of adequate access by public transportation or modes of transport other than driving. It is also possible that because we do not control for the *scale* of these new investments, the largest projects are, in fact, being constructed near arterials.

ATTENDING SCHOOL NEAR HIGHWAYS

Finally, we evaluated the distribution of Louisville schools. Though children are no more likely to live near highways than residents of the Metro overall (table 2), they may be exposed to highway-produced air and noise pollution at school, which accounts for a significant share of their weekdays. This may be particularly true for elementary school students, who go outside for recess, although students in higher grades may also go outside for sports or other extracurricular activities. Figure 8 maps the location of public schools and compares them with the location of highways across the Metro.

FIGURE 8

Distribution of Public Schools throughout the Louisville–Jefferson County Metro



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Source: Authors' calculation based on 2022 school data from LOJIC, Louisville Open GeoSpatial Data.

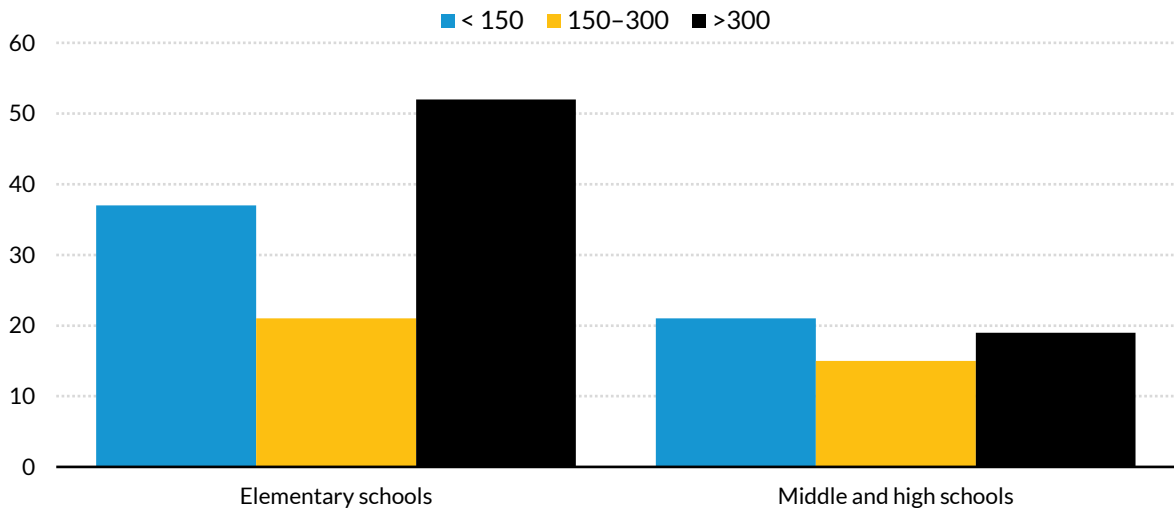
Notes: Any school that includes an elementary or pre-kindergarten component is noted as a "public elementary or pre-kindergarten school;" some middle and high schools in Louisville include elementary schools.

We calculated the distance of each Louisville public school from the nearest arterial and charted our findings in figure 9. More schools of all types are located within 300 meters of arterials than further, with a somewhat higher percentage of elementary schools located within 300 meters than middle and high schools. About one-third of public schools are located within 150 meters of arterials, and about 6 percent are located within 150 meters of Interstates (not shown), numbering seven elementary schools and two middle and high schools.

FIGURE 9

Many Louisville Metro Public Schools Are Located within 300 Meters of Arterials

Number of schools, by distance from arterials



URBAN INSTITUTE

Source: Authors' calculation based on 2022 geospatial data from LOJIC, Louisville Open GeoSpatial Data.

Note: Any school that includes an elementary or pre-kindergarten component is noted as an elementary school; some middle and high schools in Louisville include elementary schools.

Finally, we examined whether any school- or student-specific characteristics were associated with highway adjacency (table 4). Our findings show that children attending schools are somewhat equally exposed to roadway pollution by subgroup. We did not observe any patterns suggesting that students of lower-income households or students of color are more likely to attend school near arterials or Interstates. Moreover, students in elementary school or pre-kindergarten were no more likely than their older counterparts to attend schools closer to arterials and Interstates. Even so, we identified some concerning trends, including that over one-quarter of all elementary and pre-kindergarten students attend school within 150 meters of arterials. Attending school may expose these children to high levels of air and noise pollution.

TABLE 4

Characteristics of Louisville Metro Schools, by Distance from Arterials and Interstates*Percent*

	Arterials			Interstates		
	Within 150 meters	150– 300 meters	Beyond 300 meters	Within 150 meters	150– 300 meters	Beyond 300 meters
Schools (total)	34.7	22.2	43.1	6.0	5.4	88.6
Title I schools	32.1	19.8	48.1	1.5	3.8	94.7
Students (total)	35.2	25.5	39.3	2.5	5.5	92.0
Students (elementary and pre-kindergarten)	27.7	19.2	53.0	3.1	3.7	93.2
Students (other)	41.5	30.8	27.7	2.0	6.9	91.1
Students qualifying for free or reduced lunch	34.1	24.7	41.3	2.0	4.8	93.2
Students below the federal poverty level	35.8	23.5	41.3	2.2	4.3	93.6
Black students	34.5	24.7	40.7	2.7	6.5	90.9
Hispanic students	29.4	26.2	44.4	1.3	3.0	95.7
White students	37.8	26.3	35.9	2.8	5.8	91.5

Source: Authors' calculations based on 2020 school data from Urban Institute, Education Data Explorer.

Notes: All percentages are based on Metro totals or subset (e.g., 42.4 percent of all students attend schools within 150 meters of arterials). Statistics for white and Black students in this chart are for those who are non-Hispanic/non-Latino.

Conclusions

In this report, we examined scholarship on the exposure to, and effects of, air and noise pollution produced by roadways. Research demonstrates the negative health and economic impacts of highway adjacency; living near highways is associated with diseases that can lead to premature death. We then turned to Louisville as a case study to understand, at a local level, the effect that such transportation corridors have on everyday life—at home, at work, and at school. Of all residents, 7 percent live within 150 meters of Interstates—large, highly polluting highways. Nearly half of the Metro's residents live within 300 meters of an arterial; most of Louisville's jobs and schools are also located in such areas. And almost one-third of elementary and pre-kindergarten students—a population particularly vulnerable to the negative effects of air and noise pollution—attend schools within 150 meters of major arterials.

Although the people living and working near arterials are demographically similar to people throughout the Metro, disproportionate shares of such residents are renters, have incomes below the federal poverty level, receive SNAP benefits, and live in subsidized affordable housing, particularly public housing. This means that residents with lower incomes are more likely to suffer the negative health consequences of pollution. Considering that families without access to a private automobile tend to live closer to highways, it is a sad irony that those who are most likely to be exposed to roadway pollution are those who contribute least to it.

Without concerted action, these conditions will likely be further entrenched. We found that permits for new multi-family units are more than twice as likely to be located within 150 meters of arterials as those for new single-family units. This is, to a large degree, the result of land-use and transportation planning that prioritizes vehicular access over other livability considerations. Our finding that zoning

for high-density residential uses is concentrated in the neighborhoods close to highways demonstrates that reality. Future residents may experience improved health outcomes if they are able to live further from air and noise pollution. Yet, current land-use regulations make it difficult for them to do so if they plan to—or, depending on their financial situation, have to—live in apartments.

While our case-study conclusions are only directly related to Louisville, they have implications for cities across the country. Other communities could evaluate whether they, too, are disproportionately exposing their lowest-income residents, residents of color, young people, older people, and members of other protected groups to disproportionately high levels of roadway-produced pollution. They can examine the share of their residents, workers, and school students near such roads and determine whether they suffer worse health outcomes. Such data would help inform new strategies to advance environmental justice, public health equity, and economic opportunity.

Recommendations to Reduce the Negative Effects of Vehicular Pollution

As in Louisville, leaders of jurisdictions can take short-term steps to limit the negative health impacts of highways on residents. At a minimum, baseline information about exposure to roadways and their associated pollution, as we have developed for this report, could aid policymakers in choosing how to invest in improvements. Local action is best informed by an understanding of current conditions.

Local governments should consider air and noise pollution measures as they evaluate potential projects for funding. Choices in the distribution of funds for renovating publicly assisted affordable housing—both public housing and low-income housing tax credit properties—can account for the greater exposure to pollution their residents likely experience and focus on improving ventilation systems. Localities could also consider providing renovation assistance to landlords of existing, “naturally occurring” affordable private-market housing units near highways to target residents with low incomes.

If renovations of existing structures near highways could offer useful improvements over the short term, other strategies may be more effective over the long term. Local governments could incentivize development further from highways or even limit the construction of schools, office buildings, and apartment buildings within close adjacency of arterials and Interstates, where exposure to pollution is likely to be worst. In its equity review, the Louisville Metro government can rethink the land development code’s current emphasis on high-density construction near highways.

This approach to regulation is disproportionately exposing residents of apartment buildings to pollution and preventing the construction of such structures in other areas, such as those now occupied by single-family homes. Restricting apartments to areas near highways is encouraging multi-family housing construction there, to the detriment of people with low incomes.

Another possibility for local regulation reform is for localities to undertake more detailed project review for new investments in both highways and projects in highway-adjacent areas to ensure that they do not worsen the public health of their future residents, employees, or students. Review could

include mandated health impact assessments in the context of proposed roadway expansions and major roadside projects. This would allow city officials to identify a project's health impacts before it is cleared for construction. To its credit, Louisville already incorporates estimates of air quality impacts in its traffic impacts assessments for new projects, which are reviewed by the APCD. The APCD monitors ambient air and regulates pollution sources. Several of APCD's monitoring sites already specifically monitor air quality adjacent to roadways.⁴⁷

Further steps like restricting development near major roadways, however, require a more nuanced analysis. Prioritizing construction further from arterials and Interstates could lead residents to spend more time and financial resources on their commutes. Commuters could become even more car dependent, because public transit routes are typically designed to serve arterials instead of neighborhood streets. And land-use rules have encouraged a mix of uses, such as retail and employment, along highways rather than mixed between single-family homes and small apartments in calmer neighborhoods. As such, requiring development to turn away from highways could make it more difficult for many people without cars to get around.

Local agencies and developers should therefore be wary of not focusing construction too far from highways, but rather far enough to limit exposure to high concentrations of particulate matter. And development regulations should be most stringent in cases for which building users would be at the greatest risk of pollution exposure. For example, cities could allow limited developments with quality air filtration and noise abatement systems between 100 and 300 meters of Interstates but prevent apartment building development within 100 meters of such roads. Specific types of buildings that could be completely barred from being built close to highways include nursing homes and hospitals, which house vulnerable groups, particularly elderly populations significantly more susceptible to the negative health impacts associated with air pollution (Deryugina et al. 2019; Simoni et al. 2015).

A permanent ban on all construction close to arterials and Interstates may be unrealistic, particularly in downtown neighborhoods defined by both busy roads and high-density zoning. These are often the areas with the best access to public transportation and other amenities. Local leaders must therefore tread carefully in regulating future development. For existing office and school buildings and those being built close to highways, city officials should protect occupants from nearby pollution. This could involve efforts to raise awareness among building managers and homeowners about the consequences of highway pollution. Developers should follow best practices for indoor air quality design, such as those compiled by the American Society of Heating, Refrigerating and Air Conditioning Engineers (Persily and Hewett 2010). Local leaders could also provide education or even offer inspections to ensure that buildings are properly ventilated to limit the infiltration of outdoor pollution.

Local governments can also reduce exposure to air and noise pollution through direct investments in infrastructure—more feasible now thanks to expansions in federal spending. One option is to add new barriers to diminish pollution along the edge of Interstates in particularly exposed neighborhoods. Another is to pedestrianize certain streets, with the goal of significantly reducing exposure to the exhaust and other pollutants from cars. Such policies have been found to drastically reduce car emissions (Wheeler, Jones, and Kammen 2018). Louisville and other cities should more concretely

consider eliminating portions of highways and reducing the number of lanes along major arterials. Such efforts have already been successful in several cities across the country, including Portland and San Francisco, suggesting that this could be feasible and affordable (Mohl 2011).

Other policies that shift away from the polluting car culture include electrifying public transit and other government vehicles, changing the zoning code to eliminate parking minimum requirements or to enact parking maximums for new construction, and investing in the construction and maintenance of green infrastructure. Future neighborhood developments could prioritize better access to public transit and the creation of highly walkable and bikeable streets, but limit exposure to automobiles traveling along highways. These communities are likely to be more hospitable to inhabitants and result in better health outcomes.

Opportunities for Future Research

We have calculated the population, employment, and school adjacency to highways in Louisville, but there is need for better data on traffic-related air and noise pollution both nationwide and at the micro scale within neighborhoods. This could be achieved in part through more comprehensive research on local health indicators. Research would need to commence with an expansion of local air quality monitoring networks that allow researchers to compare conditions between near-roadway and more rural locations. Across the US, approximately one-third of counties have air quality monitoring data.⁴⁸ Louisville's Air Watch program directs users to real-time visualizations of Metro-wide air quality, but it has limited information about air quality at the neighborhood level.⁴⁹ There are five air quality monitoring sites in Louisville's metropolitan statistical area, one of which monitors near-road air.⁵⁰ One example to follow could be Project Eclipse, an ongoing air quality survey across multiple locations in Chicago run by Microsoft Research's Urban Innovation program (Daepf et al. 2022).⁵¹ Similar work is also underway through Green Heart Louisville, a research project deploying over 50 sensors to assess the impact of green space on air quality and health in urban communities.⁵² Such data could help cities like Louisville develop regulations that could either limit future construction or mitigate air pollution in areas where it is most harmful.

Further research efforts could help localities monitor noise pollution by developing datasets on the location of existing pollution barriers while identifying ideal locations for their future construction. Local researchers could also assess the feasibility of new barriers, as well as evaluate the effectiveness of traditional barriers versus alternative methods, such as "tredge" landscaping (Maher et al. 2022). This process would also allow policymakers to consider other interventions that help localities mitigate and adapt to climate change, such as green stormwater management. Cities can benefit from better access to data showing upcoming roadway improvement projects, as current regulations only allow federal funding for noise barriers during highway construction or renovation.

Notes

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