Home on a Highway

How Zoning, Housing Development, and Highway Construction Shape Pollution Exposure

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Abstract

High-traffic roads serve as a framework for new development in the United States, but noise and air pollution from cars and trucks negatively impact surrounding neighborhoods. We review how zoning policies have historically concentrated multi-family housing along busy roads and then evaluate three questions related to contemporary housing and transportation development. First, do zoning policies disproportionately allow for high-density housing, as compared to low-density housing, near major roads? Second, does construction of high-density housing—and specifically affordable housing projects—occur disproportionately near major roads? Third, does major road construction lead to housing development, or vice versa? Leveraging a mix of local and national data, we show the intimate connections between roadway construction, land-use policy, and housing types. We demonstrate that both zoning for and development of apartments is more common near busy roads. We then establish that the completion of new housing units is associated with subsequent highway construction, and that new highways can accelerate pre-existing development trends. These results suggest that apartment buildings and their residents are, on average, much more exposed to pollution generated by busy roadways, and that ongoing planning paradigms contribute to this outcome.

Introduction

In 2022, Americans drove approximately 3.2 trillion miles—far more per capita than residents of most peer countries (Huxley-Reicher, 2022). A majority of that mileage was within urban areas—and most travel was along major roads, including interstates, freeways, and arterial roads (Federal Highway Administration 2024). Nearly one quarter of the US population lives near high-traffic roads (Antonczak et al., 2023) and is exposed to associated air and noise pollution, itself linked with myriad negative health outcomes (Baldauf et al., 2008; Brugge et al., 2007; van Roosbroeck et al., 2007). Nationwide, neighborhoods near high-traffic roadways have higher non-white population shares and lower incomes (Rowangould, 2013), raising questions about these facilities' environmental justice impacts (Karner et al., 2017).

Even so, adjacency to large roads can be advantageous. For commercial development, traffic can translate into customer exposure and access. For residential development, proximity to highways can theoretically speed commutes. As such, and to avoid disturbing neighborhoods occupied by single-family homes, planners sometimes focus planning for high densities along relatively narrow corridors in the areas along major roadways (Kramer, 2026), particularly those with transit lines along their rights-of-way (Freemark, 2024). This could potentially facilitate transit-oriented—or at least transit-adjacent— development (Loukaitou-Sideris et al., 2013). In the context of the widespread movement to reform zoning to enable the construction of more homes (Connolly, 2026), this produces a potential tradeoff between the desire to concentrate development in areas with greater transportation access and the reality that doing so may expose residents of new homes to greater pollution.

Despite these known connections between proximity to major roads and both pollution exposure and access, there has been little research to understand how contemporary planning policies continue to influence housing development patterns around these high-traffic roads. Key gaps in the literature include: Do zoning policies disproportionately allow for high-density housing, as compared to low-density housing, near major roads? Does actual construction of high-density housing—and specifically, affordable housing projects—occur disproportionately near major roads? And does construction of major roads lead to housing development, or vice versa?

In this paper, we empirically address these questions, leveraging a mix of local and national databases of zoning, roadways, and housing development. We find evidence that zoning directs the relationship between housing investment and transportation: zones that planners have designed to permit higher-density housing are disproportionately located adjacent to high-traffic roadways relative to lower-density zones. Second, we show that actual housing construction follows patterns similar to those we observe with zoning: new multi-family housing, including affordable multi-family developments, is disproportionately located near high-traffic roads. These results suggest that apartment buildings and their residents are, on average, much more exposed to pollution generated by busy roadways. Finally, we demonstrate that housing construction is associated with the subsequent development of major roadways and *also* that new major roads are associated with accelerating preexisting rates of housing construction. This provides concrete evidence that housing development shapes transportation investment, and vice versa.

Our findings underline the key roles of planners, whose historical and present-day efforts have shaped the contours of our land use, housing, and transportation systems, often to the detriment of people living in

multi-family housing. While planning policies have created and continue to perpetuate traffic-related environmental injustices, these same policy systems offer powerful mechanisms to mitigate harms and create more equitable housing and transportation systems going forward.

Background

Transportation plays an important role in structuring metropolitan development because it provides mobility between homes, employment, and other destinations. Highway investment is associated with concentration of jobs near interchanges (Percoco, 2016), and highways may also induce development by redistributing construction from one area of a region to another (Ewing, 2008). Zoning is one mechanism that may encourage development near highways (Garcia-Lopéz et al., 2015). But living and working near such roads has negative consequences, including increasing exposure to particulate pollution linked to ill health (Boeing et al., 2023). Nevertheless, there has been only limited research to identify how housing supply growth interacts with the provision of large roads—whether new or existing—and whether planning choices inform this connection. Planning may be particularly important in influencing what types of housing—lower-density housing, such as single-family, duplexes, and triplexes, or larger apartment buildings—are built near highways, and therefore who is most impacted by both the benefits and costs of roadway adjacency.

Historical roots linking housing development and roadway adjacency

Why might different types of housing have historically been built at different distances from highways? One key explanation is that zoning maps have traditionally located commercial and industrial uses near arterial roadways: multi-lane, high-speed streets (Bartholomew, 1928; Fogelson, 1967/1993: 256-257). This approach stemmed from the early twentieth century observation that the larger buildings used for these purposes generated more trips and would therefore be less likely to cause congestion on wider streets (Heights of Buildings Commission, 1913; Purdy et al., 1920). Because zoning codes have often been at least partially 'pyramidal' or 'cumulative,' with residential uses allowed in commercial and industrial zones, much of the land where by-right multi-family dwelling construction has been allowed has been along arterials. While some cities eventually began to ban residential uses from commercial and industrial areas (Whittemore, 2012), such combinations remain common: Hirt (2015: 54) found that a quarter of commercial zones permitted residential uses in a sample of 25 large US cities.

Zoning schemes have also consistently included districts intended primarily for multi-family apartment buildings. Early twentieth century planners and zoning advocates regarded such structures first and foremost as income-generating properties, and therefore more like commercial uses (Lauster, 2016). It followed that it was sensible to use multi-family zones to buffer thoroughfare-adjacent commercial and industrial development from zones for single-family dwellings and duplexes, which planners fostered as home environments.

In the 1920s and 1930s, Clarence Perry developed variations on his influential "neighborhood unit" concept that used apartment zoning as a buffer between business and lower-density residential zoning or placed apartment zoning directly on arterials to buffer low-density residential from these roads (Talen, 2018). Mid-century Maryland courts validated zoning maps that leveraged apartments as buffers around uses including

incinerators, shooting ranges, and animal pounds (Babcock and Bosselman, 1962). In action, this approach marginalized multi-family dwellings and their residents, offering them less protection from heavily trafficked streets and other sources of pollution.

Conversely, planners often situated zoning districts allowing nothing but low-density residential uses, along with parks, churches, and schools, *away* from larger streets (Fischel 2004). The value of a single-family dwelling in Anglo-American culture had long rested on its insulation from the perceived congestion and vice of the city (Baar, 1992; Fishman, 1987; Hayden, 2004), and the isolation of low-density residential development, even from "high-class" modern apartment houses (Bartholomew, 1932: 43), was a principal motivation for early zoning (Hirt, 2015).

Present-day planning policy and impacts

While historical practices may explain why older multi-family housing was located near arterials, contemporary planning practices have in large part continued historic trends; today's zoning policies often follow long-standing patterns, producing similar outcomes as those implemented a century ago (Shertzer et al., 2022). When planners want to integrate apartments into neighborhoods largely occupied by single-family homes, they face obstacles in the form of resident opposition (Einstein et al., 2020), often because existing residents believe such buildings would reduce their communities' aesthetic quality (Larsen and Nyholt, 2024).

Seeking to encourage additional housing supply through zoning reform, planners sometimes instead focus zoning for higher densities along major roadway corridors rather than throughout neighborhoods (Kramer, 2026; consider, for example, recent rezoning plans in Columbus, Ohio, or New York City; see Gannon, 2023; Siefert, 2025).

These spatial choices matter in the context of growing public and political interest in upzoning urban areas to increase housing access, which has manifested not just in local reforms but also in federal (e.g., the 21st Century ROAD to Housing Act; Bipartisan Policy Center, 2026) and state (e.g., Colorado's Housing in Transit-Oriented Communities legislation; Colorado General Assembly, 2024) policy initiatives. In general, however, most housing supply growth in the United States is not occurring through rezonings of existing neighborhoods but rather through sprawling, large-scale construction on the urban edge, where highway use is practically obligatory for daily life (Freemark, 2026).

Many localities require traffic impact assessments for such large projects. These studies estimate future car use (Currans and Clifton, 2015), and then typically require developers to show how existing roads will handle the traffic. If they cannot, developers must sometimes fund capacity expansions—typically to accommodate more vehicles, such as by adding travel lanes (Estill et al., 2006)—in part because assessments often ignore that travel could occur through other modes, such as transit, walking, and biking. This may serve as another encouragement for apartment construction along larger roads, which may have greater excess capacity to meet the travel demand attributed to the new developments.

Other lines of reasoning also promote siting multi-family housing near major roads. Like residents of single-family homes, apartment residents theoretically benefit from the car-based mobility afforded by high-capacity roads (Levinson and Wu, 2020). Transit lines are often routed along arterial roadways (Samuels and

Freemark, 2022)—in part because their ample rights-of-way afford planners the flexibility to accommodate them; this offers the potential for transit-oriented development in the surrounding areas (Loukaitou-Sideris et al., 2013). Given the concentration of commercial land uses and the relative prevalence of transit along major roads, people who live nearby may be better able to walk, bike, or take transit to nearby destinations (Walker, 2024). But the result, ironically, is that nearby apartment residents must navigate these major roads and be further exposed to pollution to access transit or to walk and bike to nearby destinations.

Understanding the environmental health effects of co-locating housing and major roads is critical (Karner et al., 2017). People whose homes are closer to high-traffic roadways are exposed to more particulates in the air and unhealthy levels of noise (Baldauf et al., 2008; Brugge et al., 2007; van Roosbroeck et al., 2007). Residents within 300 meters of such roads suffer from higher rates of heart disease, lung cancer, and strokes, compared to those living further away (Hoek et al., 2002; Hystad et al., 2013; Kan et al., 2008; Pedde et al., 2017; Tonne et al., 2007; Yorifuji et al., 2015). While not the focus of this paper, major roads also produce negative consequences that are less directly a function of physical proximity, including water pollution and climate change-inducing emissions (Awonaike et al., 2022; Environmental Protection Agency, 2026); roadway-induced vehicle trips contribute to high rates of pedestrian and bicyclist fatalities and injuries (Buehler and Pucher, 2017); and automobile dependence often makes non-automobile travel inconvenient (Buehler and Pucher, 2023).

Exposure to pollution, and specifically vehicle-related pollution, is inequitably distributed (Morello-Frosch et al., 2001; Rowangould, 2013). Neighborhoods with more traffic, such as those with port-related truck movements, are more likely to be inhabited by people of color and families living under the poverty line (Houston et al., 2004; Houston et al., 2014). And, paradoxically, people living next to pollution-generating roads drive less than the people who commute on them; these drivers are more likely to be white (Boeing et al., 2023). The negative externalities of major roadways, then, are disproportionately inflicted on people of color and people with low incomes, even as the mobility roadways provide is consumed disproportionately by people who are white and have higher incomes.

Planning policies that position apartments closer to roadways may have additional equity implications. People of color and people with low incomes are more likely to live in rental apartments (National Equity Atlas, 2024), and especially subsidized affordable apartments (Eggers, 2021), than are white people and people with higher incomes. This disproportionate roadway-related pollution exposure could thus be related to inequities in tenure.

These inequities place residential exposure to traffic pollution within the ambit of environmental justice (EJ), which, among other goals, seeks to describe how particular groups are disproportionately (dis)advantaged by environmental factors, and to advance approaches to create more just built and social environments (Walker, 2012). Yet variation in exposure to traffic pollution by residence type is little-studied. Integrating the intersection between traffic pollution and housing type into broader EJ research and policymaking is important both because it poses a significant threat to residents' health and wellbeing in isolation and because it is critical to understanding cumulative environmental impacts (Solomon et al., 2016).

Zoning has long been recognized as a potential driver of environmental injustice (e.g., Maantay, 2002), primarily in terms of how zoning may disproportionately locate housing and sociodemographic groups

adjacent to point sources of pollution, such as heavy manufacturing (Quattro, 2025; Whittemore, 2017) and other undesirable development. More recently, zoning's influence on climate justice—including exposure to various hazards such as flooding and wildfires—has received increasing attention (Adams, 2025). But zoning's relationship with traffic pollution exposure is largely unexplored, with the exception of limited, single-city studies (Gabbe et al., 2019). Empirical, large-scale analyses of the connections between zoning, housing types, and major roads stand to clarify whether and to what extent land use policy is driving environmental injustices relating to traffic pollution.

Data and methods

Research questions

This background motivates our three research questions, which focus on how present-day housing, transportation, and land use systems intersect to produce residential exposure to traffic pollution. First, to what degree does zoning continue to separate housing types in terms of their adjacency to high-traffic roadways? Previous research in case-study cities such as Louisville suggests that multi-family zoning may disproportionately be concentrated near highways (Samuels and Freemark, 2022), but there has been no systematic effort to compare outcomes across many cities throughout the nation. We thus consider whether present-day land-use regulations in more than 150 localities continue to produce the outcomes that previous generations of planners sought to achieve.

In part because of zoning policy and in part because of dominant planning ideologies, apartments may be more likely to be constructed near busy roads. This prompts our second research question: To what degree does the form of housing vary in relation to adjacency to high-traffic roadways? We evaluate whether new apartment construction is disproportionately located near pollution-generating roads, using a case study of the Dallas metropolitan area. We also explore the location of federally subsidized apartments relative to major roads across the country.

Finally, we ask whether an area's housing stock influences the siting of new major roads, and/or whether the siting of major roads leads to housing construction. We measure this by comparing the housing and demographic characteristics and trends of all urban area tracts nationwide, based on whether a new major road is constructed within them.

Data collection and preparation

In Table 1, we map each research question to the primary methods and data sources we use to evaluate it. We follow with detailed descriptions of these data sources and methods.

TABLE 1

Overview of Research Questions, Data Sources, and Methods

Research questions	Data sources	Geographies
RQ1: Does zoning disproportionately allow for	**Independent variable**: Residential zoning (low-density vs. multifamily)	Zoning districts in a national sample of 90 US places (cities and towns)

certain housing types near major roads?	**Dependent variable**: Distance to major road **Controls**: Demographic characteristics, jurisdiction fixed effects	Zoning districts within the 64 land-use-regulating jurisdictions in the DC and Seattle metropolitan areas
RQ2: Does construction of certain housing types disproportionately occur near major roads?	**Independent variable**: Development type (single-family vs. multifamily); Low Income Housing Tax Credit developments **Dependent variable**: Distance to major road **Controls**: Demographic characteristics, jurisdiction fixed effects	Nationwide (tax credit projects) Dallas metropolitan area (large developments)
RQ3a: Does housing development influence subsequent major road construction?	**Independent variable**: Housing unit change, 2010-18 **Dependent variable**: New major roads, 2019-23 **Controls**: Demographic characteristics, population density, county fixed effects	All US urban areas
RQ3b: Does major road construction influence subsequent housing development?	**Independent variable**: New major roads, 2010-14 **Dependent variable**: Housing unit change, 2018-23 **Controls**: Demographic characteristics, population density, county fixed effects	All US urban areas

Source: Conceptual design by authors.

First, we collect two national roadway datasets:

National annual average daily traffic (AADT). We obtain data on national roadways with associated AADT estimates from the 2020 Highway Performance Monitoring System (HPMS; Bureau of Transportation Statistics, 2023). Following previous research (e.g., Gabbe et al., 2019), we define high-traffic roadways as those having more than 50,000 AADT; proximity to these roads is more likely to produce negative health impacts due to noise and air pollution. We also test proximity to roads with 25,000 or more AADT (Houston et al., [2013] define medium-traffic roads as having between 25,000 and 49,999 AADT).

National primary roads (which we refer to as "major roads"). To confirm results from the AADT-based data, we obtain data on all US primary roads, defined by the Census Bureau as "generally divided limited-access highways within the Federal interstate highway system or under state management," typically with interchanges (Census Bureau, 2020; Census Bureau, 2023a). These major roads are likely to have more traffic and thus pollution than other roadways. Because this dataset does not include AADT figures, it may not as accurately capture pollution exposure as the above. We collect these data at five points in time: for 2022, to evaluate against contemporary zoning policies; and for 2010, 2014, 2019, and 2023, to evaluate road construction over time relative to housing production.

Second, we collect two datasets related to land-use regulations. While neither is nationally comprehensive or perfectly representative, each allows us to examine zoning across multiple jurisdictions, and we include both to provide robustness against any effects that may be due to the sampling or selection of jurisdictions included in one or the other:

90 places database. This database, developed by Curran-Groome and Whittemore (2025), uses zoning maps and legal definitions to define zoning districts across 90 US places (cities, towns, and unincorporated Census-designated places). This database comprises 30 places randomly sampled from each of three population-based strata: places with populations of 10,000–49,999; 50,000–249,999; and 250,000 and more. For each district, which we map, the database identifies unit-per-lot zoning maxima in 2021. While this dataset does not constitute a representative sample of all places in the US—indeed, no places with populations under 10,000 are included—it is a multi-state sample that accounts for roughly 7% of the entire US population, and the authors report that key political, housing, and demographic characteristics of each sample stratum align with those of all similarly-sized communities nationwide.

Puget Sound and Washington, DC. This dataset, developed for Freemark (2023) and Freemark et al. (2023), categorizes unit-per-lot zoning maxima for 64 zoning jurisdictions within the Puget Sound and Washington, DC metropolitan areas, also using zoning maps and legal documents to define zoning districts.[1] While also not nationally representative, this dataset is comprehensive for two regions, adding depth of coverage as compared to the 90 places database, which covers many states but does not comprehensively cover zoning within any single region.

Third, we collect data linked to housing availability and affordability that enable us to assess construction trends:

Low Income Housing Tax Credit (LIHTC) developments. We obtain data on LIHTC developments from the National Housing Preservation Database (NHPD; Public and Affordable Housing Research Corporation and National Low Income Housing Coalition, 2023); because our research is focused on new construction, we limit this dataset to the 6,902 LIHTC projects nationwide classified as "New Construction" or "Both New Construction and Acquisition and Rehab" with estimated completion from 2010 to 2023. LIHTC is the primary financing tool for most new US subsidized housing and almost all LIHTC developments are multi-family apartment buildings. The LIHTC program is competitive, and each state designs its own Qualified Allocation Plan (QAP), which determines how the state evaluates applications for LIHTC projects. QAP criteria influence the siting of LIHTC developments, such as through preferential scoring for projects that are close to public transit (see, e.g., Texas Department of Housing and Community Affairs, 2026). Though LIHTC developments may not be representative of the broad universe of subsidized housing projects, they do comprise a large share of all such developments, particularly the newly built ones.

Large residential developments in north central Texas. We leverage a dataset of all developments of over 80,000 square feet in Greater Dallas from the regional council of governments (NCTCOG, 2024). This region has a high rate of housing supply growth and considerable single-family and multi-family construction. We subset these data to residential developments that were existing, under construction, or

[1] This includes all jurisdictions with zoning authority in the Washington, DC metropolitan area and most in the Puget Sound area.

planned; that have a year of completion that was after 2009 or unknown; that are in a Census-defined urban area; and that were in the region's central four, and most populous, counties: Collin, Dallas, Denton, and Tarrant. We retain only developments classified as "Apartments" or "Subdivisions" (a class of single-family development), which together accounted for 70% of all developments and 88% of all units in the database.

Housing supply. We assemble nationwide Census tract-level housing and demographic characteristics from the 2006–10, 2009–13, 2014–18, 2018–22, and 2019–23 five-year American Community Survey (Census Bureau, 2023b), plus the 2000 and 2010 decennial censuses, all accessed via IPUMS NHGIS (Manson et al., 2024). These allow us to evaluate change over time in housing supply and to control for neighborhood differences that could be impacting propensity for a zoning district or development to be located near a high-traffic roadway. Our primary measures of interest include the share of the population that is people of color (not non-Hispanic white); the share of households that is cost-burdened (paying 30 percent or more of incomes on housing costs); the share of households with earnings below the federal poverty line; the Gini Index (a measure of income segregation); and population density.

Analytic approach

We begin by collapsing the original zoning data into two levels: zones where the maximum number of by-right housing units per lot was four or greater ("multi-family"), and zones where the maximum number of by-right units per lot was less than four ("low density;" these zones usually only allow single-family housing[2]). We omit zones not allowing by-right residential development. We intersect this dataset with the tract dataset, then intersect that with our roadway datasets, each of which we buffered by 300 meters to represent potential exposure to roadway pollution. This produces observations reflecting zone–tract–road combinations.

Next, we aggregate data at the tract level, calculating the share of each tract zoned for any residential use, for multi-family use, and for low densities, as well as the share of residential-, multi-family-, and low-density-zoned land within 300 meters of a high-traffic road. Finally, we transform the data such that there are two observations (and geographies) per tract: one reflecting the subset of the tract zoned for low densities, and one reflecting the subset of the tract zoned for multi-family. For this zoning analysis, we omit tracts without land within 300 meters of a road and include only tracts with both multi-family and low-density zoning to avoid being biased by tracts with only one or the other.

Second, we prepare the housing construction databases. We identify how many LIHTC projects (if any) were located in each tract; for each, we measure the tract boundary's distance to the nearest high-traffic road (if the road runs through the tract, the distance is recorded as 0). Some tracts (such as in Alaska) are far from the nearest such road; as such, we subset to tracts in Census-defined urban areas, and then further subset to those within 2,500 meters (or, in alternate specifications, 1,000 meters) of a high-traffic road. For each development in the north central Texas dataset, we measure its distance to the nearest high-traffic road.

[2] We did not separate out single-family districts because many jurisdictions allow accessory dwelling units in such zones, making the separation between "single-family" districts and those where multiple units are allowed per parcel ambiguous.

We then use ordinary least squares regression analysis to test differences in zoning and development based on adjacency to high-traffic roadways.[3] We integrate tract-level demographics into regressions to control for other patterns, while ensuring that variables are not multicollinear (all variance inflation factors are less than two). We also test models with and without fixed effects for the local jurisdictions (or in the case of the LIHTC analyses, the states) where the zoning districts or developments are located.

For the zoning analysis, we evaluate whether areas zoned for multi-family development, as compared to those zoned for low-density development, are more likely to be adjacent to a high-traffic road. We regress the share of the tract portion that is located within 300 meters of such a road by a dummy variable reflecting whether that tract portion is zoned for low densities. For the construction analysis, we evaluate whether (a) tracts with LIHTC projects or (b) multi-family developments are more likely to be located adjacent to high-traffic roads than tracts without LIHTC projects or single-family developments, respectively.

To analyze the relationship between housing construction and roadway construction, we first measure which tracts experience new major road development.[4] We do this by comparing road geographies over time and identifying those where we recorded either an existing road being re-classified as a major road or a new major road being added.[5]

We then run two series of regressions: (1) where our outcome variable is a binary measure of whether a tract received a new major road in the 2019–23 period, with our primary predictor variable being the change in housing units from 2010–18 (to identify whether housing development resulted in later road construction); and (2) where our outcome variable is the change in tract-level housing units from 2018–23, with our primary predictor variable being whether the tract received a new major road from 2010–14 (to identify whether road construction resulted in later housing development). In both models, we control for demographic characteristics and population density, and run alternate specifications, including a fixed-effects term for the relevant county, and considering only tracts that did not have a major road at baseline.

To ensure the quality of our results, we run a series of robustness tests using the alternate primary roads database and using a variety of alternative distances to high-traffic roadways.

Limitations

The approach we take is not causal in character and is not uniformly national in its implications. Our zoning and development analysis is descriptive, as we do not have historical zoning data available for our comparisons, and only encompasses a subset of the nation's many zoning jurisdictions. Moreover, we only examine zoning in terms of by-right allowances, though many localities approve substantial construction via

[3] Though some of our regressions include a binary outcome (those presented in Table 4), we chose to use linear regression here for interpretability and because of the evidence that doing so produces unbiased estimates of treatment effects (Gomila, 2021).

[4] "Development" encompasses both de novo road construction as well as the expansions and attendant reclassification of existing roads. For example, a tract at baseline that has a road that is not classified as a major road would be classified as having a new major road if that non-major road were reclassified to a major road (e.g., because of a lane expansion or other increase in vehicle capacity and use).

[5] Our approach to identifying whether a new major road was added accounts for moderate changes to spatial representation of roads over time by assuming that any change within 100 meters of an existing major road is simply a change in spatial representation of the existing road; we record changes outside this area as new roads.

discretionary approvals. The by-right zoning code thus may not fully account for the end use of zoning processes, particularly after public involvement. However, this approach to quantifying zoning is consistent with other zoning codification work (e.g., Freemark et al., 2023; Curran-Groome and Whittemore, 2025), which also omits discretionary zoning allowances because they are so challenging to codify systematically for purposes of multi-jurisdictional analysis. Further, we only evaluate unit-per-lot zoning maxima, omitting other potentially important constraints, such as parking requirements and floor area ratio maximums. This means that some zoning districts we classify as multi-family based on their unit-per-lot maxima may functionally allow limited or no high-density housing because other zoning dimensions and parcel characteristics prohibit or make such development infeasible.

For our analysis of contemporary development in the Dallas metropolitan area, we rely on a dataset that only documents developments of 80,000 square feet or greater. Accordingly, our results provide no insight into how smaller-scale development—such as of a single-family house on a single parcel (as opposed to projects built as part of a subdivision, which we do study)—relates to major road proximity. This may bias our results, since larger projects may be more likely to be located near highways. Our results here also only pertain to one metropolitan area.

While we model adjacency to roads in terms of traffic level, related results are only a proxy for exposure to vehicle traffic-generated air and noise pollution. While our approach aligns with that undertaken in previous scholarship, we may neglect factors that shape traffic-generated pollution. Issues for consideration include vehicle mix (e.g., heavy trucks as compared to passenger vehicles, plus whether they are electrified); the presence of sound walls or green buffers; and the direction and intensity of wind and rain, all of which influence the volume of roadway pollution and its dispersion to nearby areas.

Our analysis of the relationships between roadway construction and housing development is designed to provide reasonable comparison groups to those “treated” by major roadway investments, for example, such that we can explore changes prior and after those projects are completed. It remains possible, however, that our results are undermined by reverse causality, as we are unable to completely disentangle the varying factors at play in housing and transportation projects.

Finally, census tracts, our primary geographic unit of analysis, are imperfect for measuring housing development and pollution exposure because they obscure where, specifically, different types of housing and different resident groups are located within each tract. For example, a given tract might primarily comprise white, owner-occupied households, where person of color and renter-occupied households account for only 20% of the tract’s population. Our analyses assume this is true for all portions of the tract, but in reality, the portion of the tract proximate to a major road could contain no residents or could disproportionately comprise persons of color and renter-occupied households. We used this level of geography for our analysis, however, because block group data feature consistently higher margins of error due to small sample sizes in American Community Survey data (Sperling, 2012), and because some variables of interest are not available at the block group level.

Findings: Zoning for multi-family housing is linked to adjacency to high-traffic roadways

Our analysis of zoning policies demonstrates the link between the content of land-use regulations and the location of high-traffic roadways. Among tracts linked to our database of zoning in 90 places, we find that those tract portions zoned for low densities average about 20 percentage points less of their land area located near a high-traffic roadway, compared to tract portions zoned for multi-family uses, after controlling for tract-level characteristics (table 2, models I and II). Among tracts in our database of jurisdictions in the Puget Sound and Washington, DC regions, we similarly find that those areas zoned for low densities have about 7 percentage points less of their land area located near a high-traffic road (models III and IV). In both cases, we control for the share of residential land in each tract's road buffer and the share of each tract zoned for residential development to reduce biases relating to some tracts being closer to roadways in general or having less space for residential land.

Our findings are similar and remain statistically significant when we include fixed effects for the locality where tracts are located (table 2, models II and IV). We reaffirm these findings when broadening our analysis to both medium- and high-traffic roads (at least 25,000 AADT). We show that, even with this expanded definition, districts zoned for multi-family residential are much more likely to be located near busy roadways than those zoned for low-density homes (appendix table A1).

TABLE 2

Zoning for Multi-Family Uses is Associated with Adjacency to Busy Roadways

Share of tract portion within 300 meters of high-traffic road (50,000+ AADT)

	90 Places Database		Puget Sound and Washington, DC Regions	
	I	II	III	IV
Is tract portion zoned for low densities? (dummy)	−19.62*** (0.70)	−19.62*** (4.89)	−7.38*** (1.09)	−7.38*** (2.03)
Tract-level data				
Residential land in road buffer (%)	0.86*** (0.02)	0.86*** (0.07)	1.06*** (0.05)	1.05*** (0.08)
Residential land (%)	−0.30*** (0.02)	−0.32*** (0.04)	−0.27*** (0.03)	−0.33*** (0.04)
Population density (logged)	−2.18*** (0.29)	−1.63 (1.54)	−1.15 (0.59)	−0.84 (0.84)
Gini index	−13.72* (5.8)	−15.63*** (4.31)	0.21 (9.04)	−4.62 (10.36)
Housing cost burden (%)	5.31* (2.58)	8.84*** (2.37)	1.47 (3.44)	3.12 (2.99)
Below federal poverty line (%)	−17.09*** (3.85)	−22.46*** (3.06)	0.57 (9.97)	5.78 (8.23)
Person of color (%)	2.40 (1.66)	1.25 (1.92)	2.02 (2.40)	−2.46 (4.98)
Intercept	62.73*** (3.00)	63.70*** (13.37)	36.03*** (6.00)	40.58*** (8.19)
Fixed effects for jurisdictions	No	Yes	No	Yes
R^2 Adj.	0.41	0.42	0.37	0.38
N	4,882	4,882	1,498	1,498

Source: Authors' analysis of American Community Survey 2018–2022 5-year estimates, 90 places zoning data from Curran-Groome and Whittemore (2025), Puget Sound and Washington DC zoning data from Freemark (2023) and Freemark et al. (2023), and Highway Performance Monitoring System (HPMS) road data from the Bureau of Transportation Statistics.

Notes: Unit of analysis: tract portions in relevant cities (each tract has two tract portions, one representing land zoned for low density residential uses, and the other representing land zoned for high densities). Coefficients represent percentage points of tract portion within 300 meters of high-traffic roads. Values in parentheses are robust (and in the case of fixed-effects models, clustered) standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. AADT = Annual Average Daily Traffic. Only tracts with both higher and lower density zoning, and with at least some residentially zoned land within 300 meters of a high-traffic road, are included in regressions.

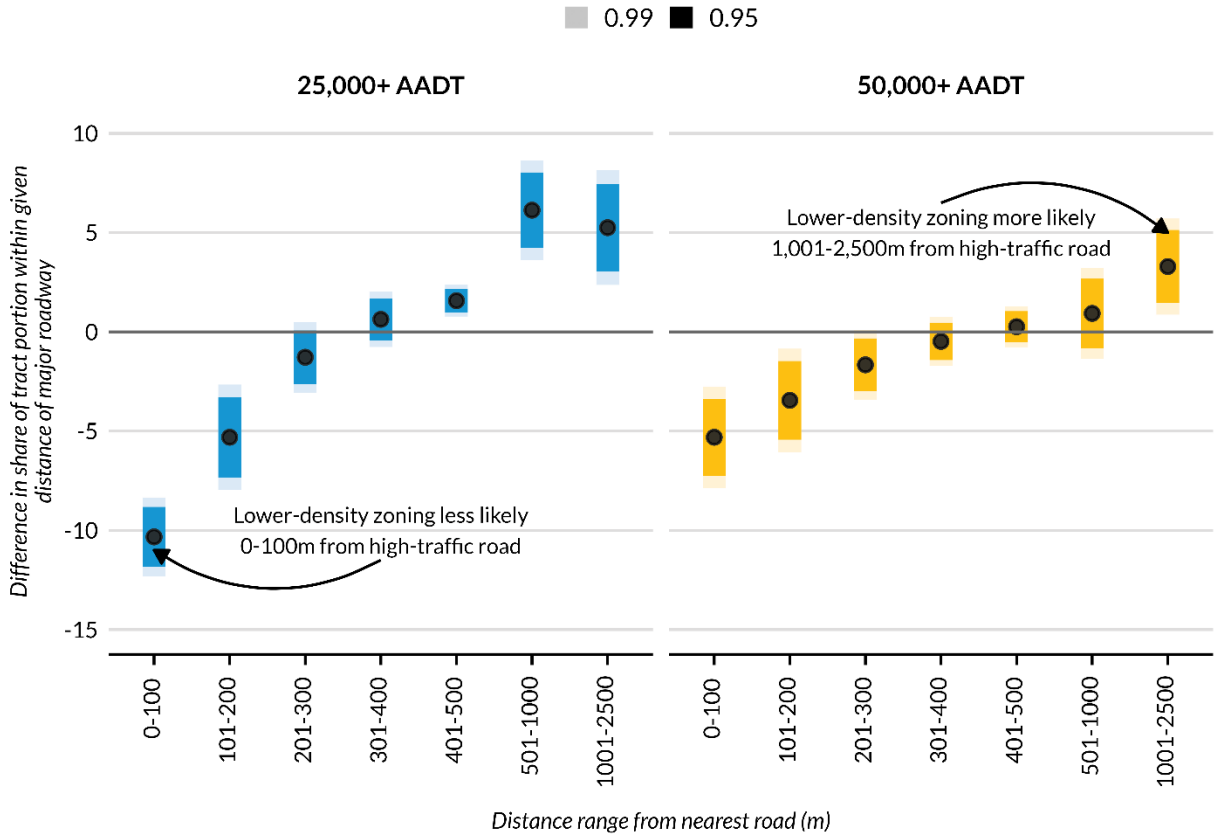
These regressions reveal few consistent connections between local demographics and roadway adjacency. We do find that tracts with higher population densities and lower housing cost burdens are, on average, less likely to be located near high-traffic roads, but these outcomes are not uniformly statistically significant. Depending on our dataset, we find varying relationships between the share of a tract whose residents live in poverty or are a person of color and the share of that tract portion that is near a roadway.

We compare the share of tract portions near roadways, using similar regressions as in model II of table 2, but divided into groups based on distance from busy roads. We graph the coefficients and confidence intervals for medium- and high-traffic roadways (figure 1); the results for each distance band are provided in Table A2. The graph shows that, as distance from such roadways increases, the prevalence of low-density zoning does, too; the opposite can be said for zoning enabling multi-family construction. For example, we find that if 20% of a typical tract's multifamily-zoned land is located between 0 and 100 meters of medium- or high-traffic roads, only 10% of its low-density-zoned land is located the same distance from such roadways.

FIGURE 1

Higher Density Zoning Is More Likely Near Heavily Trafficked Roadways

Regression coefficients and confidence intervals for a low-density zoning indicator when predicting the share of land to the nearest medium- and high-traffic road.



Sources: Authors' analysis of American Community Survey 2018–2022 5-year estimates, 90 places zoning data from Curran-Groome and Whittemore (2025), and Highway Performance Monitoring System data from the Bureau of Transportation Statistics.
Notes: The y-axis reflects the coefficient on the indicator for lower-density zoning; when the y-axis value is lower, it means that less lower-density-zoned land is within the distance band specified on the x-axis. For the first panel, where the x-axis is "0-100" meters, this would be read as: approximately 10% less lower-density-zoned land is within 0-100 meters of a 25,000+ ADT road as compared to higher-density-zoned land, after controlling for covariates. Regressions used here are structured as in table 2, model II. Only tracts with both higher and lower density zoning are included for each distance analysis. As a result, the tracts included in each model differ and are not additive. Coefficients' confidence intervals are represented at the 95% confidence (darker color) and 99% confidence (lighter color) levels. The left panel represents regression coefficients when evaluating roads with annualized average daily trip (AADT) volumes of 25,000+; the right panel reflects results when evaluating roads of 50,000+ AADT.

Findings: Apartments are more likely to be built near high-traffic roadways

Next, we examine the relationships between adjacency to high-traffic roadways and actual home building, investigating affordable housing nationwide and projects in the Dallas metropolitan area. In both cases, we find concrete evidence that new multi-family housing is disproportionately developed in areas close to high-traffic roadways. This suggests that the local land-use policies we profiled above are producing their

intended effects, and/or that such policies are consistent with historical patterns of residential development.

We find statistically significant evidence that tracts with LIHTC developments are located nearer to busy roadways than those without such developments, after controlling for local characteristics and whether using or omitting state effects. Across all analyzed tracts, the average distance to a high-traffic road is 625 meters; tracts with a LIHTC project completed since 2010 were on average 550 meters from a high-traffic road, as compared to tracts without, which averaged 631 meters away. This means tracts with LIHTC projects were about 75 meters closer to major roads than those without (table 3, models I–II). We make a similar finding when just examining tracts within 1 kilometer of high-traffic roadways (models III–IV), though the difference in distance is not as great (10 to 12 meters).

Second, we examine development patterns in north central Texas (table 3, models V–VI). Our interest here is in comparing the locations of recent apartment construction versus new developments comprising single-family homes. We again find strong associations between the type of project built and adjacency to high-traffic roads. On average, apartment projects are 1.1 kilometers closer to such roads than are single-family home projects, after controlling for tract-level population and housing characteristics. This average distance declines to an average of 880 meters closer to high-traffic roads after incorporating fixed effects to account for differences in policies between jurisdictions (model VI).

We confirmed these results by using a broader set of roadways, including both medium- and high-traffic roads (appendix table A3). Here again we demonstrate a clear link between roadway adjacency and both the likelihood of a tract housing a LIHTC project nationwide and also the likelihood of a housing project in the region being a multi-family development.

TABLE 3

New Multi-family Construction is Associated with Adjacency to Busy Roadways

Distance to nearest high-traffic road (50,000+ AADT)

	LIHTC					
	I	**II**	**III**	**IV**	**V**	**VI**
Maximum distance from roadways for tracts included	2500 m	2500 m	1000 m	1000 m	NA	NA
Were LIHTC units added in tract? (dummy)	−74.93*** (13.33)	−75.76*** (13.92)	−10.51 (6.25)	−11.73* (5.76)		
Was development type apartments? (dummy)					−1138.06*** (90.27)	−880.38*** (124.32)
Population density (logged)	74.09*** (3.05)	81.42*** (8.31)	57.35*** (1.39)	56.18*** (2.51)	−395.28*** (67.06)	−98.53 (94.56)
Gini index	−400.37*** (56.73)	−320.60*** (94.01)	2.91 (26.46)	5.17 (31.06)	−4587.81*** (632.10)	−1293.34 (900.54)
Housing cost burdened (%)	10.95 (22.31)	55.07* (27.79)	−11.71 (9.90)	−0.93 (10.67)	1188.27*** (325.01)	362.51 (626.54)
Below federal poverty line (%)	152.46*** (38.38)	−3.29 (60.82)	74.91*** (18.52)	54.61** (20.64)	−2371.42*** (485.86)	−1659.86** (618.23)

Person of color (%)	−226.18*** (15.85)	−179.34*** (36.84)	−56.70*** (7.39)	−43.59*** (11.24)	−1256.78*** (193.63)	−106.57 (324.31)
Intercept	344.83*** (29.48)	158.76* (71.89)	−208.90*** (13.45)	−215.33*** (19.62)	7871.55*** (567.18)	3101.67* (1210.27)
Fixed effects for states / jurisdictions	No	Yes	No	Yes	No	Yes
R^2 Adj.	0.02	0.03	0.06	0.06	0.16	0.56
N	42475	42475	29949	29949	2523	2523

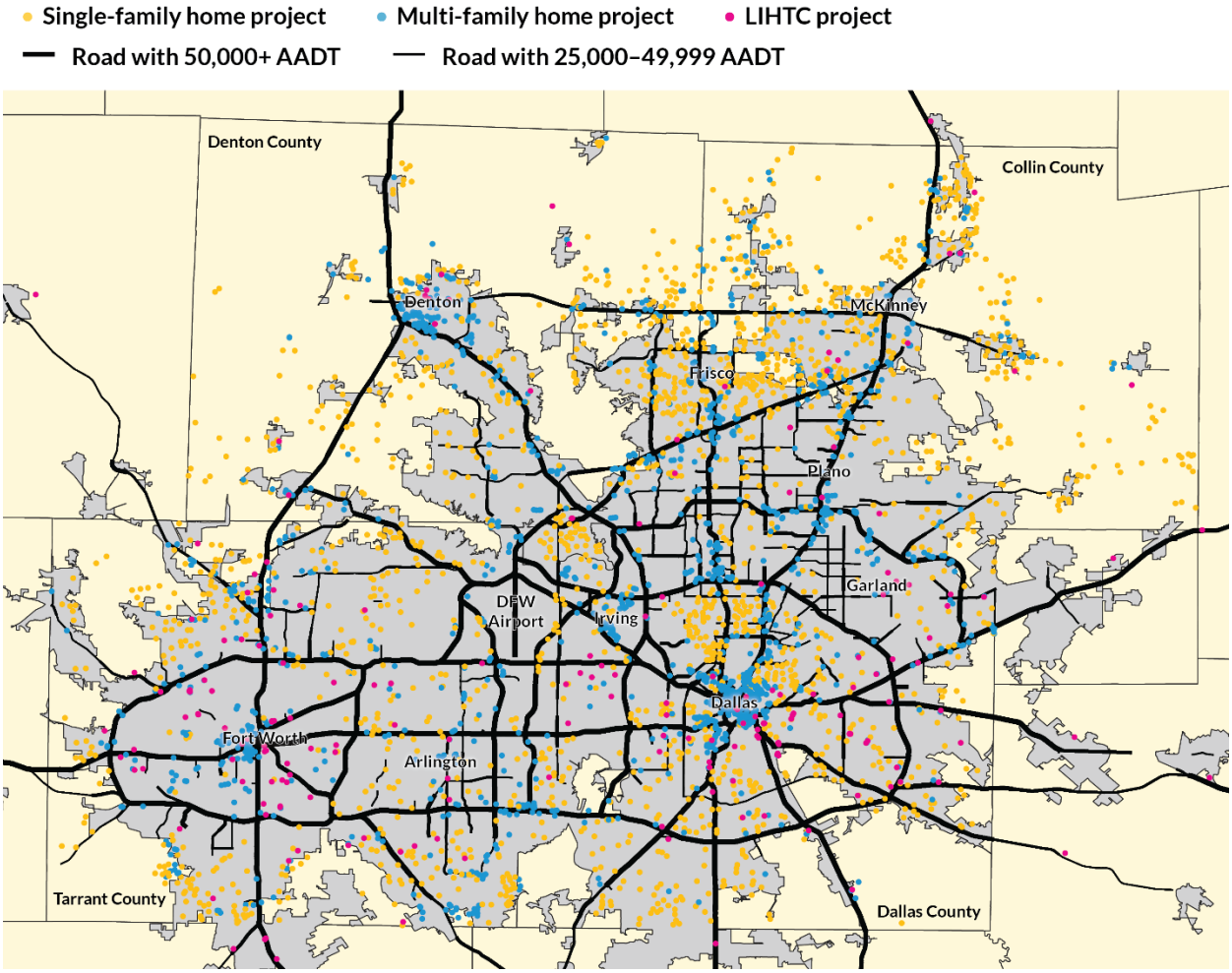
Sources: Authors' analysis of American Community Survey 2018-2022 5-year estimates, LIHTC developments from the National Housing Preservation Database (NHPD) located within Census-defined urban areas, developments in the greater Dallas region from North Central Texas Council of Governments, and Highway Performance Monitoring System (HPMS) road data from the Bureau of Transportation Statistics.
Notes: Unit of analysis: Models I–IV: tracts in urban areas across the United States; Models V–VI: large development projects in urban areas in the North Central, Texas, region. Values in parentheses are robust (and in the case of fixed-effects models, clustered) standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. AADT = Annual Average Daily Traffic. "LIHTC in tract" is a dummy indicator for whether the tract contained any LIHTC developments. "Development type: apartment" is a dummy indicator for whether the development was an apartment building.

These data also provide evidence that tracts with a higher share of people of color are more likely to be located closer to major roads, as are Dallas-region developments located in tracts with a higher share of people of color. This reaffirms previous findings suggesting that people of color are disproportionately exposed to the pollution effects of roadway adjacency. We find less consistent evidence related to tracts with a higher share of residents living below the federal poverty line.

In figure 2, we illustrate development in the core of the north central Texas region. Though not uniformly true, multi-family developments (shown with blue dots) are generally either clustered in city downtowns or along high-traffic roadways. Single-family projects, on the other hand, are largely distributed in the interstitial space between the high-traffic roads.

FIGURE 2

New Construction Multi-Family Apartments and LIHTC Projects Are Concentrated Near High-Traffic Roads in North Central Texas



Sources: Authors' analysis of developments since 2010 in the greater Dallas region from North Central Texas Council of Governments and Highway Performance Monitoring System data from the Bureau of Transportation Statistics, combined with data from the National Housing Preservation Database of new construction LIHTC projects completed since 2010.

We re-run our analyses related to zoning and construction using census primary roads data as a robustness check. In appendix table A4, we document findings using that roads data both for the 90 places zoning dataset and the LIHTC projects dataset, comparing it to the AADT–based roadway information. This alternative specification produces almost identical results as the traffic-based indicators presented in tables 2 and 3.

Findings: Relationships between Road Building and Housing Production

Our final question is whether there are relationships—in both directions—between housing development and the construction of major roadways. We begin by conducting a nationwide assessment of whether neighborhoods that had growth in their housing stock were more likely to subsequently be the site of new major roadways. Here, we find evidence that highways are more likely to be built in tracts with housing construction in the previous period. Controlling for local characteristics, we find that an increase in housing units is associated with a significantly higher likelihood of a tract later being the site of a new major road (table 4, model I). This finding remains true when incorporating fixed effects for counties (model II), and among tracts that did not have any major road before (model III). We lose statistical significance in a model with only tracts without major roads before and incorporating fixed effects, but the coefficient remains positive (model IV).

This finding reflects a common transportation planning paradigm: new high-vehicle-capacity roads are built to connect new housing development to existing transportation networks. We find that this phenomenon is driven by lower-density (e.g., exurban and suburban) areas: pre-period housing construction predicts the later construction of major roads in areas with densities of 2,000 people per square mile or less but does *not* in more densely populated areas (appendix table A5).

TABLE 4

Tracts with Greater Housing Unit Growth Were More Likely to Experience Subsequent Major Road Construction

Likelihood that a major road was constructed between 2019 and 2023

	All tracts		**Only tracts without a major road in 2010**	
	I	**II**	**III**	**IV**
Housing units (change, 2010–18)	0.09*** (0.03)	0.06** (0.02)	0.11* (0.05)	0.04 (0.04)
Population density (logged)	−5.27*** (0.36)	−3.71*** (0.43)	−3.91*** (0.73)	−3.39*** (0.85)
Person of color %	−0.03 (0.02)	−0.05* (0.02)	0.01 (0.02)	−0.08* (0.03)
Median family income (logged)	−4.93*** (0.90)	−1.21 (1.06)	−3.12** (1.17)	1.79 (1.44)
Fixed effects for counties	No	Yes	No	Yes
Intercept	0.10*** (0.01)	0.03** (0.01)	0.07*** (0.01)	0.01 (0.02)
N	65,557	65,557	15,518	15,518
R^2 Adj.	0.01	0.21	0.01	0.47

Sources: Authors' analysis of American Community Survey five-year estimates, accessed from IPUMS NHGIS for the years 2014-2018 and 2006-2010, and TIGER/Line shapefiles from the US Census Bureau for 2019 and 2023.

Notes: Unit of analysis: tracts in urban areas nationwide. Values in parentheses are robust standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. Changes are measured as the value at follow-up minus the value at baseline, divided by the value at baseline. Only tracts in metropolitan core-based statistical areas are included in this analysis.

Conversely, when we examine whether the construction of major roads is associated with subsequent housing development, we find mixed evidence (table 5). We find no statistically significant or consistent relationships between the construction of a new major road and subsequent housing construction (models I and IV). Even so, when we interact the construction of a new road with pre-period housing construction (models II, III, V, and VI), we find significant evidence (except in model V) that housing construction rates increase after major roads are installed. This suggests that building highways does not necessarily produce housing development absent pre-existing housing growth, but that it can contribute to accelerating housing growth, particularly in low-density neighborhoods (appendix table A6). The small R2 values of these models, however, suggest highway construction is only one marginal factor contributing to housing growth.

TABLE 5

Construction of Major Roads Can Accelerate Housing Production

Housing unit change, 2018 to 2023

	All tracts			Only tracts without a major road in 2010		
	I	**II**	**III**	**IV**	**V**	**VI**
Did tract add a new road from 2010–14? (dummy)	−1.26 (1.27)	−5.69*** (1.49)	−6.56*** (1.76)	0.12 (4.29)	−5.19 (2.70)	−6.93 (5.04)
New road dummy x change in housing units, 2000–10		0.29** (0.11)	0.28*** (0.06)		0.45 (0.30)	0.39** (0.15)
Population density (logged)	−3.08*** (0.77)	−3.11*** (0.77)	−6.22*** (0.32)	−15.65*** (0.94)	−7.07** (2.32)	−15.67*** (0.94)
Person of color %	−0.12*** (0.02)	−0.12*** (0.02)	−0.09*** (0.02)	−0.08 (0.04)	−0.12*** (0.03)	−0.08 (0.04)
Median family income (logged)	5.21*** (0.95)	5.12*** (0.94)	0.49 (1.26)	−5.36* (2.39)	2.39* (1.17)	−5.45* (2.39)
Housing units (change, 2000–10)	0.29*** (0.03)	0.27*** (0.03)	0.22*** (0.02)	0.17*** (0.04)	0.18*** (0.04)	0.15*** (0.04)
Fixed effects for counties	Yes	No	Yes	Yes	No	Yes
Intercept	−27.13*** (7.20)	−25.66*** (7.08)	32.59 (26.07)	169.36 (95.56)	37.91 (26.91)	171.33 (95.54)
N	65,557	65,557	65,557	15,518	15,518	15,518
R^2 Adj.	0.01	0.01	0.02	0.03	0.02	0.03

Sources: Authors' analysis of American Community Survey five-year estimates, accessed from IPUMS NHGIS, for the years 2006-2010, 2010-2014, 2014-2018, and 2019-2023, as well as decennial census data accessed from IPUMS NHGIS for the years 2000 and 2010, and TIGER/Line shapefiles from the US Census Bureau for 2010 and 2014.

Notes: Unit of analysis: tracts in urban areas nationwide. Values in parentheses are robust standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. Change is measured as the value at follow-up minus the value at baseline, divided by the value at baseline. Only tracts in metropolitan core-based statistical areas are included in this analysis.

Discussion

Taken in concert, our findings paint a troubling picture of the relationships between housing development, land-use policy, and transportation planning and their impacts on environmental justice outcomes. Beyond encouraging development generally near highways (Garcia-Lopéz et al. 2015), land-use policy is spatially structuring housing development such that multifamily buildings and their residents are disproportionately exposed to air and noise pollution from vehicle traffic on major roads, while lower-density development is more likely to be safely distanced from such health threats. Subsidized housing is more likely to be located near major roads, a finding that reaffirms previous research (Houston et al., 2013). Because residents of apartments—especially subsidized units—are more likely to be people of color, these outcomes may entrench existing environmental injustices (Houston et al., 2014; Morrelo-Frosch et al., 2001). With growing calls to end single-family zoning (e.g., Manville et al., 2020) that advocate for removing barriers to growth, our findings emphasize the importance of considering proximity to major sources of pollution as communities look to zone for more and denser housing.

Suburban and exurban housing development often precedes subsequent highway construction, continuing long-standing and unsustainable patterns of auto-centric sprawl. In parallel, in areas that have already experienced housing growth, highway construction catalyzes further housing development, often in low density rural and exurban areas. The United States is already undertaking most of its housing supply growth through outward development (Freemark, 2026); highway construction is a facilitator of that trend.

Additional research is necessary to substantiate our findings. Case studies can assist us in identifying examples where planners have adopted alternative approaches to coordinating transportation and housing planning. Causal quantitative research could potentially compare changes before and after highway investment. Nevertheless, the evidence we assemble describes a policy paradigm that has been informed by a century of intertwined land-use and transportation planning strategies. These strategies have created highways in both urban and rural areas without sufficiently evaluating their negative effects on health and wellbeing; separated low-density development from highways, recognizing the undesirability of living near these major sources of air and noise pollution; and simultaneously ignored or overlooked such concerns while concentrating multi-family buildings near these major roads. The result is that people who want to—or can only afford to—live in apartment buildings are much more likely to suffer from the effects of living near high-traffic roads.

Residents of apartment buildings—especially affordable buildings, such as those subsidized by LIHTC—are disproportionately likely to be people of color and people with relatively low incomes. And because state QAPs often specify criteria for competitive LIHTC applications that influence the locations of proposed developments—for example, in areas well served by public transit, which in turn may be disproportionately close to major roads (e.g., Texas Department of Housing and Community Affairs, 2026)—the LIHTC program as implemented in some states may unintentionally contribute to elevating pollution exposure of affordable housing residents.

This means that transportation investments and zoning policy, and their collective effects on the location and types of new residential development, are mechanisms by which US policymakers reinforce inequitable

health outcomes along race and income lines. Policies designed to encourage certain types of building forms in certain parts of the community thus likely impact resident health.

In some cases, this outcome may result from a tension where policymakers, planners, and developers want to locate new development to maximize residents' access to services and goods. While siting housing along busy roads may mean residents are closer to amenities such as transit service, restaurants, and stores, because of the very nature of those roadways, amenities may be difficult or unpleasant to access—and living nearby exposes residents to pollution.

In areas where walking, biking, and transit are feasible modes of transportation, zoning for apartments near heavily trafficked roads—along with practices such as auto-centric traffic impact assessments and mandatory parking minimums—is particularly problematic. Apartment residents may disproportionately use and prefer these alternate modes of transportation, but they are nonetheless forced to pay the health and financial costs associated with automobile transportation systems. And as cities increasingly develop protected biking networks, as electric bicycle adoption continues to grow, and as transit-oriented development becomes a key feature of urban life, this dynamic—where apartment residents do not drive but still shoulder the burdens of living near to major roads and their pollution—is likely to become more widespread.

Planners should evaluate and revise existing policies to minimize the production of roads-based pollution and to limit all residents' exposure to such pollution. Given the inequities we document in terms of apartment residents' disproportionate exposure at present, and the fact that they are disproportionately people of color and lower-income, planners should prioritize protecting them. While expanding housing availability is necessary to meet rising demand in many cities—and doing so through zoning policy that enables apartment construction is a reasonable approach—we must be cognizant that if apartments are mostly allowed, and largely built, in areas near high-traffic roads, increased housing availability may also be associated with poor health.

In this context, can cities develop major transit corridors, like new bus rapid transit or light rail lines, that do not have to be adjacent to high-traffic roadways? Some European cities, such as Amsterdam, Netherlands, Freiburg, Germany, and Toulouse, France, have created densely populated, mixed-use ecodistricts with excellent transit service that maintain good connections to the rest of the city without building large arterial streets that expose residents to air and noise pollution.[6] And in the United States, cities from Minneapolis to New York have converted what were once major roadways dominated by private vehicles into bus-only corridors. Such strategies could help communities throughout the nation ensure access to opportunity for their residents without hurting—and perhaps while even promoting—their health.

Conclusion

American cities have encouraged housing to be built near high-traffic roadways since such roadways were first developed. And many advocates, planners, politicians, and researchers have argued for decades that such proximity is undesirable, with effects on residents including exposure to high and sustained levels of

[6] Consider Overhoeks in Amsterdam (with 2,200 housing units); Vauban in Freiburg (2,000 housing units); and the Cartoucherie in Toulouse (3,525 housing units).

noise and air pollution. While recent research has established the volume of housing units near major roads, prior work has not explored what mechanisms produce this residential exposure to high-traffic roads, whether exposure varies across different types of housing, nor whether these mechanisms are currently in effect or whether road-related pollution exposure is merely a vestige of planning and development patterns that have since been abandoned.

Homes continue to be built near major roads, and we find that such housing is disproportionately multifamily housing. We demonstrate that zoning policies—which shape where different types of housing can be built—disproportionately allow for multifamily housing in the areas most likely to be burdened by harmful levels of road-related pollution. And we establish self-reinforcing connections between the construction of housing and the construction of major roads, including that new housing development in lower-density areas (e.g., on the urban fringe) may lead to the construction of new major roads, and that new major roads in lower-density areas may accelerate housing development.

If we believe there are no alternatives to the status quo, some of these findings may strike the reader as obvious. Of course denser housing is located closer to major roads: lots of people require lots of cars, which in turn require and generate high-traffic roads.

But this reasoning is flawed for at least two reasons. First, we could build high-traffic roads but disallow housing in areas immediately adjacent to them, where residents are most harmed by road pollution. We could instead encourage greater housing density in other parts of our communities. Second, the reasoning that denser housing requires more cars and higher-traffic roads is simply a restatement of how cities often currently plan for housing and transportation—planning that produces inequitable outcomes for residents of multifamily housing, as we demonstrate. Rather, greater housing density is what enables *fewer* vehicle trips, because walking, biking, and various forms of public transit all become easier and more appealing when people and their desired destinations are all located nearby.

It is incumbent on local and state planners and policymakers to not just interrupt the production of additional, inequitable exposure to road pollution going forward, but to also mitigate current exposure resulting from historical roads and housing development. Our results highlight the importance of zoning as one key mechanism to bring about these changes, and they also highlight the intertwined effects of transportation planning and investment.

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Appendix

TABLE A1

Zoning for Multi-Family Uses is Associated with Adjacency to Busy Roadways

Share of tract portion within 300 meters of a medium- or high-traffic road (25,000+ AADT)

	90 Places Database		Puget Sound and Washington, DC Regions	
	I	II	III	IV
Is tract portion zoned for low densities? (dummy)	−24.56*** (0.56)	−24.56*** (3.80)	−15.36*** (0.87)	−15.36*** (2.22)
Tract-level data				
Residential land in road buffer (%)	0.87*** (0.01)	0.87*** (0.09)	1.04*** (0.03)	1.02*** (0.06)
Residential land (%)	−0.36*** (0.01)	−0.36*** (0.05)	−0.30*** (0.02)	−0.36*** (0.04)
Population density (logged)	−2.91*** (0.26)	−1.54 (1.70)	−1.98*** (0.47)	−2.72*** (0.75)
Gini index	−25.19*** (4.61)	−20.51*** (4.24)	6.23 (7.88)	−3.23 (7.45)
Housing cost burden (%)	6.41** (2.03)	6.90** (2.67)	4.16 (2.65)	3.54 (3.98)
Below federal poverty line (%)	−20.81*** (2.97)	−18.36*** (2.37)	−4.29 (8.30)	8.87 (7.97)
Person of color (%)	5.01*** (1.24)	0.93 (1.70)	2.96 (1.90)	0.63 (4.01)
Intercept	82.37*** (2.50)	65.15*** (8.31)	48.02*** (4.79)	59.17*** (9.60)
Fixed effects for jurisdictions	No	Yes	No	Yes
R^2 Adj.	0.42	0.45	0.43	0.45
N	8474	8474	2900	2900

Sources: Authors' analysis of American Community Survey 2018–2022 5-year estimates, 90 places zoning data from Curran-Groome and Whittemore (2025), Puget Sound and Washington DC zoning data from Freemark (2023) and Freemark et al. (2023), and Highway Performance Monitoring System (HPMS) road data from the Bureau of Transportation Statistics.

Notes: Unit of analysis: tract portions in relevant cities (each tract has two tract portions, one representing land zoned for low density residential uses, and the other representing land zoned for high densities). Values in parentheses are robust (and in the case of fixed-effects models, clustered) standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. Only tracts with both higher and lower density zoning are included in regressions.

TABLE A2

Zoning for Multi-Family Uses is Associated with Adjacency to Busy Roadways

Difference in share of tract portion zoned for low-density versus high-density uses, within given distance (meters) of high-traffic roadways

Distance (meters)	25,000+ AADT Roads	50,000+ AADT Roads
0-100	−10.33*** (0.77)	−5.31*** (0.99)
101-200	−5.31*** (1.03)	−3.45*** (1.01)
201-300	−1.28 (0.69)	−1.66* (0.68)
301-400	0.63 (0.54)	−0.48 (0.48)
401-500	1.57*** (0.31)	0.26 (0.40)
501-1,000	6.13*** (0.97)	0.93 (0.89)
1,001-2,500	5.25*** (1.12)	3.29*** (0.94)

Sources: Authors' analysis of American Community Survey 2018–2022 5-year estimates, 90 places zoning data from Curran-Groome and Whittemore (2025), and Highway Performance Monitoring System (HPMS) road data from the Bureau of Transportation Statistics.
Notes: Unit of analysis: tract portions in relevant cities (each tract has two tract portions, one representing land zoned for low density residential uses, and the other representing land zoned for high densities). Values in parentheses are robust, clustered standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. AADT = Annual Average Daily Traffic. Only tracts with both higher and lower density zoning are included in regressions.

TABLE A3

New Construction Multi-family Development is Associated with Adjacency to Busy Roadways

Average distance to a medium- or high-traffic road (25,000+ AADT)

	LIHTC					
	I	**II**	**III**	**IV**	**V**	**VI**
Maximum distance from roadways for tracts included	2500 m	2500 m	1000 m	1000 m	NA	NA
Were LIHTC units added in tract? (dummy)	−47.23*** (8.44)	−51.56*** (11.16)	−9.15* (3.92)	−11.62* (4.75)		
Was development type apartments? (dummy)					−547.78*** (34.93)	−513.66*** (97.16)
Population density (logged)	2.97 (1.90)	−6.61 (6.52)	26.55*** (0.81)	21.62*** (4.08)	−134.01*** (26.26)	−61.17 (62.16)
Gini index	−293.88*** (36.70)	−292.84*** (66.85)	−12.65 (16.77)	−27.91 (20.04)	−1726.45*** (268.02)	−354.77 (382.78)
Housing cost burdened (%)	−96.06*** (14.46)	−46.04* (19.57)	−37.85*** (6.12)	−21.14** (8.05)	84.24 (131.91)	−288.93 (278.06)
Below federal poverty line (%)	475.37*** (26.05)	338.45*** (53.82)	146.46*** (12.02)	110.58*** (17.24)	−29.59 (170.65)	−429.03 (438.48)
Person of color (%)	−230.40*** (10.24)	−129.03*** (23.45)	−62.80*** (4.58)	−25.84* (12.1)	263.84** (83.85)	393.35* (163.54)
Intercept	515.55*** (18.78)	432.09*** (69.37)	−43.25*** (8.20)	−54.09 (40.90)	2699.17*** (230.37)	1543.40* (607.53)
Fixed effects for jurisdictions / states	No	Yes	No	Yes	No	Yes
R^2 Adj.	0.01	0.04	0.03	0.05	0.14	0.30
N	60967	60967	52479	52479	2523	2523

Sources: Authors' analysis of American Community Survey 2018-2022 5-year estimates, LIHTC developments from the National Housing Preservation Database (NHPD) located within Census-defined urban areas, developments in the greater Dallas region from North Central Texas Council of Governments, and Highway Performance Monitoring System (HPMS) road data from the Bureau of Transportation Statistics.
Notes: Unit of analysis: Models I–IV: tracts in urban areas across the United States; Models V–VI: large development projects in urban areas in the North Central, Texas region. Values in parentheses are robust (and in the case of fixed-effects models, clustered) standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. "Population Density (logged)" reflects the logged number of individuals per square kilometer of land area. "LIHTC in tract" is a dummy indicator for whether the tract contained any LIHTC developments. "Development type: apartment" is an indicator for whether the development was an apartment building (rather than comprised of single-family homes).

TABLE A4

Regression Findings are Robust to Different Road Classifications

Distance to nearest road (LIHTC) and share of tract within 300 meters of road (90 places)

	LIHTC			
	I	II	III	IV
	Primary Roads	AADT 50,000+	Primary Roads	AADT 50,000+
Maximum distance from roadways for tracts included	1000 m	1000 m	NA	NA
Were LIHTC units added in tract? (dummy)	−19.69** (6.00)	−11.73* (5.76)		
Is tract portion zoned for low densities? (dummy)			−19.42*** (4.72)	−19.62*** (4.89)
Residentially zoned land in road buffer (%)			0.88*** (0.08)	0.86*** (0.07)
Residentially zoned land (%)			−0.32*** (0.04)	−0.32*** (0.04)
Population density (logged)	48.63*** (1.78)	56.18*** (2.51)	−0.97 (1.86)	−1.63 (1.54)
Gini index	54.05 (29.28)	5.17 (31.06)	−18.07*** (4.76)	−15.63*** (4.31)
Housing cost burdened (%)	−8.29 (10.37)	−0.93 (10.67)	10.02*** (2.39)	8.84*** (2.37)
Below federal poverty line (%)	34.97 (18.08)	54.61** (20.64)	−21.80*** (2.61)	−22.46*** (3.06)
Person of color (%)	−34.20** (10.86)	−43.59*** (11.24)	0.40 (1.56)	1.25 (1.92)
Intercept	−169.84*** (16.37)	−215.33*** (19.62)	58.68*** (16.69)	63.70*** (13.37)
Fixed effects for jurisdictions / states	Yes	Yes	Yes	Yes
R^2 Adj.	0.08	0.06	0.42	0.42
N	38087	29949	4938	4882

Sources: Authors' analysis of American Community Survey 2018-2022 5-year estimates, 90 places zoning data from Curran-Groome and Whittemore (2025), LIHTC developments from the National Housing Preservation Database (NHPD), and Highway Performance Monitoring System (HPMS) road data from the Bureau of Transportation Statistics.

Notes: Unit of analysis: Models I–II: tracts in urban areas across the United States; Models III–IV: tract portions in relevant cities (each tract has two tract portions, one representing land zoned for low density residential uses, and the other representing land zoned for high densities). Values in parentheses are robust clustered standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. "Population Density (logged)" reflects the logged number of individuals per square kilometer of land area. "LIHTC in tract" is a dummy indicator for whether the tract contained any LIHTC developments. AADT = Annual Average Daily Traffic. For models I and II, only tracts in Census Bureau-defined urban areas and within 1,000 meters of a specified road (either a primary road, for model I, or a road with an AADT of 50,000 or more, for model II) are included in the analysis. For models III and IV, only tracts with both higher and lower density zoning are included in regressions.

TABLE A5

Major Road Construction Following Housing Growth Occurs Primarily in Lower Density Areas

Likelihood that a major road was constructed between 2019 and 2023

	Tracts with less than 2,001 people per square mile	Tracts with more than 2,000 people per square mile
	I	II
Housing units total (change, 2010-2018)	0.11** (0.03)	0.01 (0.01)
Person of color %	0.01 (0.03)	−0.01 (0.02)
Median family income (logged)	−1.51 (1.59)	−0.04 (0.96)
Fixed effects for counties	Yes	Yes
Intercept	0.02 (0.02)	0.00 (0.01)
N	46,411	19,146
R^2 Adj.	0.19	0.46

Sources: Authors' analysis of American Community Survey five-year estimates, accessed from IPUMS NHGIS for the years 2014-2018 and 2006-2010, and TIGER/Line shapefiles from the US Census Bureau for 2019 and 2023.

Notes: Unit of analysis: tracts in urban areas nationwide. Values in parentheses are robust standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. Changes are measured as the value at follow-up minus the value at baseline, divided by the value at baseline. Only tracts in metropolitan core-based statistical areas are included in this analysis.

TABLE A6

Major Road Construction Contributes to Housing Growth Primarily in Lower Density Areas

Housing unit change, 2018 to 2023

	Tracts with 2,000 or fewer people per square mile	Tracts with more than 2,000 people per square mile
	I	II
Did tract add a new road from 2010–14? (dummy)	−5.03* (2.31)	1.14 (0.63)
New road dummy x change in housing units, 2000–10	0.34*** (0.08)	−0.02 (0.03)
Person of color %	−0.05 (0.04)	0.03*** (0.01)
Median family income (logged)	2.66 (1.90)	−0.88** (0.33)
Housing units (change, 2000-2010)	0.28*** (0.03)	0.07*** (0.01)
Fixed effects for counties	Yes	Yes
Intercept	−26.59 (32.86)	12.19 (7.99)
N	46,996	18,561
R^2 Adj.	0.02	0.04

Sources: Authors' analysis of American Community Survey five-year estimates, accessed from IPUMS NHGIS, for the years 2006-2010, 2010-2014, 2014-2018, and 2019-2023, as well as decennial census data accessed from IPUMS NHGIS for the years 2000 and 2010, and TIGER/Line shapefiles from the US Census Bureau for 2010 and 2014.

Notes: Unit of analysis: tracts in urban areas nationwide. Values in parentheses are robust standard errors. Symbols denote p-value thresholds: * = .05, ** = .01, *** = .001. Change is measured as the value at follow-up minus the value at baseline, divided by the value at baseline. Only tracts in metropolitan core-based statistical areas are included in this analysis.