Cleaner Cars, Cleaner Air

Replacing California's Oldest and Dirtiest Cars Will Save Money and Lives

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Introduction

California has a long history of poor air quality resulting from transportation pollution on its roads. Toward reducing such pollution, the federal Clean Air Act, enacted in 1963, expanded states' ability to set tailpipe emissions standards. As early as 1966, California's climate, geography, and large number of vehicles led it to initiate regulatory action to reduce pollution from passenger cars and trucks (CARB, n.d.a). Since 1970, the state has used its authority under the Clean Air Act to require technological solutions to minimize emissions, initially using measures like mandating catalytic converters in new cars and now requiring the sale of electric vehicles and other zero-emissions vehicles (Reichmuth 2022).[1]

As a result of these regulations, the air-polluting emissions of today's new passenger vehicles are much lower than those of older ones. However, the improved tailpipe-pollution regulations only apply to new cars and trucks. Older vehicles are tested for emissions through the Smog Check program, but those inspections only verify that they meet the standards in place when the vehicles were manufactured (BAR 2022). Therefore, even with fully functional emissions equipment, older vehicles will pollute at higher levels than newer ones.

Currently, gasoline engines power the overwhelming number of passenger vehicles on the road. Their emissions both directly and indirectly produce fine particulate matter, defined as airborne particles less than 2.5 micrometers in diameter. These particles, referred to as $PM_{2.5}$, are small enough to penetrate deeply into the lungs, and some can enter the bloodstream. $PM_{2.5}$ is responsible for significant and life-shortening health impacts, including but not limited to lung disease, cardiovascular disease, and cancer.

Previous studies by the Union of Concerned Scientists (UCS) and others have shown that exposure to $PM_{2.5}$ pollution from on-road transportation is inequitably distributed (Reichmuth 2019; Plummer et al. 2022). On-road vehicles in California expose people of color to disproportionately high levels of $PM_{2.5}$ pollution. On average, Black Californians are exposed to 43 percent more $PM_{2.5}$ pollution than are White Californians and Latino Californians to 39 percent more (Reichmuth 2019).[2]

Cleaner Cars, Cleaner Air builds upon those findings by examining the impact specifically of older cars. While older vehicles are a relatively small fraction of personal vehicles, the large amount of pollution they create is experienced inequitably across California, just as with transportation pollution in general. Latino and Black Californians and low-income and disadvantaged communities face the brunt of the impacts of old vehicles. Policies to reduce the use of older vehicles would yield environmental, public health, and economic benefits for Californians, as well as taking a step toward addressing longstanding environmental injustices.

Tribal communities throughout the state also bear unacceptable levels of pollution, but, due to data limitations, we could not analyze the number of old vehicles owned by Tribal residents or estimate the health and economic impact of their pollution on tribal communities (August et al. 2021). Among the relevant factors is the persistence of many infrastructure needs. For example, rural dirt roads often provide the access to Tribal communities where the associated exposure to dust and dirt impacts upper respiratory illnesses (August et al. 2021).

A Fraction of the Vehicles on California Roads, Older Cars and Trucks Pollute More Than Newer Ones

Beginning with model year 2004, California has implemented Low-Emission Vehicle (LEVII) tailpipe pollution standards for passenger vehicles (CARB 2008). As a result, passenger cars and trucks made before that year produce much more tailpipe pollution per mile than do newer passenger cars and trucks.[3] In fact, pre-2004 vehicles emit almost three times as much smog-forming nitrogen oxides pollution as do all 2004 and later vehicles combined. This is the case even though older passenger vehicles make up only 19 percent of those in the state and 12 percent of miles driven. They are responsible for 73 percent of all nitrogen oxides exhaust from passenger vehicles and 64 percent of reactive organic gases. Both types of pollutant can react in the atmosphere to form $PM_{2.5}$.

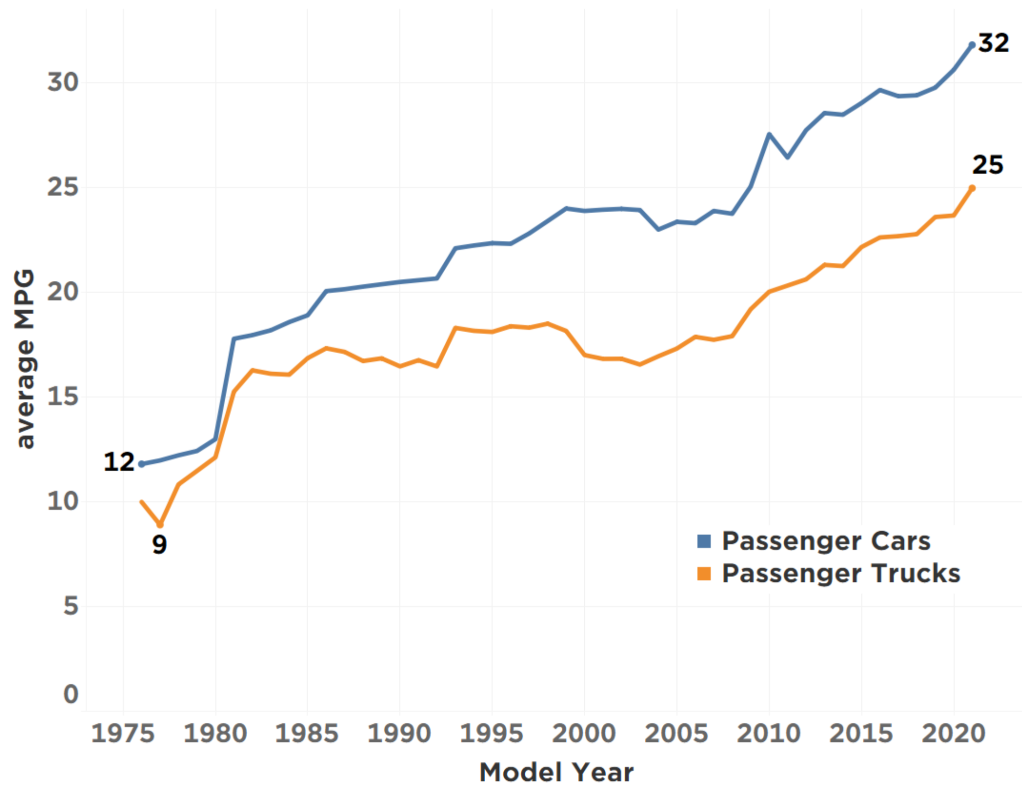
In addition to causing more air pollution due to lower emissions standards, the poorer fuel economy of older cars increases global warming emissions per mile driven while increasing fuel costs for drivers (Table 1 and Figure 1). Older cars average 23 miles per gallon (MPG); older trucks average 17 MPG. In contrast, new cars in California average more than 30 MPG and new trucks 25 MPG. Moreover, older cars cost more to maintain. For example, 20-year-old cars fail the required Smog Check twice as often as do 10-year-old vehicles (BAR 2022).

TABLE 1. Older Vehicles Produce a Disproportionate Amount of Harmful Air Pollutants

	Pre-2004 Passenger Vehicles	2004–2021 Passenger Vehicles
Vehicles registered	4.8 million (19%)	20.7 million (81%)
Annual mileage	33 billion miles (12%)	253 billion miles (88%)
Annual emissions of nitrogen oxides (NO_x) exhaust	39,900 tons (73%)	14,500 tons (27%)
Annual emissions of reactive organic gases	43,400 tons (64%)	24,300 tons (36%)

Although older vehicles represent fewer than one-fifth of the cars on California roads, they produce more nitrogen oxides and reactive organics gas emissions than all newer vehicles combined.

FIGURE 1. The Rising Fuel Efficiency of Gasoline and Diesel Passenger Cars and Trucks



The fuel efficiency of older gasoline and diesel vehicles is much lower than that of current cars and trucks, with well over a two-fold improvement for both cars and trucks between 1976 and 2021. SOURCE : EMFAC n.d.a.

To put that in perspective, driving a 20 MPG car for 10,000 miles would produce over five metric tons of carbon dioxide and the fuel would cost $2,500 at $5 per gallon; an efficient gasoline car (40 MPG) would emit half the amount of carbon dioxide and cut the fuel costs in half. The emissions from driving the average electric car in California 10,000 miles are even lower: less than 1 metric ton of global warming pollution per year (Reichmuth 2023). And global-warming emissions from using electric vehicles should fall further as the state transitions to lower-carbon sources of electricity (CEC 2021).

Fine Particulate Matter Pollution Has Significant Health Impacts

Passenger cars and trucks from model year 2003 and earlier emit tailpipe pollutants that lead to the formation of fine particulate matter at a much higher rate than do vehicles beginning with model year 2004.[i] In particular, the emissions of nitrogen oxides and reactive organic gases are significantly higher than those from newer gasoline or diesel vehicles. These pollutants are emitted in the vehicle exhaust. (Volatile organic compound emissions also come from gasoline that evaporates during refueling and from leaks in vehicle fuel tanks and lines.)

Pollutants like nitrogen oxides and reactive organic gases react in the atmosphere to form $PM_{2.5}$ in addition to the $PM_{2.5}$ present in vehicle exhausts.

It has been estimated that $PM_{2.5}$ is responsible for the vast majority of the 3 to 4 million annual deaths attributed to air pollution worldwide. While $PM_{2.5}$ is not the only air pollutant that adversely affects health, it is estimated to be responsible for approximately 95 percent of the global public health impacts from air pollution (Landrigan et al. 2018; Lelieveld et al. 2015). Using 2014–2016 data, the California Air Resources Board (CARB), the state's air-quality regulator, has estimated that cardiopulmonary causes related to $PM_{2.5}$ exposure contribute to roughly 5,400 premature deaths in the state each year, as well as 2,800 hospitalizations for cardiovascular and respiratory diseases and 6,700 emergency room visits for asthma (CARB, n.d.b.).

Both acute and chronic exposure to $PM_{2.5}$ have been linked to illness and death (Brook et al. 2010). Short-term exposure to elevated levels of $PM_{2.5}$ can exacerbate lung and heart ailments, cause asthma attacks, and lead to both increased hospitalizations and mortality from cardiovascular diseases (Orellano et al. 2017; Pope and Dockery 2006). Chronic exposure also increases death rates attributed to cardiovascular diseases, including heart attacks, and it has been linked to lung cancer and other adverse impacts (Fine, Sioutas, and Solomon 2008). Chronic exposure to $PM_{2.5}$ in pregnancy and childhood has been linked to slowed lung-function growth and the development of asthma, among other negative health impacts (ALA 2018; Gehring et al. 2015; Gauderman et al. 2004; Johnson et al. 2021).

Exposure to Harmful Air Pollution from Older Vehicles Is Inequitably Distributed

The California Air Resources Board has published data on the fuel type, model year, vehicle class, and registration location of most of the state's passenger cars and trucks.[4] CARB also estimates the rate of air-pollution emissions for vehicles by fuel type, model year, region of the state, and vehicle class. By combining these datasets, we estimated the local air-pollutant emissions from both older and newer cars. Using the InMAP air-quality model, we estimated the formation and transport of $PM_{2.5}$ pollution in the state from the use of older passenger vehicles (defined as model years 1976 through 2003) and newer ones (model years 2004 through 2021) (Tessum, Hill, and Marshall 2017).[5] These results were used with US Census data to estimate the exposure of Californians to harmful $PM_{2.5}$ pollution from the use of passenger cars and trucks and from the subset of pre-2004 vehicles.[ii] *See the appendix for more information on the methodology.*

Our analysis shows that $PM_{2.5}$ exposure is inequitably distributed across California's racial and demographic groups. All of the areas with the highest exposure to $PM_{2.5}$ from older vehicles are in the southern half of California and mainly in central Los Angeles (Figure 2). The communities with the highest pollution burden due to $PM_{2.5}$ from older vehicles—more than twice the state average—have higher percentages of low- and moderate-income households than areas unburdened by air pollution from these vehicles.

Exposure is also inequitably distributed by income. In the parts of the state with the highest exposure to $PM_{2.5}$ pollution from older vehicles, over half of households have an income of less than $60,000 a year. In areas with the least exposure, only 35 percent of households have an income of less than $60,000 a year (Figure 3). On average, higher income households are exposed to lower concentrations of $PM_{2.5}$ from all passenger vehicles; lower-income households have higher exposure.

The disparity based on income is significantly worse when considering only older vehicles. Higher-income households (over $200,000) have on average 18 percent lower exposure than the state average (Table 2).

TABLE 1. Exposure to Older-Vehicle $PM_{2.5}$ Pollution Is Much Lower for the Highest-Income Households

Household Income	Less than $20,000	$20,000 – $60,000	$60,000 – $100,000	$100,000 – $150,000	$150,000 – $200,000	Greater than $200,000
Exposure relative to state average from all passenger vehicles	4%	1%	1%	-2%	-4%	-9%
Exposure relative to state average from older passenger vehicles	5%	3%	0%	-5%	-9%	-18%

Higher-income households in California are exposed to exposure to fewer vehicle emissions. The disparity is especially evident for pollution from older vehicles.

We also found racial and ethnic disparities in exposure to air pollution from passenger vehicles. For all passenger cars and trucks, White people are on average exposed to 17 percent lower concentrations of $PM_{2.5}$ than the state average; Latino Californians are exposed to 13 percent higher concentrations; Black people are exposed to 11 percent higher concentrations.

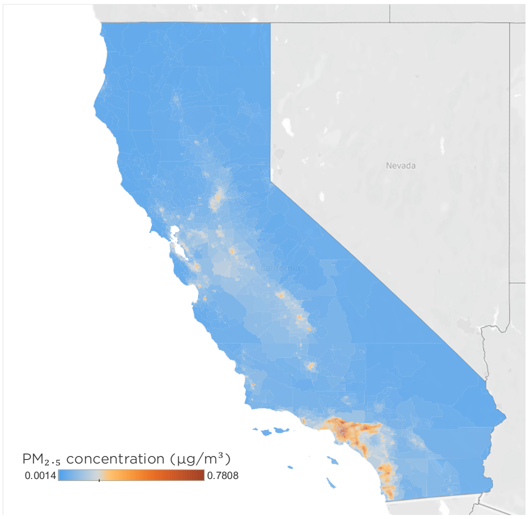
These disparities, too, are greater when considering only pollution from older vehicles. White people are on average exposed to 20 percent lower concentrations of $PM_{2.5}$ from older vehicles than the state average. Latino Californians are exposed to concentrations 19 percent higher than the state average; Black people are exposed concentrations 12 percent higher.

Communities with the highest exposure to $PM_{2.5}$ from older vehicles—greater than twice the state average—are home to much higher percentages of people of color than the state as a whole. In these areas with the highest exposure, 67 percent of residents are Latino and 8 percent are Black; the statewide population is 40 percent Latino and 5 percent Black. In contrast, those same areas of highest exposure are only 13 percent White; the state population is 36 percent White (Figure 4).

Further, Californians who already face the worst exposure to pollution from all sources combined also face the brunt of emissions from older vehicles. Increased exposure to $PM_{2.5}$ pollution from older vehicles correlates with a community's score on CalEnviroScreen 4.0, a screening methodology that helps identify communities that are disproportionately burdened by multiple sources of pollution. People in the highest-scoring (most-burdened) census tracts in CalEnviroScreen 4.0 are exposed to twice the concentration of pollution from older vehicles as are those in the lowest-scoring census tracts (Figure 5).

FIGURE 2: $PM_{2.5}$ Pollution from Older Vehicles Is Highest in Southern California

2a



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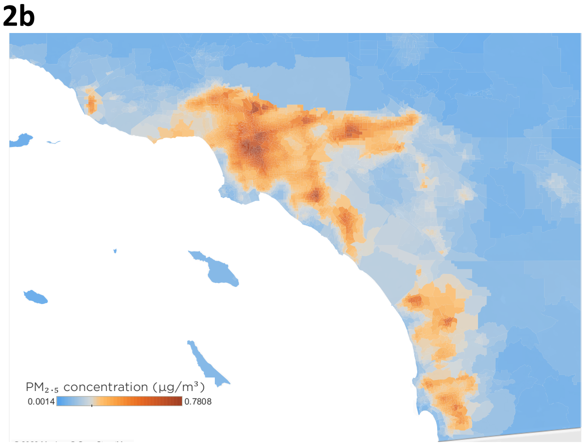

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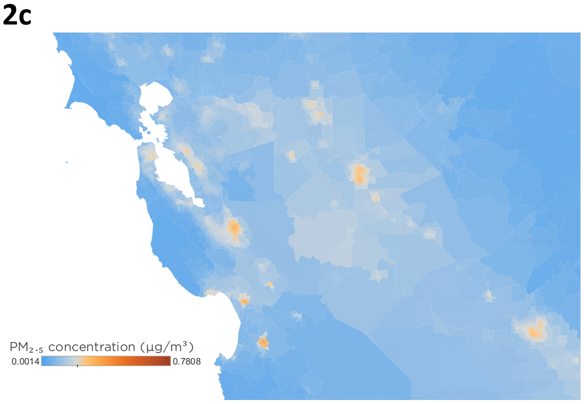
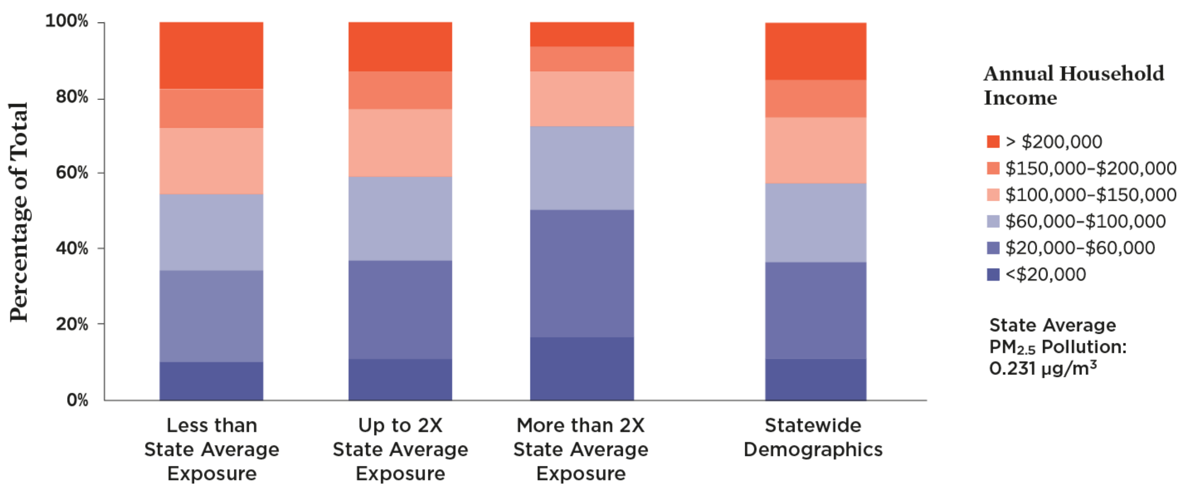


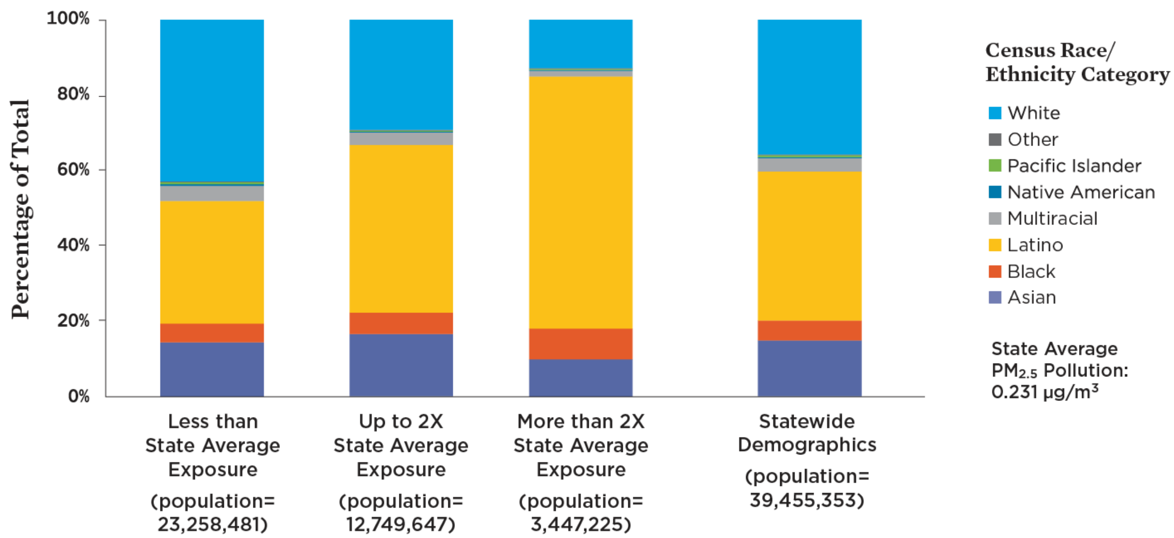
$PM_{2.5}$ pollution from older vehicles is highest in the southern half of California (2b), particularly in Los Angeles and Long Beach. $PM_{2.5}$ pollution concentrations reflect total emissions from older vehicles, including driving, starting, and evaporative emissions.

FIGURE 3. Household Income and Pollution from Older Cars



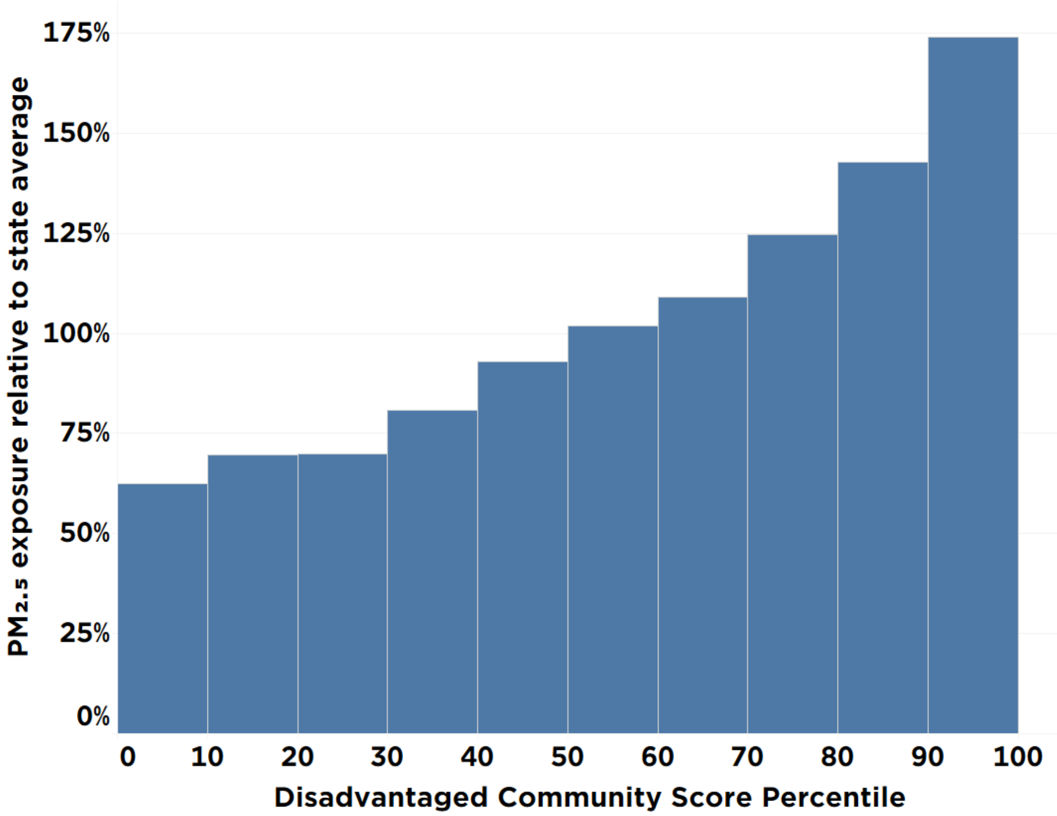
Communities with the highest exposure to pollution from older cars have higher fractions of lower-income households. More than half the households are low income (less than $60,000 household income) in the areas with highest exposure to $PM_{2.5}$ air pollution from older cars and trucks.

FIGURE 4. $PM_{2.5}$ Pollution from Older Cars and Race/Ethnicity



Communities with higher exposure to $PM_{2.5}$ pollution from older vehicles have higher fractions of Latino and Black people than do low-exposure communities. For example, Latino Californians are exposed to concentrations 19 percent higher than the state average.

FIGURE 5. Exposure of Environmentally Disadvantaged Communities to Older-Vehicle Pollution



Communities that are designated as disadvantaged based on their CalEnviroScreen Score have more exposure to pollution from older vehicles. One factor California uses to designate disadvantaged communities is a score above the 75th percentile from the CalEnviroScreen tool.

Estimating Premature Deaths Due to Pollution from Older Vehicles

To estimate premature deaths from $PM_{2.5}$ pollution exposure resulting from using older vehicles, we examined two scenarios. One scenario evaluated only emissions from starting a vehicle; the second considered all tailpipe and evaporative emissions. We chose these scenarios because the rates of air-pollution emissions from gasoline vehicles are much higher when starting a vehicle engine after a period of inactivity as a cold exhaust system results in lower catalytic converter performance and therefore more air pollutant emissions.

For passenger vehicles, it is reasonable to assume that cold starts often occur at or near where the vehicle is registered. Emissions also occur as the vehicle moves, with some likely occurring in or near the registration location. However, the fraction of emissions occurring near that location is not known. Similarly, we do not know the location of evaporative emissions, though some fraction likely occurs at the registration location.

These scenarios provided a range for the estimated premature deaths in California, in one case only considering cold-start emissions at the location of vehicle registration and in the second case assuming that all tailpipe emissions happen where the vehicle is registered (Table 3). We estimated that older-vehicle emissions led to between 97 and 421 premature deaths per year. The impacts were concentrated in Southern California, especially Los Angeles County.

TABLE 3. Premature Deaths Due to Older-Vehicle Emissions in California

	Estimated Premature Deaths Due to Older-Vehicle Start Emissions	Estimated Premature Deaths Due to Older-Vehicle Total Emissions
Los Angeles County	34	170
San Diego County	10	43
Orange County	9	43
San Bernardino County	5	23
Riverside County	5	20
All Other California Counties	34	122
Total	**97**	**421**

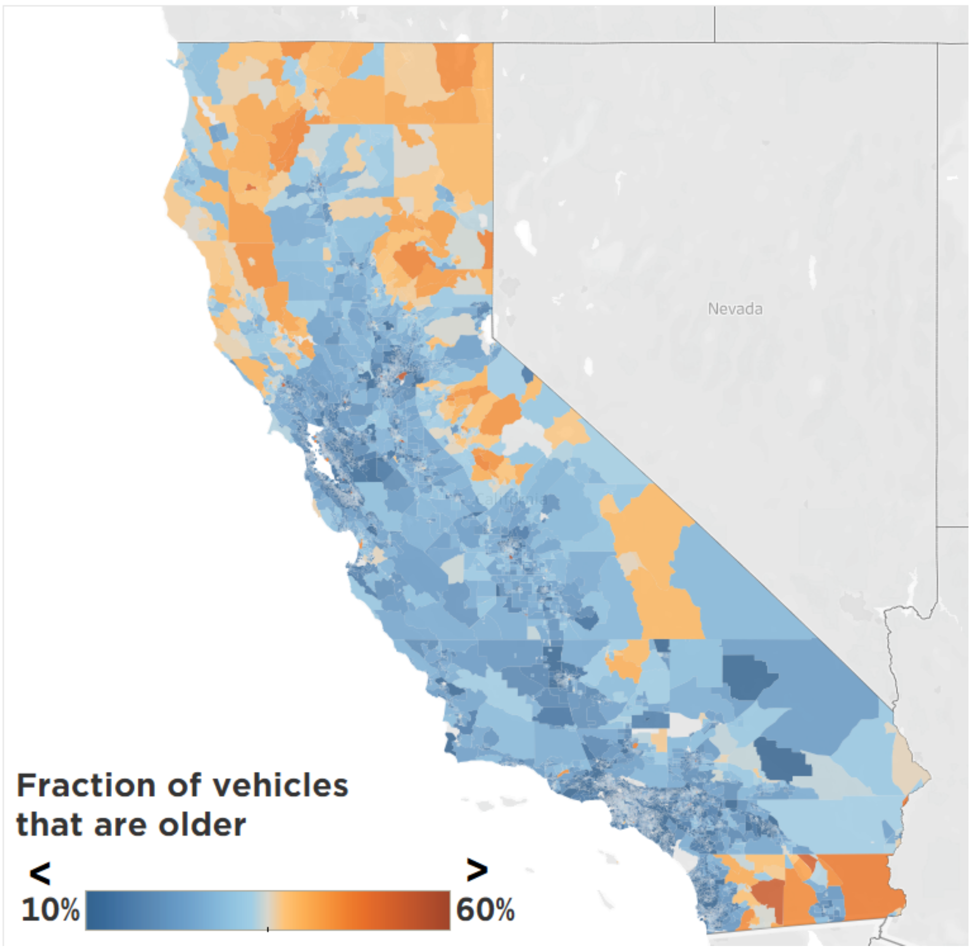
Premature deaths due to older-vehicle emissions are higher in Southern California. Los Angeles County alone accounts for over one-third of the state total.

Note: Total emissions includes driving, starting, and evaporative emissions.

Rural Areas Have a Higher Proportion of Older Vehicles

While Southern California's urban areas have the most older vehicles (and highest exposure to the resulting pollution), rural areas have higher proportions of older vehicles (Figure 6). For example, in rural Modoc, Trinity, and Sierra counties, over 40 percent of vehicles are model year 2003 or older. In contrast, Orange, San Francisco, and Riverside counties, all of which are much more urban, have the lowest percentages of older cars.

FIGURE 6. The Fraction of Older Vehicles in Rural and Urban Areas



Rural areas of California have higher proportions of older cars even though the total number of old cars is lower than in urban areas.

Recommendations: Policies to Reduce Inequitable Exposure to Pollution

Based on the impacts of older cars on local air quality and public health, it is imperative that the California agencies administering incentive programs for retiring and replacing vehicles prioritize getting the oldest cars off the state's roads. Policymakers should also ensure that programs benefit disadvantaged and low-income communities. Moreover, when developing policies and programs, California should involve—and in meaningful ways—the communities most impacted by older-vehicle emissions. This will help the state identify approaches to reducing the inequitable distribution of this pollution from older passenger vehicles.

UCS and The Greenlining Institute recommend the following changes in state policies and programs:

- **Prioritize incentives toward priority populations owning old cars.** State agencies should integrate programmatic changes to existing incentive programs, such as Clean Cars All and the Clean Vehicle Assistance Program, to prioritize investing in low-income and disadvantaged communities with high concentrations of older cars.[6] By doing so, the state can target high-polluting cars and make better use of limited funding. Given the high concentration of old-vehicle pollution in Southern California—and particularly in the Los Angeles area—the state should evaluate whether current incentive programs adequately serve the most deserving old-car owners in those regions. Incentives need to be logistically and economically attractive to old-car owners to encourage them to upgrade to cleaner electric cars or more fuel-efficient gas models that are more affordable to operate.

- **Target outreach and education to areas with high concentrations of old cars and limited uptake of zero-emissions vehicles.** State and local agencies should target their limited outreach and education funds. In light of our analysis, state outreach and education must be sensitive to the fact that older-car pollution disproportionately burdens Latino and Black communities. Multilingual and culturally accessible outreach and education are essential, and collaboration with trusted community-based organization can improve the results.

- **Provide transportation solutions that go beyond private passenger vehicles.** Even as California seeks to reduce vehicle miles traveled, it continues to invest in vehicle incentive programs that prioritize car ownership. Agencies should consider higher funding for programs that promote alternative modes of transportation, such as e-bikes, car sharing, and public transportation. One option is to dedicate more funding to the Clean Mobility Options component of Clean Cars 4 All, along with supporting other efforts that use a bottom-up approach and enabling communities to define their needs. Also key are land-use decisions that reduce the need to drive and encourage the use of alternative modes of transportation. This strategy could be particularly fruitful in the denser, urban hubs of greater Los Angeles where a substantial portion of older-vehicle pollution is concentrated.

- **Evaluate and adjust incentive programs based on changing conditions in the electric-vehicle market.** While California mandates that all new vehicles sold in the state by 2035 be zero-emissions, today's selection of zero-emissions vehicle (ZEV) models is limited. Not many lower-priced ZEV models are available, and even fewer are available in larger-size classes like SUVs and full-size pickup trucks. Despite generally declining prices for electric vehicle components like batteries, the pandemic's impact on the supply chain has led to price increases for both new and used EVs. California should continue to evaluate and adapt its incentive programs to best assist people based on their needs. While a complete switch to zero-emissions technology will happen in the longer term, the prices and limited supply of electric vehicles can make their purchase difficult in the near term. Thus, the state should not discourage owners from switching to other types of cleaner and cheaper-to-fuel vehicles, even those that are not zero-emissions. In rural areas, where alternatives to personal vehicles are less prevalent, California should continue encouraging people to switch to cheaper-to-fuel vehicles, especially drivers and owners of larger-size classes like pickup trucks. This is particularly important given that the largest proportion of older cars are in largely rural areas where public transit and micro-mobility alternatives are more difficult to implement. Transportation electrification should continue to be a priority, but simply switching from older to newer vehicles can still result in meaningful emissions reductions under current economic conditions.

Saving Money and Lives

As California endeavors to decarbonize its transportation sector, it must place a strong emphasis on phasing out the worst-polluting vehicles. This analysis by UCS and the Greenlining Institute demonstrates that pollution from older vehicles disproportionality burdens Latino and Black Californians, low-income communities, and other populations already experiencing substantial exposure to pollution. To reduce climate-changing emissions and protect communities from harmful air pollution, California must make retiring older vehicles a priority.

State regulators and policymakers will need to ensure that *all* Californians have access to cleaner transportation options. Vehicle incentive programs must be adequately funded and prioritize populations most burdened by older-vehicle pollution. More broadly, transportation options in both cities and rural areas must be improved and expanded to offer affordable, accessible alternatives to owning passenger vehicles.

A cleaner, safer transportation future for all Californians is possible. To realize it, the state must commit to retiring the dirtiest polluters on the road. With sustained investment and targeted policies, California can protect its vulnerable communities from harmful air pollution, saving money and lives.

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Appendix: Methodology

Estimating Vehicle Emissions

To estimate the location of light-duty vehicles in California, we used the EMFAC Fleet Database of the California Air Resources Board (CARB) for vehicle model years 1976 through 2021 (EMFAC, n.d.a). That database provides on-road vehicle population estimates at the level of US Census Block Group. The EMFAC data are generated based on vehicle registration data from the California Department of Motor Vehicles.

The EMFAC Fleet Database gives the number of vehicles in a census block group of a particular model year, fuel type, and vehicle type. We filtered the data to eliminate other vehicle types by selecting EMFAC Fleet Database vehicle types P, T1, T2, and T3, corresponding to passenger cars and trucks with gross vehicle weight ratings up to 8,500 pounds.

The data were also filtered to remove census block groups with low population but anomalously high numbers of vehicle registrations, such as airport rental-car facilities, used automobile wholesalers, and auction storage facilities. The analysis excluded vehicles powered by natural gas.

We merged the filtered EMFAC Fleet Database with the EMFAC2021 Emissions Inventory (v1.0.2) per vehicle of NO_x, reactive organic gases, SO_x, direct $PM_{2.5}$, and NH_3 emissions for calendar year 2020 using vehicle type, fuel type, sub-area, and model year (EMFAC, n.d.b). Emissions rates were calculated using only cold-start emissions as a lower bound and total running emissions as an upper bound. The resulting dataset of emissions was summed by census block group and combined with the census block shapefile from the Census Bureau.

Modeling $PM_{2.5}$ Exposure

We estimated formation and transport of $PM_{2.5}$ using the InMAP v1.9.6 reduced-form, air-quality model with variable grid size between 1 and 12 kilometers (Tessum, Hill, and Marshall 2017).

We mapped the resulting $PM_{2.5}$ concentrations to census block groups using area-weighted interpolation. We combined the concentrations with data from the American Community Survey for the years 2017 through 2021 to determine particulate air-pollution exposure by demographic groups (US Census Bureau, n.d.). The $PM_{2.5}$ concentration data were also combined with scores on the California Environmental Protection Agency's CalEnviroScreen to provide a framework for stratifying estimated $PM_{2.5}$ exposures across census tracts (OEHHA 2023). We used the population-weighted annual average concentration as the primary metric of exposure to $PM_{2.5}$. For health impacts, we assumed a no-effect threshold concentration of zero micrograms per cubic meter because a lower bound has not been established for health effects of chronic $PM_{2.5}$ exposure (Pinault et al. 2016). We used the hazard ratio for all-cause mortality from Krewski et al. (2009).

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Organizational affiliations are listed for identification purposes only. The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. The Union of Concerned Scientists and The Greenlining Institute bear sole responsibility for the report's contents.

ENDNOTES

[1] The Clean Air Act allows other states to adopt California's stronger vehicle standards.

[2] This report uses the term Latino to describe persons answering "yes" to the US Census question "Is this person of Hispanic, Latino, or Spanish origin?" The census collected race data in a separate question. The term White describes persons answering "no" to the Hispanic, Latino, or Spanish ethnicity question and choosing the response "White" in response to "What is this person's race?" The term Black describes persons answering "no" to the Hispanic, Latino, or Spanish question and choosing "Black or African Am." in response to "What is this person's race?" (US Census Bureau 2021).

[3] On-road vehicles also produce $PM_{2.5}$ from wear on tires and brakes.

[4] CARB's publicly available data do not include model year for vehicles manufactured before 1976, and some data are masked for privacy reasons.

[5] We excluded vehicles older than 1976; our input sources lacked detailed data on vehicles manufactured before 1976. The newest vehicles in the dataset were model year 2021.

[6] Clean Cars 4 All provides an incentive to scrap older, polluting cars and replace them with a zero- or low-emissions vehicles or transit vouchers. See: https://ww2.arb.ca.gov/our-work/programs/clean-cars-4-all. The Clean Vehicle Assistance Program provides grants and loans to lower-income buyers for the purchase of a zero-emissions vehicle. See https://cleanvehiclegrants.org/.

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