UCLA Luskin Center for Innovation

Informing effective and equitable environmental policy

What Defines a Plastic-Burdened Community?—Part II

PLASTIC, FOSSIL FUELS, AND INEQUITABLE SITE-BASED EXPOSURE RISKS

BY VERONICA HERRERA AND DANIEL COFFEE

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UCLA Luskin Center for Innovation

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AUTHORSHIP

This report was produced by the UCLA Luskin Center for Innovation and is Part II of the *What Defines a Plastic-Burdened Community?* research series. Part I proposes a conceptual framework for assessing communities' plastic burden and explores exposures in California from downstream (waste- and disposal-related) sites. This report was authored by:

- Veronica Herrera, principal investigator (vherrera@luskin.ucla.edu)
- Daniel Coffee, project manager and researcher (dcoffee@luskin.ucla.edu)

Research assistance provided by Manasi Vartak.

This report is accompanied by an interactive map of exposure to sites and facilities associated with the plastic supply chain in California.

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GLOSSARY OF KEY TERMS

Abbreviation	Meaning
CalEnviroScreen (CES)	The California Communities Environmental Health Screening Tool, an index that uses 21 indicators of environmental, public health, and socioeconomic conditions to assess burdens among Californian communities at the census tract level. Currently in version 4.0.
Downstream	The stage of the plastic life cycle during which items reach the end of their life and escape into the environment or are disposed of via various methods.
Midstream	The stage of the plastic life cycle where fossil fuel-derived precursors are refined into plastic resins and plastic items are manufactured, bought, and used.
Plastic Life Cycle	The entire process by which a plastic product is made (including the extraction and refining of raw materials), used, and disposed of. Includes three major stages: upstream (extraction and refining), midstream (manufacturing and use) and downstream (final disposal).
PPMF	The Plastic Pollution Mitigation Fund established by SB 54, which state agencies are tasked with using to remediate and lessen the impacts of plastic on Californian communities.
SB 54	California's comprehensive plastic legislation enacted in 2022, also known as the California Plastic Pollution Prevention and Packaging Producer Responsibility Act.
Upstream	The stage of the plastic life cycle where feedstocks—crude oil and natural gas—are extracted, transported, stored, and refined into monomers and petrochemicals.

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EXECUTIVE SUMMARY

The proliferation of cheap, fossil fuel-derived plastic has created a global pollution crisis, impacting communities and the environment around the world in innumerable ways. In addition to the direct damage done to public health and the environment from widespread, uncontrolled (micro)plastic contamination, profligate plastic use contributes to the climate crisis. Plastic is derived from fossil fuels and can act as a source of greenhouse gases at the end of its life. Even as individuals, businesses, and countries increasingly seek to reduce their carbon emissions, fossil fuel corporations and petrostates are expanding plastic production to maintain revenue streams. As a result, plastic represents a growing portion of the harms created by oil and gas extraction and refining.

As part of its overarching strategy to address the plastic waste crisis, California will begin administering its Plastic Pollution Mitigation Fund (PPMF) in 2027, with the goal of using plastic industry remittances to address the negative effects of plastic on Californian communities. In our 2024 report *What Defines a Plastic-Burdened Community?*, we proposed a framework for identifying communities that are disproportionately burdened with harms from plastic supply chain infrastructure, dietary contamination, and consumer goods use. In this report, we explore a component of this framework: site-based exposures from the upstream stage of the supply chain at which the raw materials and precursors used to manufacture plastic (i.e., unprocessed fossil fuels and their refined derivatives) are extracted and refined.

Despite California's reputation for progressive action on environmental and climate issues, the state's long history with fossil fuel development (primarily oil) means that thousands of wells dot the landscape, many within residential neighborhoods. The state also continues to be among the highest in crude oil refining volume, even after years of industry contraction, and SB 237 (Grayson, 2025) seeks to expand oil drilling in Kern County. A review of scientific epidemiological research shows that people living near wells and refineries are at heightened risk for many different damaging health outcomes, including cancer, respiratory disease, and poor reproductive outcomes, and that these communities are more likely to be Hispanic/Latino and Black, raising important environmental justice concerns.

We build on this literature by conducting a statewide geospatial analysis of fossil fuel infrastructure, showing that exposure risk to these sites places the brunt of harms on a narrow slice of Californians. Over 2.5 million Californians live within 1 km of an oil and gas well, and refinery infrastructure is heavily concentrated in Los Angeles, the most populous county in the country. We find that communities in the state with greater exposure to wells and refineries tend to have the following: disproportionately high populations of Hispanic/Latino and Black Californians and lower populations of White Californians; significantly lower incomes and higher rates of poverty; lower levels of educational attainment; and, especially for refineries, higher incidence of negative health conditions (e.g., asthma, cardiovascular disease). Notably, the magnitude of the relationship between oil and gas sites and these community descriptors consistently increases with proximity to the sites in question. When data on exposure to sites from the downstream stage of the supply chain—those related to plastic disposal—are incorporated, we find that these relationships hold with respect to the number of unique facility types to which a community is exposed. People living close to sites along the upstream and downstream plastic supply chain are more likely to experience negative health outcomes, and these are more strongly concentrated for communities of color.

We recommend that as California law- and policymakers move forward with plastic pollution mitigation efforts, they recognize plastic's inherent status as a fossil fuel product, monitor trends in global oil and gas consumption for plastic end markets, channel community health resources towards residents living near fossil fuel facilities, and make communities with high exposure risk from multiple stages of the plastic supply chain high priority for comprehensive investments.

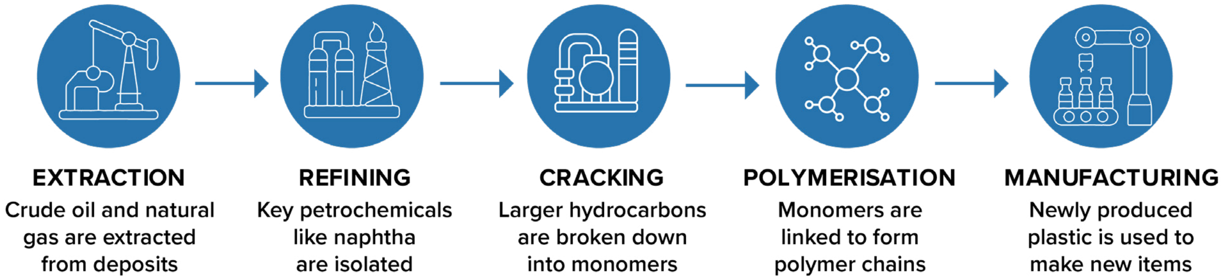
1. PLASTIC IS A FOSSIL FUEL PRODUCT

In August 2025, international negotiations on a global treaty to address plastic pollution deadlocked. The pivotal, insurmountable challenge was the unwillingness of a minority of countries—primarily petrostates whose economies depend disproportionately on fossil fuels—to entertain measures to reduce plastic production (Stallard & Poynting, 2025; Tabuchi, 2025). Without strong action to reverse the current trend, the Organisation for Economic Co-operation and Development (OECD) predicts that plastic production will triple by 2060, with a commensurate increase in plastic waste (OECD, 2022). Plastic is a subdivision of the global fossil fuel industry, which has a strong incentive to prioritize revenue in spite of overwhelming evidence of the downsides for the environment and human health.

Despite efforts to find alternatives, over 99% of plastic is made from fossil fuel-derived chemicals (Center for International Environmental Law, n.d.). Once crude oil and natural gas are extracted from the ground, the refining process distills the raw resources into many different petrochemicals. Among these are monomers—such as ethylene, propylene, and butylene—which are later polymerized into the molecular chains that make up familiar plastic (Figure 1). Oil and gas extraction and refining therefore make up the "upstream" of the plastic supply chain—the stage where the raw materials are gathered and processed prior to being used to manufacture plastic items.

FIGURE 1

How Plastic Is Derived from Fossil Fuels



Because oil and gas are not exclusively used in the manufacture of plastic, it is important to contextualize how much production is consumed by the plastic sector. Although information on global trends vis-à-vis the quantity of fossil fuels consumed to produce plastic is limited, it was estimated that as of 2008 plastic consumed approximately 4% of global oil and gas as feedstock and an additional 3%–4% to meet the energy demands of the manufacturing process (Hopewell et al., 2009). Under current trends, the plastic sector is expected to consume 20% of global oil by 2050 (Ellen MacArthur Foundation, 2016).

Recognition of plastic's status as a fossil fuel product—one that industry is counting on as an outsized driver of oil consumption in the next few decades (Brigham, 2022)—is highly relevant to California's burgeoning effort to mitigate plastic-related impacts on its residents.

Despite its reputation as an environmentally minded state and its leadership on climate action, California has long been home to a robust oil industry. Because oil and gas are global, fungible commodities, it does not matter to what extent the specific fossil fuels produced in-state are used to produce plastic. Oil is interchangeable, and therefore impacts from extraction and refining in the state are attributable to plastic production based on global consumption rates. Thus, plastic is responsible for a sizable and growing portion of the myriad impacts of oil and gas operations on Californian communities.

This research expands upon our 2024 report *What Defines a Plastic-Burdened Community?*, where we proposed a framework for assessing the heightened risks communities are exposed to from plastic. Our framework identified three general categories of risk from plastic—site-based exposures, dietary exposures, and consumer goods exposures—and articulated how information on these exposure risks could be used by state agencies to identify the areas in greatest need of investments from the state's Plastic Pollution Mitigation Fund. Here, we explore the upstream component of the plastic supply chain as part of our broader, ongoing effort to develop the site-based exposures piece of the framework. The goals of this research are to:

1. Assess the spatial footprint of oil and gas extraction and refining infrastructure in California.
2. Characterize the communities that face heightened levels of exposure risk from said infrastructure, identifying whether and to what degree these communities differ from the average in terms of their demographics, income, and measures of environmental burden and socioeconomic disadvantage.
3. Begin the process of synthesizing data into a holistic measure of site-based exposure risk across the entire plastic supply chain.

2. THE FOSSIL FUEL INDUSTRY'S FOOTPRINT IN CALIFORNIA

2.1. California's Early Crude Oil Deposits and Haphazard Development

California's first "gusher"—an uncontrolled eruption of oil columns—spouted in 1876 in the California Star Oil Works' Pico Canyon oil well north of Los Angeles. The site was soon producing 25 barrels a day, launching a new California industry that included pipeline construction and the establishment of Pioneer Refinery in Newhall, south of Santa Clarita, for kerosene production (American Oil and Gas Historical Society, n.d.). California's oil production model was founded on the principle of individual, private ownership of land and mineral resources. Private ownership meant "the rule of capture"—the doctrine that the first person to exploit a natural resource becomes its owner—governed extraction. Small-scale drillers ("wildcatters") raced to develop common oil pools in the late 19th century as the federal government opened public domain to land speculators (Sabin, 2004, Chapter 1; Takahashi & Gautier, 2007).

From 1899 to 1902, about 2,400 new oil companies were incorporated in California. Of these, only about half built a drilling rig; the large supply of oil in Kern County created economic conditions that forced many smaller operations into bankruptcy (Takahashi & Gautier, 2007, p. 9). "Black gold" quickly outpaced metallic gold in attracting migration to the West and shaped urbanization patterns throughout California (Schnalzer, 2021). Haphazard drilling throughout the state by wildcatters, developers, and oil companies both small and large proceeded with abandon during this period, causing well infrastructure to proliferate in a disorganized and poorly regulated fashion. Consequently, California became the highest petroleum-producing U.S. state, unearthing 29.6 million barrels annually by the early 1900s, a third more than second-place Texas (Takahashi & Gautier, 2007, p. 9).

As urban and suburban developments spread, they did so around well and refinery infrastructure, both active and abandoned. Zoning requirements for cities accommodated existing fossil fuel infrastructure, especially in the San Joaquin Valley and the Los Angeles Basin. California is still dealing with the legacy of the fossil fuel industry's early years and how closely oil and gas development has become enmeshed in the state's urban fabric. Driving around Southern California, visitors can see oil pumpjacks along the corridor to the Los Angeles airport in the Inglewood Oil Field, the largest urban oilfield in the United States; the offshore oil rig two miles from the University of California, Santa Barbara campus; or, until 2017, the oil derrick pumping on the grounds of the Beverly Hills High School, concealed in a flower-painted tower (Morrison, 2021).

2.2. Current Economic Activity for Wells and Refineries

California's oil industry was dominant nationwide in production until the 1930s, peaking in 1985 before going into a steady and accelerating multi-decadal decline. California's crude oil production today is one quarter of its 1985 levels. This decline is due more to geology than environmental policy. The state's 150 years of highly active drilling has emptied the readily available natural reserves. Early drilling was facilitated by expansive deposits in oil reservoirs whose pressure was so intense that it spewed gushers; these are long gone. Drilling now often requires energy-intensive and expensive steam or hot water injection into heavily depleted oil fields whose reserves are viscous and heavy. This makes California's crude oil increasingly less economically competitive against its domestic and international counterparts. It is currently the eighth-largest producer of crude oil among the 50 states, with a field crude oil production of 109.8 million barrels in 2024 (U.S. Energy Information Administration, 2025c, 2025d). The economic limitations of in-state oil production can also be seen in permitting, with nearly half of recently approved drilling permits going unused (Sivas, 2025).

California's refineries have also decreased in number and adjusted their operating strategies. As of 2024, California has 13 refineries operating in the Bay Area, Los Angeles, and the Central Valley, down from 42 in 1982. These facilities currently account for about 9% of refineries in the United States by facility count (U.S. Energy Information Administration, 2025b; U.S. Census Bureau, n.d.-a). California's crude oil distillation capacity has likewise contracted to 1,637,871 (barrels per calendar day) in 2025, down from 2,534,665 (barrels per calendar day) in 1982 (U.S. Energy Information Administration, 2025a).

Despite these declines, California remains the third largest crude oil refining state in the United States, after Texas and Louisiana. In the last few decades, California's refineries have switched from processing majority Californian crude oil to processing imported oil from foreign countries. Globally, the refining industry has more installed capacity than it processes (Deloitte, 2021, p. 5), which has led to increasing crude oil imports as refineries look to remain profitable. In 1982, California's refineries processed 61% of the crude oil from California, 33% from Alaska, and only 5% from foreign countries (California Energy Commission, 2025a). By 2024, this breakdown shifted to 23% of crude oil from California, 13% from Alaska, and 63% from foreign countries. Over half of these foreign inputs originated from Central and South America and about 9% from Canada, while the single largest exporter nation of crude oil to California was Iraq with 21% of foreign imports (California Energy Commission, 2025b).

Most of the sector's in-state workforce is concentrated in southern inland California (Kern County and the Inland Empire) and the eastern part of the Bay Area (Contra Costa Country). The fossil fuel industry employs approximately 94,000 workers,[1] accounting for about 10% of all Californian energy jobs (Bohn et al., 2025). Of these, 7,207 workers are employed in petroleum refineries (there are 56,748 petroleum refinery workers nationwide; U.S. Census Bureau, n.d.-b). While demographic representation in the California's oil and gas workforce is relatively in line with the state's population breakdown—43% of oil and gas employees are white, 41% Latino, 11% Black—representation among the cadre of senior management and professional positions is far less equal (only 20% of positions held by Latinos and 2% by Black persons; Gender Equity Policy Institute, 2023). Reducing the fossil fuel imprint in California is critical, but must be done while ensuring the refinery workforce is part of a just transition (World Resources Institute, 2024).

1 Estimates on the exact size of California's fossil fuel workforce vary by source.

The declines in California's oil extraction and refining capacity have coincided with increasing scrutiny of and competition with petroleum-based energy. Concerns about fossil fuel-driven climate change and the negative effects of petrochemicals such as PFAS have grown, alongside the expansion of the renewable energy industry and diverse efforts to reduce carbon emissions. Thus, fossil fuel companies no longer enjoy the dominant market position they once had. In the 1980s, oil and gas companies represented seven of the top 10 companies in the S&P 500, but today, this space is occupied almost exclusively by tech companies. ExxonMobil, the industry leader, dropped out of the S&P's top 10 for the first time in 100 years in 2019 (Sanzillo, 2020).

2.3. Plastic Is the "New Frontier" for the Fossil Fuel Industry

In response to declining profits in their traditional end markets, the fossil fuel industry has pivoted. Refineries that once processed predominantly transportation fuels are now increasingly creating petrochemical feedstocks used to make plastic The American Chemistry Council (ACC) notes that since 2010, the U.S. chemical and plastic industry has invested over $200 billion in 333 projects in the United States focused on shale gas exploitation, which is expected to spur "$292 billion per year in new chemical and plastic industry output" by 2025 (ACC, 2018). A 2025 ExxonMobil sustainability brief titled, "Expanding the plastics life cycle," argues that "plastics will be instrumental in supporting many of the United Nations Sustainable Development Goals" (ExxonMobil, 2025). Oil companies like ExxonMobil, Chevron and Shell and national companies like Sinopec and SABIC now have chemical divisions for petrochemicals and plastic productions.

Plastic production is the fossil fuel industry's revenue generation focal area amid a declining market, a strategic shift that promises increased returns in a growing field. Global oil demand for plastic production was 9 million barrels in 2019. It is expected to grow to 23 million barrels per day by 2060 (Statista Research Department, 2025). Oil companies are ramping up plastic output as demand for transportation fuels decreases. Petrochemicals are seen as a "bright spot" in the portfolio of top companies if developed with distinctive technologies and if they integrate refining and petrochemical installations (Barbosa et al., 2020).

Petrochemicals are a broad category of chemicals that are derived from petroleum products, such as ethane and naphtha, or from natural gas. "High-value chemicals" (HVCs) such as light olefins (ethylene and propylene) and aromatics (benzene, toluene, and mixed xylenes) are found in the production of plastic, synthetic fibers, and rubber (International Energy Agency [IEA], 2018, p. 17). Demand for plastic has grown much faster than demand for other petrochemical byproducts and "shows fewer clear signs of saturation," particularly for packaging, which makes up 36% of global plastic demand (IEA, 2019, p. 18). To a large degree, this demand is the result of a concerted effort by industry to cultivate plastic consumption in developing countries while simultaneously using paid influence campaigns to undercut support for source reduction policies (Brigham, 2022; Tabuchi, 2024). In 2019, petrochemicals (plastic-related and otherwise) accounted for 14% of oil use (13 million barrels per day) and are projected to account for nearly half of growth in oil demand by 2050, making them one of the largest drivers of global oil consumption (IEA, 2019, pp. 13–14). Alarmingly, demand for fossil fuel feedstocks to produce petrochemicals and plastic is left largely unaddressed in international arrangements on the transition away from fossil fuels, such as COP28 and the International Energy Agency's Net Zero by 2050 Scenario (Tilsted & Newell, 2025, pp. 1217–1218).

2.4. Vertical Integration: The Petroleum-Chemical-Plastic Nexus

Production of petrochemical feedstock alone is not profitable for refineries; instead, vertical integration between refining and petrochemical production offers the highest margins, and much more so than fuels (IEA, 2019, p. 40). Despite their known environmental impacts, the petrochemical industry continues to develop locked-in technologies—systems that industry becomes heavily dependent on and that are difficult and costly to switch away from—that integrate clusters and refineries. In petrochemical clusters, production sites often co-produce different chemicals derived from the same processes. Once produced, these chemicals are used as feedstocks to create a wide variety of synthetic materials, including plastic (Tilsted & Newell, 2025, p. 1217).

These strategies depend on vertical integration and produce a "carbon lock-in" for the plastic era. Institutional "lock-in" involves the rules, norms, and constraints that favor the extraction and processing of fossil fuels. Behavioral lock-in encompasses the lifestyles, cultural norms, and patterns of consumption—such as reliance on single-use plastic—that perpetuate the use of fossil fuels. Institutionally, behaviorally, and economically, the fossil fuel era for transportation fuels is transitioning into the fossil fuel era for petrochemicals and plastic manufacturing (Tilsted et al., 2023, p. 609). The underlying infrastructure of fossil fuel for transportation—including existing pipelines, steam crackers, and downstream processing units—is being retrofitted and reimagined for plastic production. The price of naphtha, an intermediate oil product used to produce petrochemicals (including plastic via ethylene cracking), has risen compared to crude oil, an indicator of the ongoing shift toward plastic production by the fossil fuel industry (Çetinkaya et al., 2024).

3. THE PETROLEUM IN CALIFORNIA'S NEIGHBORHOODS: HEALTH DISPARITIES AND ENVIRONMENTAL INJUSTICE

The United States' long history of oil and gas exploitation has created a status quo where millions of Americans live close to fossil fuel infrastructure. Approximately 17.6 million people in the United States live within 1 mile of an active oil or gas well, including 2.1 million Californians (Czolowski et al., 2017a). Nearly 9 million Californians—22.9% of the state's population—live within 1 km of plugged wells that are no longer in operation (González et al., 2023). Communities living near oil and gas development—especially refineries—are exposed to a wide range of public health hazards. Oil extraction and production create numerous harmful chemicals, including carcinogens, mutagens, reproductive toxins, irritants, and endocrine disruptors. These substances enter our environment through spills, leaks, vaporization, and disposal (Johnston et al., 2024, p. 505). Public health hazards from fossil fuel infrastructure have been found to disproportionately impact communities of color, where historic exclusionary housing policies contributed to well and refinery placement. The following section reviews the existing literature, beginning with a focus on studies conducted on California, to inform policy interventions and our geospatial mapping exercise.

3.1. Fossil Fuel Siting and Environmental Injustice in California

Prior research has documented negative public health outcomes associated with living near wells and refineries in California, and the concentration of these impacts on communities of color. For example, the proportion of Black residents living near active wells was 42%–49% higher than the proportion of Black residents across California, and in areas with the highest oil and gas production, the proportion of Black residents was 105%–139% higher than statewide (González et al., 2023). In some cases, adverse health outcomes have particularly strong effects on vulnerable groups (see *Adverse Birth and Reproductive Outcomes* below).

Prior research has clearly identified how past policies have contributed to environmental injustice today. Historic redlining and discriminatory housing policy, in particular, have led to environmental exposure disparities. Racially discriminatory security maps developed by the Home Owner's Loan Corporation in the 1930s reflect higher concentrations of well exposure throughout the United States. Redlined D-graded neighborhoods have nearly twice the density of well infrastructure than those graded A (D. J. Gonzalez et al., 2023). California is no exception. In Los Angeles, archival research has shown that underground mapping of oil deposits was associated with restrictive property rights (Cumming, 2018). In Los Angeles County, redlining and segregation predict water contamination risk from oil development, with higher percentages of Hispanic, Black, and Asian/Pacific Islander residents impacted (Berberian et al., 2023a). Simply put, fossil fuel infrastructure impacts communities of color more acutely due to proximity of siting as well as maintenance and regulatory compliance. As Shamasunder and Johnston note, "oil wells in low-income communities of color in Los Angeles often operate much closer to residents than in wealthier neighborhoods, have uncovered as opposed to enclosed fields, lack noise protections, and maintain outdated emissions equipment" (2023, p. 1179).

3.2. Review of Epidemiological Literature

The following section provides a brief summary of scientific research on patterns of community exposure to oil and gas development that focus on the recurring health issues associated with living in proximity to conventional oil drilling and refineries. This review focuses primarily on research conducted in the United States and, where possible, California.[2] Epistemological studies are inherently limited, as it is not possible to ethically conduct controlled trial studies, and disentangling the impacts of other compounding factors is difficult. Nevertheless, these observational epistemological studies point to recurring and pressing health concerns that have been documented in both the United States and internationally.[3] Plastic's status as a fossil fuel product makes a growing portion of these harms part of the sector's negative footprint and an important area for mitigation investments.

3.2.1. Air and Water Pollution

Many oil and gas sites operate for decades, and the extraction and refining processes release toxic chemicals into the air. Both steps produce numerous pollutants (Johnston et al., 2019a, p. 9; O'Rourke & Connolly, 2003, p. 603). These include:

- **Particulate matter (PM)**, which contributes to health conditions such as respiratory and cardiovascular disease (Anderson et al., 2012).
- **Nitric oxides**, which is linked to asthma, among other conditions (Chen et al., 2007).
- **Methanol**, which can pose an acute poisoning risk (Ashurst et al., n.d.).
- **Naphthalene**, which has been shown to have neurotoxic and other harmful effects, including via subchronic inhalation (Bhardwaj & Yadava, 2025).
- **Volatile organic compounds (VOCs**), including xylene, toluene, benzene, and ethylbenzene, which increase risk of cancers and other health conditions and which contribute to ground-level ozone and smog formation (Zhou et al., 2023).
- **Formaldehyde**, which has been linked to both acute and chronic harms, including respiratory and reproductive issues (K.-H. Kim et al., 2011).
- **Sulfuric acid**, which is both a respiratory irritant (Amdur, 1989) and a key factor in acid rain.

Researchers have documented higher concentrations of ambient air pollutants within 4 km of preproduction wells and within 2 km of producing wells using air quality monitors (D. J. Gonzalez et al., 2022).

2 We exclude from our analysis the numerous public health science studies on unconventional oil and gas development (OGD), such as hydraulic fracking, and their adverse health outcomes.

3 This review excludes extensive analysis of the many studies that have been conducted globally on these issues due to their sheer volume as well as the different conditions presented in petrochemical facilities with little environmental and public health regulations, particularly in the Global South.

Refineries are particularly potent pollution sources. U.S. refineries are the second-largest industrial source of nitrogen oxides, the largest stationary source of VOC emissions, and the fourth-largest source of toxic air pollutants (O'Rourke & Connolly, 2003). Most refinery emissions occur through leaks. In California, refineries are responsible for over 90% of all accidental releases in the state, and disposal methods for toxic refinery waste have "tended to take advantage of wide open spaces instead of environmentally sound waste management techniques," according to the U.S. Environmental Protection Agency (O'Rourke & Connolly, 2003, p. 604). Most waste from the petrochemical industry comes in the form of "produced water": a toxic effluent containing industrial-strength chemicals, which can even be radioactive. Produced water is extracted from the ground along with oil, and when not reinjected is discharged into surface waters (O'Rourke & Connolly, 2003, pp. 594–595).

3.2.2. Cardiopulmonary Issues

Living near oil and gas infrastructure has been linked to numerous types of respiratory distress. Researchers examining health outcomes for 972 residents living near the Las Cienegas Oil Fields in South Los Angeles found that residents living less than 200 meters and downstream from oil and gas development had higher incidence of reported wheezing, sore throats, chest tightness, irritation of the nose and eyes, and ringing of the ears, and tested for lower lung function (Johnston et al., 2021, pp. 4–6). Exposure was also linked to higher diastolic blood pressure and lower lung function for these residents, who were predominantly Black and Hispanic/Latino (Johnston et al., 2021, 2024). Likewise, living near refineries can cause residents to exhibit higher rates of asthma, coughing, wheezing, bronchitis, and rhinitis. These respiratory symptoms have been linked to petrochemical facilities in at least eight different countries (Marquès et al., 2020, pp. 2–5; Tavella et al., 2025).

3.2.3. Adverse Birth and Reproductive Outcomes

Several studies have documented issues that pregnant women experience when living near oil wells, such as preterm birth or low birth weight. One retrospective study of a cohort of nearly 3 million births to mothers living within 10 km of at least one active well in California found higher rates of adverse birth outcomes—including low birth weight, small size for gestational age, and preterm birth—in rural areas (Tran et al., 2020). A study of births in mothers in the San Joaquin Valley found increased likelihood of preterm births in mothers who had high exposure to wells in their first and second trimesters. The association was strongest for Hispanic women with less formal education (D. J. X. González et al., 2020). Globally, 27 studies identified links between living near a petroleum complex and increased prevalence of negative reproductive outcomes (Tavella et al., 2025, p. 17).

3.2.4. Cancers

In addition to the aforementioned carcinogenic risks posed by oil- and gas-related pollutants, the evidence linking leukemias and proximity to petrochemical facilities is particularly consistent. Living close to oil or gas wells is associated with increased mortality in children living with cancers, specifically acute myeloid leukemia (AML) and acute lymphocytic leukemia (ALL) (Hoang et al., 2024; McKenzie et al., 2017). Moreover, studies in Colorado and Texas found that people living close to these installations were more likely to develop ALL (Hoang et al., 2024; McKenzie et al., 2017). While some international studies on petrochemical facilities have linked residential exposure to cancers of the lung, liver, and central nervous system, scoping studies on refineries and cancers show that leukemia and similar hematological illnesses are most common, and associations have been found in at least 10 different studies spanning Asia, Europe, and Africa (Domingo et al., 2020, p. 8; Tavella et al., 2025, p. 14). Higher risk of lung cancer is also highlighted in several international studies (Tavella et al., 2025, p. 14).

3.2.5. Disamenities and Emergencies

Oil and gas operations' impact on nearby residents can also take the form of degradations to quality of life—termed "disamenities"—and put them at risk should industrial accidents occur. Within disamenities, the two negative effects most commonly associated with living near oil and gas development are noise and odors. Well operations, such as maintenance and drilling activities, can produce levels of noise and vibrations that disrupt local communities (Butler et al., 2018). For residents, this can lead to impaired quality of life and health via sleep disturbance, increased risk of cardiovascular illness, and increased levels of anxiety or annoyance (Hays et al., 2017). Odors—especially the widely recognized "rotten egg" smell associated with hydrogen sulfide gas—can also occur in the vicinity of oil and gas development, though conditions vary based on geography (Butler et al., 2018). Unpleasant smells may also be indicative of other, more severe risks, such as health harms from exposure or dangerous buildups of gas (Butler et al., 2018; Collins & Lewis, 2000).

Oil and gas facilities are inherently at risk for accidents resulting in spills, fires, or explosions, owing to the hazardous nature of the materials they process (Nolan, 2014). Such events pose significant risks to workers and potentially to nearby communities. Recent examples in California include:

- The October 2025 explosion and fire at the Chevron refinery in El Segundo (Harter et al., 2025).
- Numerous, long-running oil spills from Kern County oil fields that have released millions of gallons of wastewater and crude oil. Among these, one, GS-5, has been running for 21 years, exceeding the *Exxon Valdez* disaster in scale (Wilson, 2024).
- The September 2025 explosion of a vacuum truck in the Elk Hills Oil Field, causing a 12-acre fire (BakersfieldNow Staff, 2025).
- A multiday fire that occurred at the Martinez Refinery in the East Bay area in February 2025 (Small & Green, 2025).
- A burst pipe at the Warren Resources facility in Wilmington, which spewed petroleum onto the street (Purtill, 2024).

- A spill of over 40 barrels (1,600 gallons) of oil in the Inglewood Oil Field in April 2021, which occurred near a park (Doherty & Yesenofski, 2021).
- The large explosion and subsequent fire at the Marathon Los Angeles Refinery in Carson in February 2020, which led to the temporary shutdown of the 405 Freeway (Lenghi, 2020; MPC Los Angeles Refinery Carson North Area Fire Investigation, 2020).
- The February 2015 explosion at the ExxonMobil refinery in Torrance (Chemical Safety Board, 2017).

3.2.6. Exposures in High-Risk Populations

The risks associated with living near oil and gas development are especially pronounced in high-risk populations, including children, older adults, and those living with preexisting conditions. Particulate matter (PM) is a demonstrative case, with these groups showing increased risk of respiratory harm from PM pollution. Children living within 5 km of a refining facility experience heightened risk of reduced lung function and higher rates of asthma, (Tavella et al., 2025, pp. 10, 17). Risk of childhood leukemia is also consistently higher in areas near petrochemical facilities, both domestically and internationally (McKenzie et al., 2017; Tavella et al., 2025, p. 17). Other risks have been documented but are not as widely represented in the literature. In one such case, a Taiwan-based study associated living near petrochemical facilities with higher incidence of childhood attention deficit disorder (Huang et al., 2022). Education and awareness of these risks are insufficient, as parents face immense structural limitations in protecting their children from impacts of oil and gas infrastructure (Malin et al., 2025, pp. 2–3). These limitations may be more pronounced for low-income communities that have been historically marginalized.

4. MAPPING EXPOSURE RISK FROM PLASTIC PRECURSOR PRODUCTION AND REFINING SITES

This study assesses spatial exposure risk for Californian communities from proximity to oil and gas wells and refineries, the sites producing raw materials that become plastic. Building on existing epistemological research that connects fossil fuel infrastructure to health disparities and inequitable burdens on populations, we conduct a statewide geospatial analysis of exposure to active petroleum operations juxtaposed against demographic and public health data. We use spatial renditions of impacted areas to assess the number of facilities a community is exposed to, cross-referencing with community characteristics. Our analysis showcases the characteristics of disproportionately exposed communities with a high level of granularity at multiple distance scales that reach beyond current statutory thresholds. Simultaneously, we further our efforts to measure "site-based exposures" in our Three-Part Plastic-Burdened Communities Framework from our prior report, *What Defines a Plastic-Burdened Community?* (2024) by including the upstream stage of the plastic supply chain.

Our analysis focuses on identifying which areas of the state experience high exposure risk, based on the number of proximate facilities affecting a community and to what degree these communities differ from the average. We also identify which portions of the state are exposed to impacts from multiple disparate types of plastic-related facilities.

4.1. Data Sources

For purposes of locating oil and gas infrastructure in California, we rely on two sources:

1. The Well Statewide Tracking and Reporting System (WellSTAR) maintained by the Geologic Energy Management Division of the California Department of Conservation.[4]
2. The California Energy Commission's geodatabase of Oil Refineries and Terminals, published by the California Governor's Office of Emergency Services (Cal OES) GIS Data Manager.[5]

4 The WellSTAR database is created from operator-submitted data, and past research has called into question the frequency of updates (Berberian et al., 2023b). However, it is still generally recognized as the best available comprehensive data source on California's oil and gas wells.

5 This analysis is confined to currently operational refining facilities. Though shuttered facilities are not devoid of impacts—past studies have identified legacy pollution risks associated with nonoperational refineries (Khaitan et al., 2006; Shriver et al., 2020), and 10 refinery sites are listed in the California Department of Toxic Substances Control EnviroStor system for tracking cleanup sites and hazardous waste facilities—environmental and health impacts of such sites are not as well-studied as those from active ones, and are narrower in scope.

4.2. Data Processing and Classification

WellSTAR data were restricted to only oil and gas wells—excluding geothermal—and confined only to wells whose status is active or idle.[6] Permitted or cancelled wells were not included, as the well infrastructure is not currently in place. While plugged wells—especially older ones that may have been subject to less rigorous regulation—are not devoid of impacts, multiple studies emphasize the role of unplugged wells as pollution sources (Kang et al., 2023; Plas, 2023; Warner & McConnell, 1993). Plugged wells also do not produce impacts associated with ongoing operations and are unlikely to in the future. Therefore, they were excluded from this analysis.

Street addresses of refineries were geocoded using ArcGIS Pro.

4.3. Mapped Facility Descriptions

The two categories of facilities considered part of the upstream component of the plastic supply chain are:

1. Oil and gas wells: Sites where crude oil and natural gas are extracted from deposits in the ground.
2. Refineries: Large facilities where crude oil and natural gas are refined into a variety of different fossil materials, including hydrocarbon monomers that can subsequently be processed into plastic polymers.

4.4. Determining Distance of Heightened Exposure Zones

To determine the size of the area around a given site that would be considered the area of heightened exposure risk, we sought to identify well-established figures within the body of research studying the health and environmental effects of oil and gas infrastructure. These distances would be used to model radial areas, or “buffers,” around each individual site for purposes of spatial analysis (see Table 1). Due to the degree of variance in figures used across studies, and in consultation with stakeholder advisors, we elected to use multiple distance figures for each site type. Doing so facilitates a “sensitivity analysis”—examining how analytical results vary with different parameters.

The buffer distances used for each site type are shown in Table 1. Having discussed the nature of health and environmental impacts associated with these sites in The Petroleum in California’s Neighborhoods: Health Disparities and Environmental Injustice above, a brief discussion of the spatial parameters used in reviewed studies follows below.

6 As with refineries, abandoned wells are not devoid of impacts, particularly when they are improperly retired. However, evidence on the impacts of operational wells is more abundant in the scientific literature, and the mechanism of impacts for abandoned wells is narrower.

TABLE 1

Distance Specifications for Heightened Exposure Zones (Buffers) by Site Type

Site Type	Buffer Distances		
Oil and Gas Wells	1 km	10 km	
Refineries	2.5 km	5 km	16.1 km (10 mi)

4.4.1. Oil and Gas Wells

We used buffer parameters of both 1 km and 10 km to identify heightened exposure zones for oil and gas wells. The proximate effects of oil and gas drilling are relatively well-studied in the United States, including within California. In the research reviewed, 1 km is the most common threshold used in studying the effects of wells on nearby populations. The 1 km parameter is used as the sole distance measure or as one of multiple in studies examining how oil and gas wells affect pediatric cancer risk (Hoang et al., 2024), birth outcomes (Tran et al., 2020, 2021), skin and respiratory conditions (Rabinowitz et al., 2015), metal exposures (Quist et al., 2022), airborne contaminant exposures (Kang et al., 2023), cardiovascular health (Johnston et al., 2024), and drinking water contamination (Berberian et al., 2023b). However, there are also numerous examples of studies that do not follow this trend or supplement it with additional levels of analysis. Research on various health, environmental, or economic risks has examined effects to distances of 1.5 km (Ellsworth, 2013), 3 km (D. J. X. González et al., 2020; Long et al., 2015), 4 km–5 km (Boxall et al., 2005; D. J. X. González et al., 2020; Johnston et al., 2019b; Stanton et al., 2023), and more than 10 km (D. J. X. González et al., 2020; McKenzie et al., 2017). A few studies have examined particular impacts within less than 1 km of sites (Anders et al., 2022; Czolowski et al., 2017b; Johnston et al., 2021; Long et al., 2015; Steinzor et al., 2013).

State law also adheres to the 1 km designation in certain instances, lending further credence to it. Senate Bill 1137 (González and Limon, 2022) established health protection zones (HPZs) within 3,200 feet (1 km) of various types of “sensitive receptors”—a designation that includes residences, schools, parks, and healthcare facilities, among others—and banned the issuance of permits for new oil and gas drilling in those areas. Additional health and safety-related requirements were put in place on existing wells that lie within HPZs. The statutory significance of the 1 km figure increases its legitimacy, but also may motivate more recent research to focus on that boundary even when a different threshold could be more suitable.

Given the prominent representation of 1 km as an accepted distance for identifying localized impacts from oil and gas wells, we adopted it as one of our buffer parameters. To adequately reflect the body of research that demonstrates impacts beyond that mark, and as a conservative measure, we also implemented buffers out to 10 km.

4.4.2. Refineries

In contrast to the large amount of academic literature related to localized impacts of wells, we identified fewer instances of refinery-focused research that examined impacts based on distances from the facility, almost all of them conducted internationally. In general, these studies tend to be narrower in scope, often focusing on a single facility and associated population. Most of these focused on incidence of harmful conditions (e.g., cancer rates, toxic contamination, air pollution, respiratory disease).

Of the studies that provided a specific distance parameter, the most common was in the band of 2 km–5 km (Barregard et al., 2009; Cordiano et al., 2022; Domingo et al., 2020; H. Kim et al., 2022; Marquès et al., 2020; Tavella et al., 2025; Yang et al., 2004). There are a few examples of research focused on areas of less than 2 km (Chettouh et al., 2018; Khatatbeh et al., 2020; Yuan et al., 2016), while some papers—most notably a 2020 Texas-based analysis (Williams et al., 2020)—use a larger study area.

Due to the lack of a clear consensus, and being mindful that impacts from international facilities may not be representative of domestic ones, we opted to adopt three measures of varying distance for refineries' heightened exposure zones. All three—2.5 km, 5 km, and 16.1 km (10 mi)—have been applied in research conducted within the United States.

4.5. Spatial and Statistical Methods

We applied two different methods in our spatial analysis to the two facility types, due to data constraints. For refineries, we modeled heightened exposure zones at each distance parameter (2.5 km, 5 km, 16.1 km) and coded areas of overlap to indicate how many facilities affect a given geographic area. These data were rasterized—converted to visual, pixelized data—with which we calculated the average number of refineries a given area (census block, block group, or tract) was exposed to.

For oil and gas wells, we calculated centroids—the geographic central point of an area—for every 2020 census block. Blocks are the smallest, most granular unit of area at which census data are available. We then calculated the number of wells within 1 km and 10 km of each block's centroid. To upscale this to larger geographic areas, we rasterized the block values and calculated the average number of wells at the block group and tract levels.

To assess multisite unique exposures, we used a similar approach to refineries: first, creating a model of overlapping exposure areas across all six site types (oil and gas wells, refineries, and the four downstream sites—incinerators, landfills, transfer and processing stations, and plastic-related recyclers), then coding it to indicate the number of different types of facilities affecting a given area. We then rasterized these data and calculated average values for the different levels of geographic area.

To identify linkages between indicators of community demographics and socioeconomic status and exposure to upstream plastic-related facilities, we performed a series of simple linear regressions. In each case, the number of facilities affecting a community was treated as the dependent variable and the demographic or socioeconomic indicator was treated as the independent variable. Demographic analysis was conducted at the block level using 2020 decennial census demographic data from the U.S. Census Bureau, with race/ethnicity population totals converted to percent values. Income analysis used the 2023 American Community Survey five-year averages for median household income at the 2020 block group level. Other indicators were obtained from CalEnviroScreen 4.0 and conducted at the 2010 census tract level.

We selected a subset of indicators from CalEnviroScreen to analyze for linkages to oil and gas infrastructure exposure, in addition to raw score. A brief explainer of these indicators is provided below. For full details, visit https://oehha.ca.gov/calenviroscreen/indicators-overview.

1. **CES 4.0 score**: An aggregate measure of pollution exposure, environmental effects, sensitive population characteristics, and socioeconomic factors created from 21 statewide indicators.
2. **Asthma:** Rate of asthma-related visits to emergency departments, per 10,000 people.
3. **Low birth weight:** Percentage of infants born underweight.
4. **Cardiovascular disease:** Rate of heart attack-related visits to emergency departments, per 10,000 people.
5. **Education:** Percentage of adults ages 25 and over with less than a high school education.
6. **Poverty:** Percentage of population with incomes less than two times the federal poverty level.

For more detail on our data processing and analytical methods, see Appendix A.

4.6. Results

For detailed analysis results, see Appendix B: Statistical Analysis Results Tables.

4.6.1. Oil and Gas Wells

Oil and gas well exposures are concentrated in a relatively limited number of California communities (Figure 2). The greatest exposures, by far, occur in the Bakersfield area, owing to the outsized number of active and idle wells clustered together. Other areas with especially high numbers of wells include the greater Los Angeles area, Pleasant Valley, and Santa Maria. Lower-density exposures are present in portions of the state, most notably the northern San Joaquin Valley and the Sacramento Valley.

The exposure gap between the most-exposed communities and the rest of the state is significant, and rises precipitously when examining areas with the highest risk. The 95th percentile cutoff for census blocks is less than one (0.92) well within 1 km, though this rises to approximately 2,482 wells within 10 km. In contrast, the top 1% of exposed blocks have approximately 80 wells within 1 km and nearly 7,000 within 10 km. This more than doubles for the top 0.1% (over 304 wells within 1 km, over 14,600 within 10 km).

We find that, all other factors equal, communities exposed to wells are home to greater proportions of Hispanic or Latino and Black residents and fewer White residents (Table B1):

- For every 100 wells within **1 km**, an area's residents are 1.8% more Hispanic/Latino, 2.9% more Black, and 7.5% less White.
- For every 100 wells within **10 km**, an area's residents are 0.2% more Hispanic/Latino, 0.07% more Black, and 0.16% less White. Notably, though these figures are significantly smaller than those for 1 km, highly-impacted communities have many more wells within 10 km.

American Indian/Alaskan Native (AIAN) and Other/Mixed Race also exhibited statistically significant, negative linkages—meaning more exposed areas tend to have smaller proportions of these groups—but the difference is very small (less than 1% per 100 wells within 1 km). For all racial/ethnic groups, the magnitude of the linkage is stronger for wells within 1 km than those within 10 km.

FIGURE 2

Exposure to Active and Idle Oil and Gas Wells in California (2020 Census Block Level)

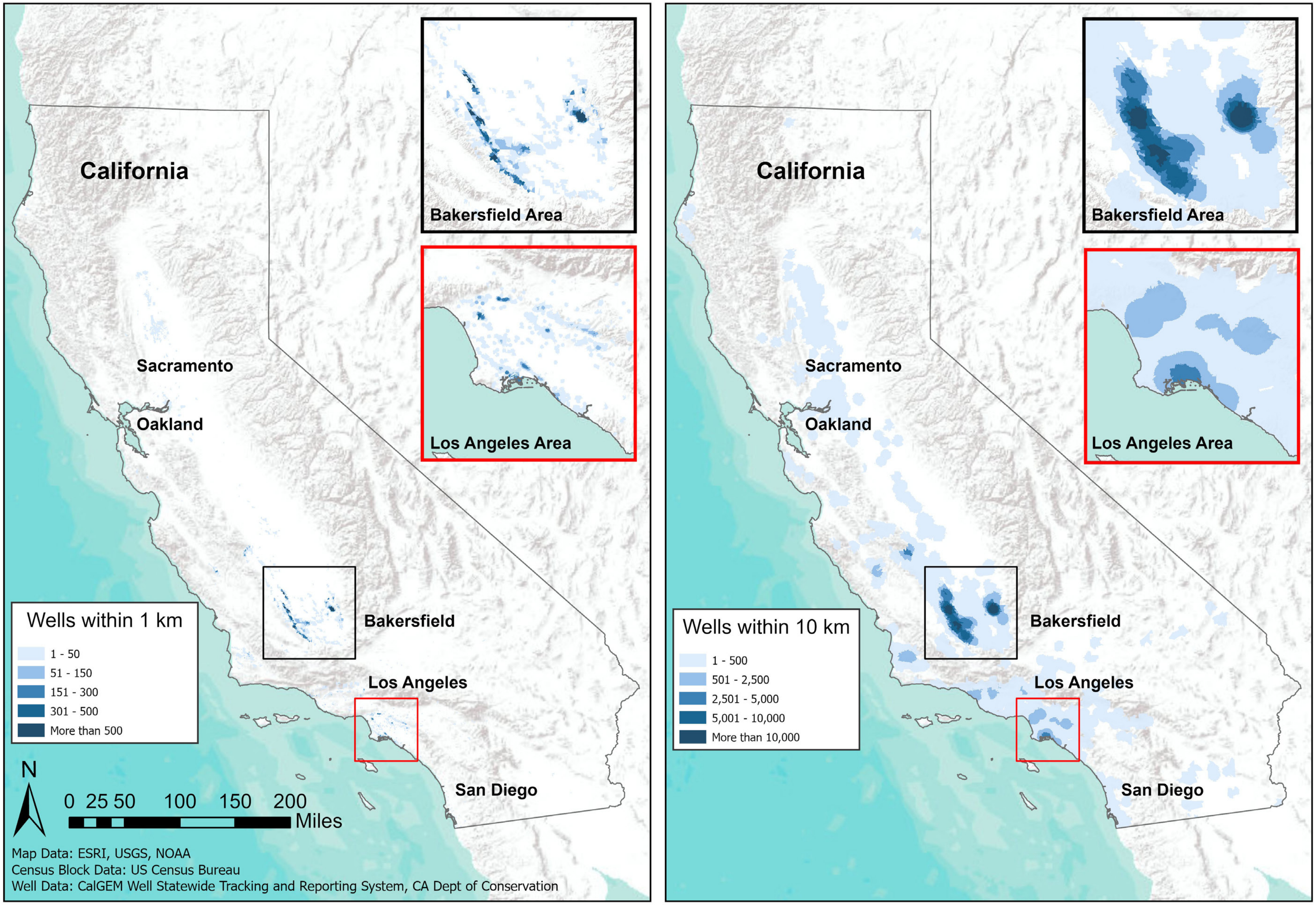
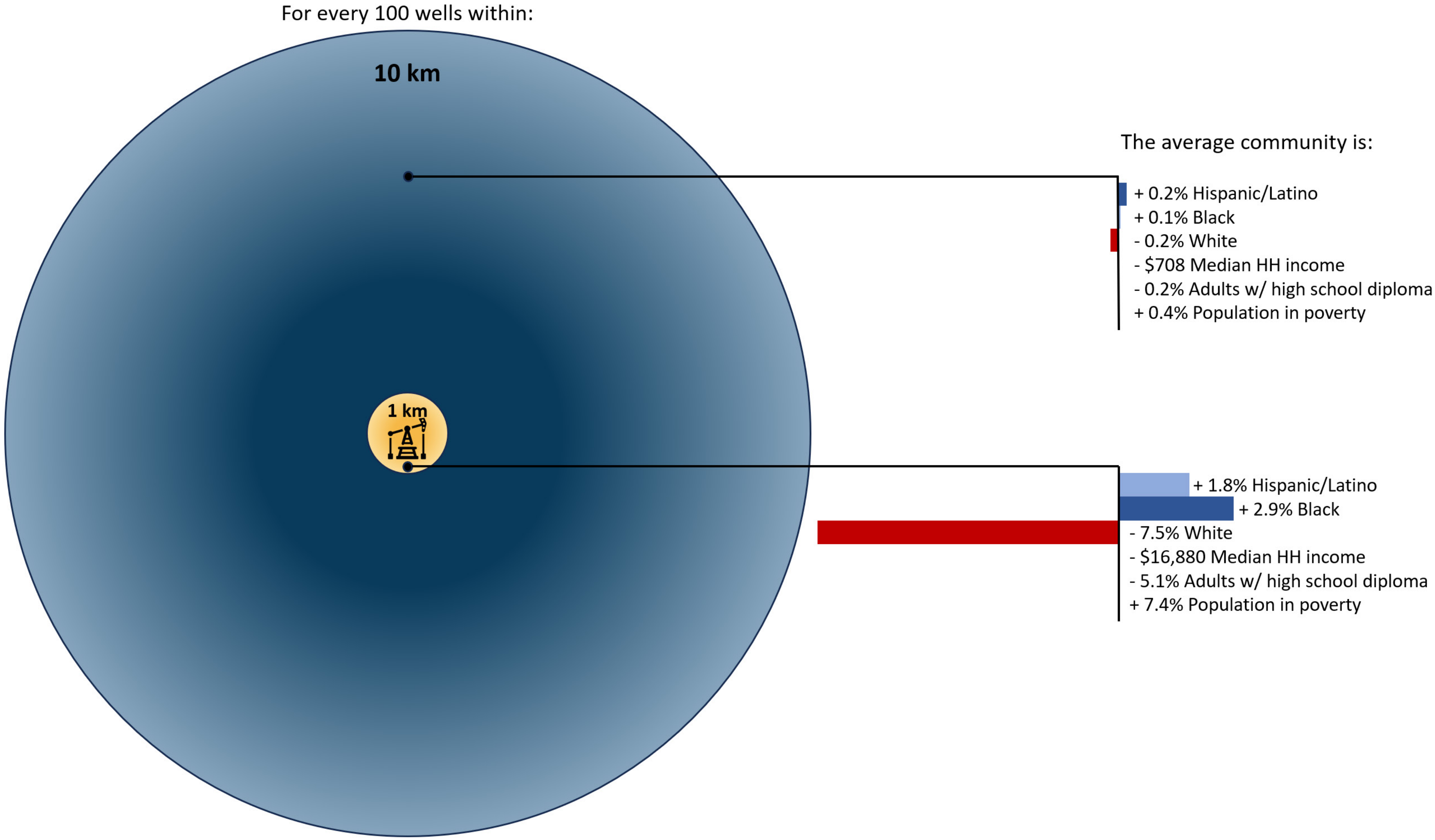


FIGURE 3

Expected Change in Community Characteristics per 100 Nearby Wells, by Distance



Incomes in well-exposed communities are substantially lower, on average, than incomes in communities with lower or no exposure (Table B2). For every 100 wells within 1 km, 2023 median household income was nearly $17,000 lower. When considering wells within 10 km, income is over $700 lower per 100 wells.

When examining indicators of environmental and socioeconomic burden from CalEnviroScreen 4.0, the most notable finding is that areas exposed to oil and gas wells are significantly higher aggregate burden (as measured by CalEnviroScreen score), are less educated, and have a higher portion of households living in poverty (Table B3):

- For every 100 wells within **1 km**, CES 4.0 score is about 9.4 points higher. For context, the standard deviation of CES 4.0 scores is about 17, with a maximum value of 82.4.
- For every 100 wells within **1 km**, about 5% more of adult residents ages 25 and over do not have a high school diploma, and about 7.4% more of the population lives in poverty.

Once again, these linkages persist in a statistically significant manner at the 10 km distance.

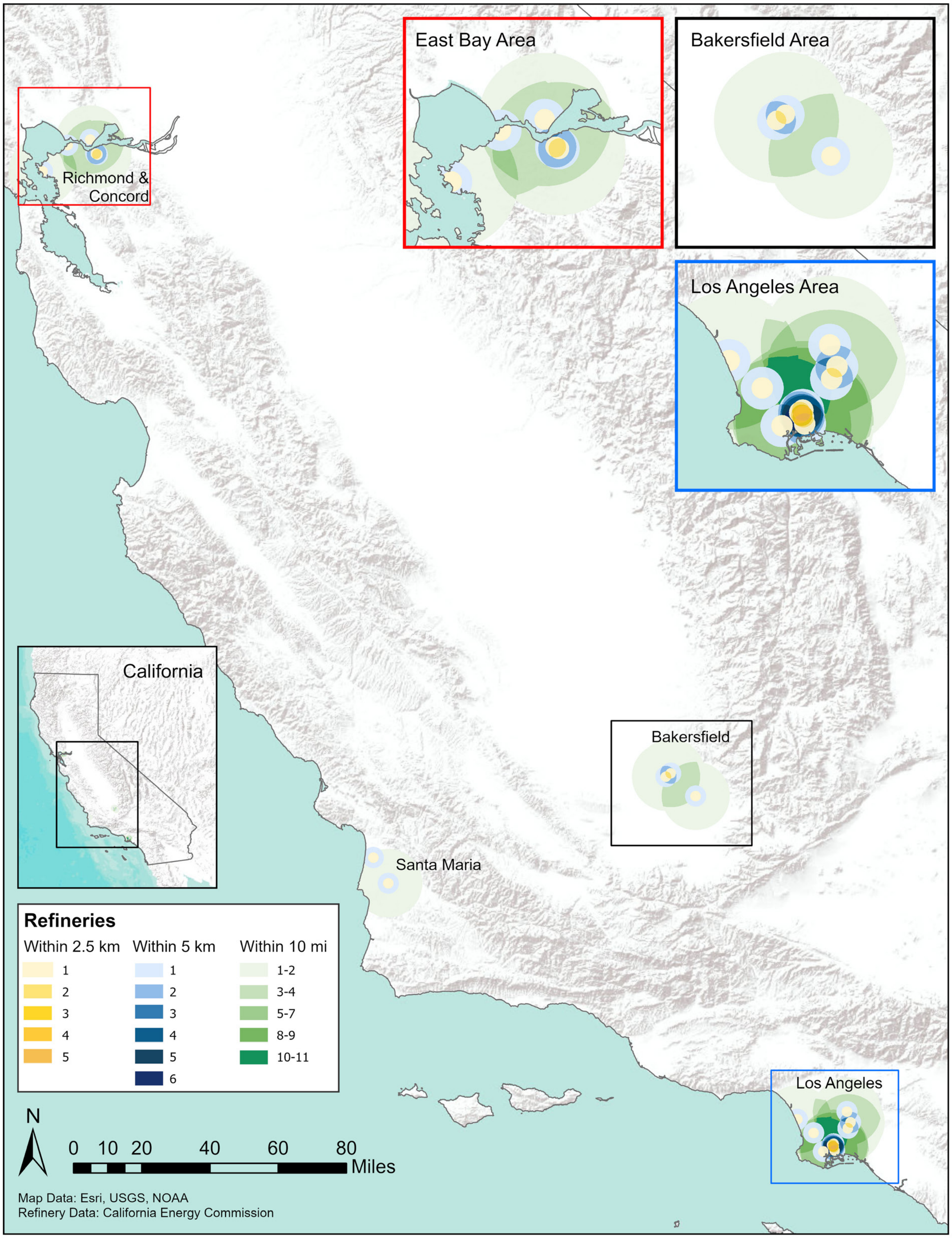
4.6.2. Refineries

Refinery exposures are likewise very uneven in their distribution across the state (Figure 4). For example, 95% of the state has no or almost no exposure[7] to refineries within 2.5 km, while the top 0.1% have nearly three refineries (2.74) within 2.5 km, on average. The Los Angeles area is home to the most significant concentration of refinery facilities in California, by a large margin. Several facilities are located in close proximity to each other in the Bakersfield and East Bay areas, along with two facilities near Santa Maria.

7 The 95th percentile threshold for refineries within 2.5 km is 0.013.

FIGURE 4

Exposure to Refineries in California



The demographic patterns of refinery-exposed areas are stark. At all three distance parameters analyzed, communities near refineries are more proportionally Hispanic/Latino and Black, while being less White (Table B4). In the case of Hispanic/Latino and White residents, the magnitude of the relationship increases as the distance to the refinery narrows. When considering refineries within 2.5 km, an average community will be over 10% more Hispanic/Latino and nearly 10% less White for each facility present. This pattern does not hold for Black residents, who are more likely to make up a larger portion of the community based on refineries within 5 km or 16.1 km (1.3% and 1.1% per facility, respectively) than when looking at facilities within 2.5 km (<1% per facility). Statistically significant relationships were also found with other racial groups, but these were generally small (<1% per facility).

Refinery-exposed communities also show markedly lower incomes than other communities, all other factors equal (Table B5). This pattern holds at all three levels of proximity examined, with the difference growing larger the closer a community is to facilities. On average, for each refinery within 16.1 km, median household income is over $2,100 lower. This disparity grows to over $7,300 lower for each refinery within 5 km, and nearly $11,200 lower per facility within 2.5 km.

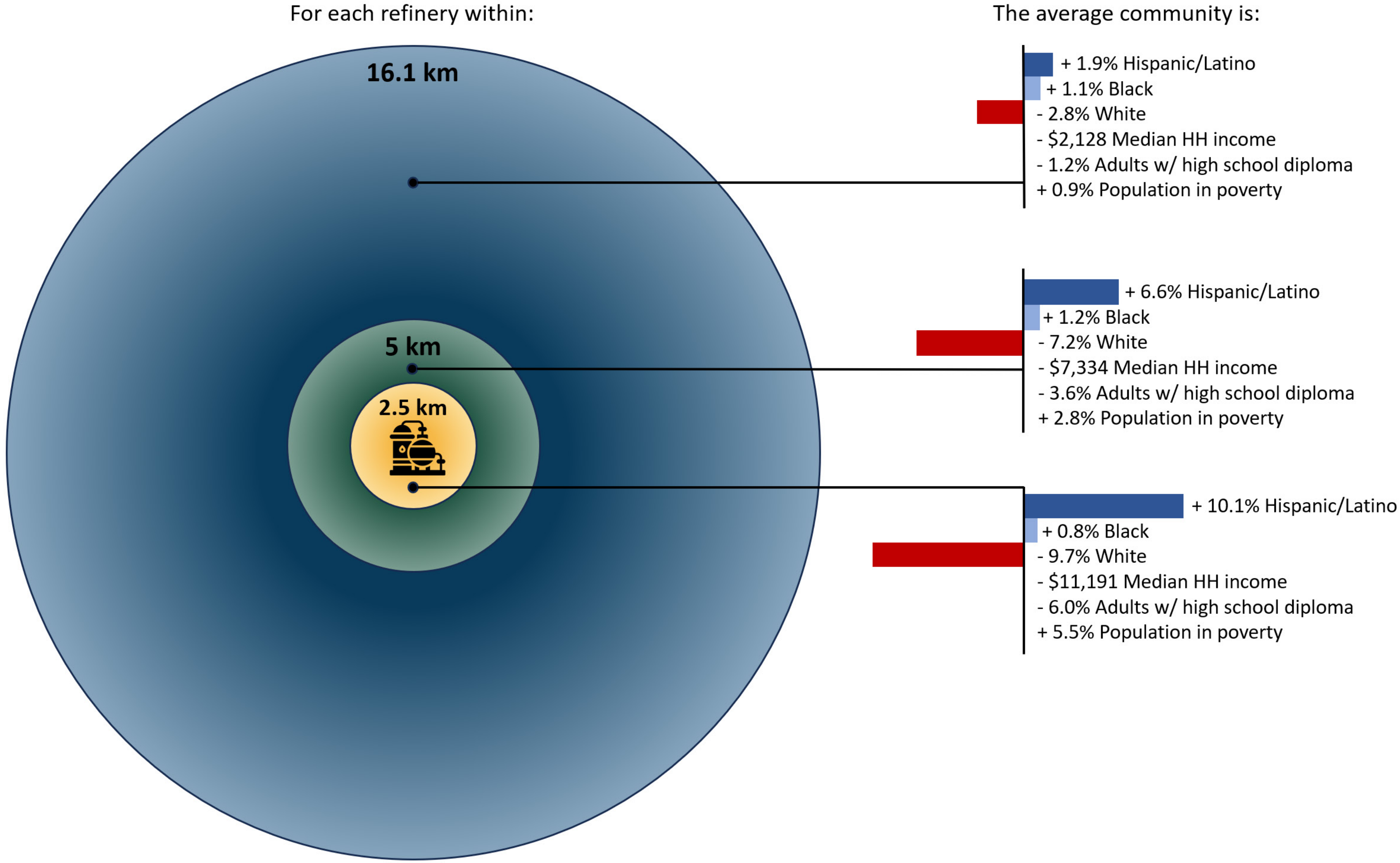
REFINERIES

Refineries show a larger, more consistent link to indicators of environmental and socioeconomic burden in comparison to wells (Table B6). In addition to refinery-exposed areas having higher levels of aggregate burden, lower educational attainment, and more households living in poverty, they also exhibit higher rates of asthma, low birth weight, and cardiovascular disease. Notably, in all cases, the magnitude of these linkages increases as proximity to facilities increases. When examining the most significant relationships—the effects observed for each refinery within 2.5 km, an average community sees:

- A 12-point rise in CES 4.0 score—almost ¾ of a standard deviation.
- About seven more asthma-related and 2.5 more heart attack-related emergency room visits per 10,000 people.
- Nearly 6% more of adults ages 25 and over without a high school diploma.
- Over 5.5% more of the population living in poverty.

FIGURE 5

Expected Change in Community Characteristics per Nearby Refinery, by Distance

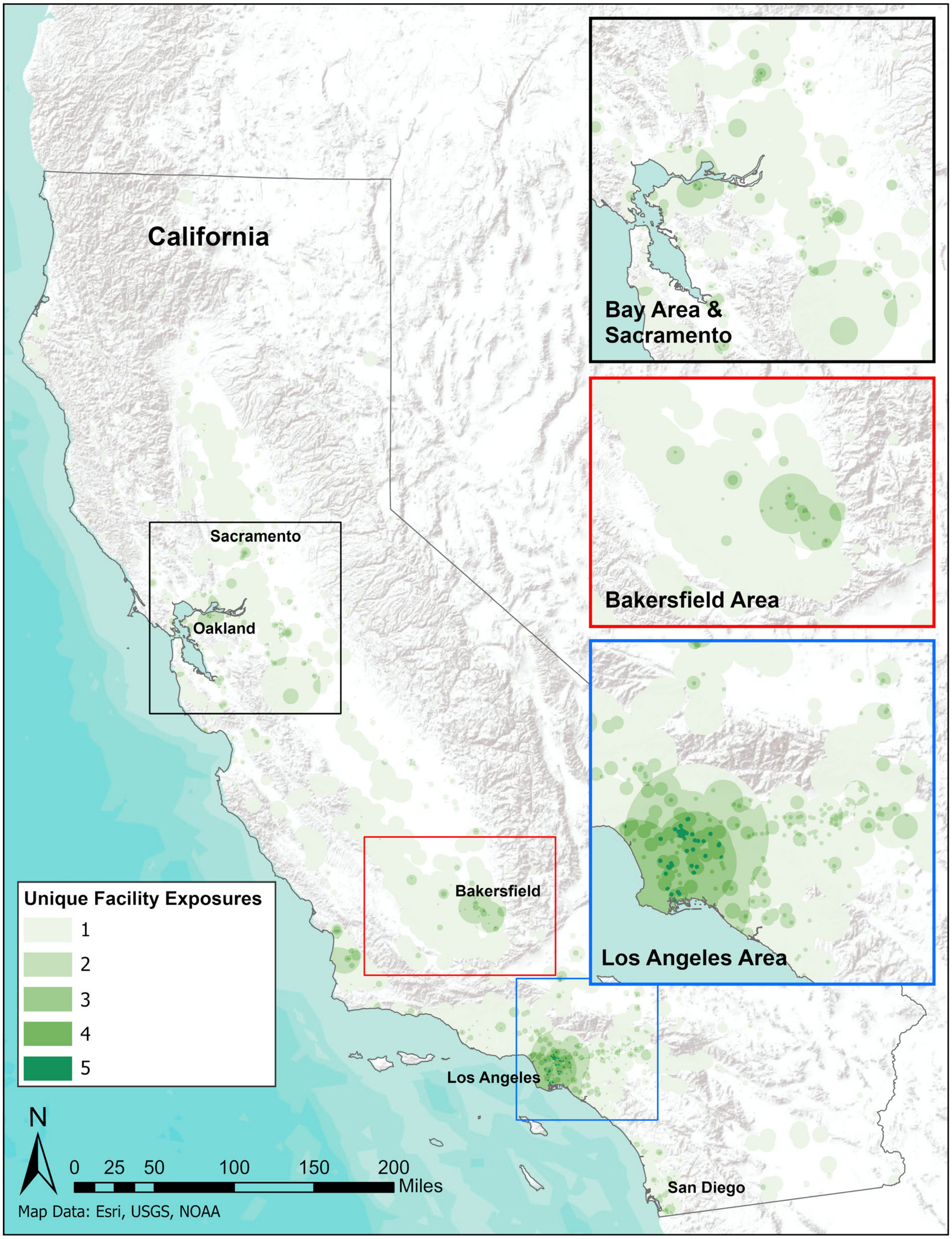


4.7. Unique Facility Exposures—Upstream and Downstream

By combining the downstream waste-related site data from our 2024 report with the upstream data presented above, we take a first step toward creating a comprehensive picture of Californians' exposure risk across the entire plastic supply chain. To do this, we identified linkages based on the number of unique facility types a community is exposed to. This analysis identifies the number of different facility types—six in total—to which a given area is exposed to at least one of (Figure 6). It uses the most expansive parameters for oil and gas wells (10 km) and refineries (10 mi).

FIGURE 6

Distribution of Unique Exposures to Upstream and Downstream Facilities in the Plastic Supply Chain in California



On average, for each unique exposure facing a community, people of color make up a greater percentage of the population—approximately 5.3% more Hispanic/Latino and 1.4% more Black, while being 6.5% less White. These exposed communities also have substantially lower median household incomes (nearly $6,500 less per exposure), higher poverty rates, greater measures of aggregate burden and harmful health conditions, and lower educational attainment (Table 2).

TABLE 2

Community Linkages To Unique Exposures From Facilities in the Downstream and Upstream Stages of the Plastic Supply Chain[8]

Community Variable	Average Change per Unique Facility Exposure
Demographics	
% Hispanic/Latino	5.323
% White	-6.477
% Black	1.423
% American Indian/Alaskan Native	-0.291
% Asian American/Pacific Islander	0.788
% Other or Mixed Race	-0.765
Income (2023 Median Household)	-$6,498.16
Environmental and Socioeconomic Burden	
CES 4.0 Score	6.179
Asthma	1.521
Low Birth Weight	0.190
Cardiovascular Disease	0.412
Education	3.627
Poverty	2.963

Demographics: Excludes 2020 blocks with zero population and four blocks with non-zero population where analysis produced no data; n = 377,587

Income: Excludes 1,572 block groups from 2020 with $0 reported income; n=24,027

8 Additional information available in Appendix B, Table B7

5. KEY FINDINGS, RECOMMENDATIONS, AND FUTURE RESEARCH NEEDS

Our analysis of active and idle oil and gas wells and operational refineries—the facilities that extract and refine the raw materials used to make plastic—shows that exposure risks from these sites are concentrated among a relatively limited area of California, placing a disproportionate amount of environmental and health impacts on specific communities. The Los Angeles and Bakersfield areas are the densest in terms of oil and gas infrastructure, followed by the Santa Maria[9] and East Bay areas. With all other factors equal, we find that exposed communities have lower incomes and educational attainment, are more proportionally Hispanic/Latino and Black, and have higher levels of aggregate environmental burden and public health risks—patterns that follow well-established trends of environmental injustice in other contexts. Because cumulative impacts create compounding levels of harm in heavily impacted communities, it is likely that harms from oil and gas exposure in these places are exacerbated by other, co-occurring challenges. In almost all cases, the magnitude of these linkages increases with proximity to the facilities in question.

5.1. Key Findings

1. Oil and gas development is highly concentrated, with the highest 1% or 0.1% of exposed communities having orders of magnitude higher exposure—10 times to 100 times or more—than even some of the highest 5% of exposed communities. Over 2.4 million people live in the 5% of census blocks with the most wells within a 1 km radius, and the greatest concentration of refinery infrastructure is located in Los Angeles—the most populous area of the state.
2. On average, populations in communities exposed to wells and refineries have significantly higher proportions of Hispanic/Latino and Black residents and significantly lower proportions of White residents. Other racial groups saw very small and varied, but still statistically significant, linkages.
3. Exposed areas have significantly lower median household incomes. For every 100 wells within 1 km, median household income is nearly $17,000 lower than the general population, and over 7% more of the population lives in poverty. For each refinery within 2.5 km, median household income is nearly $11,200 lower than the general population, and over 5.5% more of the population lives in poverty.
4. Communities with greater exposure to wells and refineries have worse educational outcomes. For every 100 wells within 1 km or refinery within 2.5 km, approximately 5% or 6% more of adults do not have a high school diploma, respectively.
5. Incidence of harmful health conditions for which we examined publicly available data—asthma, low birth weight, and cardiovascular disease—are significantly higher

9 Coastal California south of San Luis Obispo, near Vandenberg Space Force Base.

in areas with greater refinery exposure. Our survey of public health research strongly corroborates this with epidemiological observational studies on human populations. This body of public health research also establishes that members of communities near oil and gas wells face heightened risks of numerous health conditions.

6. In nearly every case—demographics, income and poverty, education, and health conditions—the magnitude of the effect increases with proximity to the facilities. For example, median income decreases as distance from refineries decreases. Expected median household income per refinery is approximately $2,100 lower for facilities within 10 mi, over $7,300 lower at 5 km, and nearly $11,200 lower at 2.5 km.

5.2. Recommendations and Future Research Needs

The catalyst for this research is the impending rollout of California's Plastic Pollution Mitigation Fund (PPMF), which aims to mitigate the disproportionate harms of plastic on Californian communities. In this report we further developed our framework for defining plastic-burdened communities by adding exposures along the upstream supply chain related to oil wells and refineries. With the efficacy of these mitigation investments foremost in mind, we recommend that the state legislature and agency administrators do the following:

- Formally recognize that plastic is an extension of the fossil fuel industry and that impacts from fossil fuel extraction and refining are directly attributable to plastic production.
- Monitor global trends in the portion of oil and gas supply that goes toward plastic production and adjust state policy accordingly. As oil and gas supplies shift from feeding transportation fuels to plastics products, it will be increasingly important for California's governance decisions for the fossil fuel industry to take plastic-related environmental injustices into account.
- Community health resources should also be targeted toward residents living near fossil fuel facilities, including expanded health-related testing and culturally relevant educational resources. A public health advisory committee could be created that is charged with developing and implementing actionable interventions, helping ensure that the communities most impacted by fossil fuel infrastructure receive timely, effective support.
- Communities that are highly exposed to infrastructure from multiple stages of the plastic supply chain are good candidates for comprehensive investment programs.

Given the highly dynamic and complex nature of plastic waste and pollution as a public policy issue—especially the potential ramifications for public health—it is important that the momentum of rigorous research and timely policy intervention be preserved. One of the most important information gaps is the lack of large-scale data on microplastic contamination in food and water. Identifying risks of and mechanisms for this dietary contamination, as well as important and related natural resources (e.g., aquifers, natural bodies of water) should be a top priority. There is also room to refine the methods we have thus far applied to site-based exposures.

This includes expanding the scope of analysis to address retired or abandoned infrastructure—shuttered refining sites and abandoned or plugged oil and gas wells—and applying more sophisticated methods to help disentangle exogenous factors and co-occurring risks.

APPENDIX A. SPATIAL AND STATISTICAL ANALYSIS METHODS

Refinery exposure zones were modeled in ArcGIS Pro as radial buffers around each geocoded point that represented a facility, at 2.5 km, 5 km, and 16.1 km. A union process was run on the buffer polygons to create a map layer of all areas where refinery exposure zones overlapped, which were then coded to reflect the number or refinery zones affecting a given area. This process was repeated for each of the three distance parameters. The coded polygon layers were transformed into a raster layer—a format that assigns a value to each individual cell or pixel of a given area—using the polygon to raster tool. The raster calculator was used to assign a value of 0 to all cells in California with no assigned value—areas not within the exposure zone of any refinery. We then used the Zonal Statistics as Table tool to calculate mean raster values—the average number of refinery exposure zones affecting a given area—for 2020 census blocks and block groups and 2010 census tracts.

Oil and gas wells required a new analytical approach. Because certain regions of the state contain such large numbers of wells in close proximity, attempting to apply the Union tool to a buffer layer, as above, creates exponentially large numbers of individual polygons. Even within small, isolated parcels of land, this level of complexity quickly surpasses the processing capacity of ArcGIS Pro.

Instead, we utilized a centroid-based approach, which calculates how many well exposure zones intersect the physical center of a geographic area. We created geographic centroids from the U.S. Census Bureau's 2024 census block shapefile, which provides a high level of geographic resolution (there are over 500,000 polygons in the state of California data), using the polygon to point tool. Geocoded point data on active and idle wells was obtained from WellSTAR. Calculating intersections was done using R. The program imported the requisite datasets, created well buffers (1 km and 10 km), calculated the number of buffers intersecting each centroid, then output a CSV file with the number of intersections corresponding to each census block's geographic identifier (GEOID) number. This table was imported into ArcGIS Pro and joined to the 2024 census block shapefile. To estimate well exposures at other levels of geographic granularity, we created a raster layer for the number of intersecting wells from the joined 2024 census block shapefile. We produced mean intersecting well values for 2020 census block groups and 2010 census tracts using this raster with the Zonal Statistics as Table tool.

To assess trends in which communities are more likely to experience exposures from multiple types of facilities within the plastic supply chain, we created a raster layer from the Union output of six dissolved layers, corresponding to the six types of facilities assessed across this study and our 2024 report. The most expansive exposure zone parameters were used for wells and refineries. The Zonal Statistics as Table processes were repeated with this new raster to produce mean values at each of the aforementioned levels of geographic units.

Readers of the 2024 report will note a marked difference in our methodological approach here: We do not attempt to create any sort of index of exposure risk based on risk factors associated with wells and refineries. Instead, we focus on the more straightforward measure of how many sites are in proximity to a community. This shift in approach is due to the scale of fossil fuel extraction operations in California. Simply put, oil and gas wells (primarily oil) are so prolific in the state, with over 98,000 active and idle wells, and, in certain areas, so densely clustered, with thousands of wells within a few square kilometers that applying our original classification approach would lead to wells drowning out all other facility types. Examining multiple portions of the supply chain simultaneously also further complicates the challenge of assigning proportionality to a given facility, based on how much of their operations are plastic-related and to what degree plastic is responsible for a disproportionate amount of their localized impacts.

APPENDIX B. STATISTICAL ANALYSIS RESULTS TABLES

Full tables on simple linear regression results, including stipulations, sample sizes, and p-values.

TABLE B1

Demographic Linkages to Oil and Gas Well Exposure

Demographic Variable	**Oil and Gas Wells**			
	Per 100 wells within **1 km**		Per 100 wells within **10 km**	
	Coefficient	***p*-Value**	**Coefficient**	***p*-Value**
% Hispanic/Latino	1.803	<0.001	0.199	<0.001
% White	-7.452	<0.001	-0.160	<0.001
% Black	2.918	<0.001	0.070	<0.001
% American Indian/Alaskan Native	-0.276	<0.001	-0.006	<0.001
% Asian American/Pacific Islander	3.150	<0.001	-0.072	<0.001
% Other or Mixed Race	-0.144	<0.001	-0.031	<0.001

Excludes 2020 blocks with 0 population; n=377,591

TABLE B2

Income Linkages to Oil and Gas Well Exposure

	Oil and Gas Wells			
	Per 100 wells within **1 km**		Per 100 wells within **10 km**	
	Coefficient	***p*-Value**	**Coefficient**	***p*-Value**
Income 2023 Median Household	-16,880.40	<0.001	-708.05	<0.001

Block groups with income reported as “$250,000+” or “$2,500-“ recoded as “$250,000” and “$2,500,” respectively. Excludes 1,579 block groups with $0 reported income; n=24,027

TABLE B3

Linkages between Measures of Environmental and Socioeconomic Burden and Oil and Gas Well Exposure

Measure	Sample Size	Oil and Gas Wells			
		Per 100 wells within **1 km**		Per 100 wells within **10 km**	
		Coefficient	***p*-Value**	**Coefficient**	***p*-Value**
CES 4.0 Score	7,932	9.410	<0.001	0.389	<0.001
Asthma	8,024	-3.426	0.15	0.362	<0.001
Low Birth Weight	7,808	0.426	<0.001	0.021	<0.001
Education	7,932	5.051	<0.001	0.221	<0.001
Poverty	7,960	7.374	<0.001	0.352	<0.001

Excludes tracts where no score or indicator data are available, resulting in varying sample size.

TABLE B4

Demographic Linkages to Refinery Exposure

Demographic Variable	Refineries					
	Within 2.5 km		**Within 5 km**		**Within 16.1 km**	
	Coefficient	***p*-Value**	**Coefficient**	***p*-Value**	**Coefficient**	***p*-Value**
% Hispanic/ Latino	10.091	<0.001	6.622	<0.001	1.913	<0.001
% White	-9.710	<0.001	-7.206	<0.001	-2.817	<0.001
% Black	0.837	<0.001	1.248	<0.001	1.126	<0.001
% American Indian/Alaskan Native	-0.281	<0.001	-0.193	<0.001	-0.091	<0.001
% Asian American/ Pacific Islander	-0.048	0.802	0.206	<0.01	0.106	<0.001
% Other or Mixed Race	-0.889	<0.001	-0.677	<0.001	-0.238	<0.001

Excludes 2020 blocks with 0 population; n=377,591

TABLE B5

Income Linkages to Refinery Exposure

	Oil and Gas Wells					
	Within **2.5 km**		Within **5 km**		Within **16.1 km**	
	Coefficient	***p*-Value**	**Coefficient**	***p*-Value**	**Coefficient**	***p*-Value**
Income 2023 Median Household	-11,190.80	<0.001	-7,333.66	<0.001	-2,127.55	<0.001

Block groups with income reported as “$250,000+” or “$2,500-“ recoded as “$250,000” and “$2,500,” respectively. Excludes 1,579 block groups with $0 reported income; n=24,027

TABLE B6

Linkages between Measures of Environmental and Socioeconomic Burden and Refinery Exposure

Measure	**Sample Size**	Oil and Gas Wells					
		Within **2.5 km**		Within **5 km**		Within **16.1 km**	
		Coefficient	***p*-Value**	**Coefficient**	***p*-Value**	**Coefficient**	***p*-Value**
CES 4.0 Score	7,932	12.031	<0.001	6.250	<0.001	2.294	<0.001
Asthma	8,024	7.182	<0.001	6.143	<0.001	2.472	<0.001
Low Birth Weight	7,808	0.283	<0.05	0.181	<0.001	0.116	<0.001
Cardiovascular Disease	8,024	2.454	<0.001	1.458	<0.001	0.399	<0.001
Education	7,932	5.988	<0.001	3.566	<0.001	1.197	<0.001
Poverty	7,960	5.536	<0.001	2.800	<0.001	0.907	<0.001

Excludes tracts where no score or indicator data are available, resulting in varying sample size.

TABLE B7

Community Linkages to Unique Exposures from Facilities in the Downstream and Upstream Stages of the Plastic Supply Chain

Community Variable	**Coefficient** Per Unique Facility Exposure	***p*-Value**
Demographics		
% Hispanic/Latino	5.323	<0.001
% White	-6.477	<0.001
% Black	1.423	<0.001
% American Indian/Alaskan Native	-0.291	<0.001
% Asian American/Pacific Islander	0.788	<0.001
% Other or Mixed Race	-0.765	<0.001
Income (2023 Median Household)	-$6,498.16	<0.001
Environmental and Socioeconomic Burden		
CES 4.0 Score	6.179	<0.001
Asthma	1.521	<0.001
Low Birth Weight	0.190	<0.001
Cardiovascular Disease	0.412	<0.001
Education	3.627	<0.001
Poverty	2.963	<0.001

Demographics: Excludes 2020 blocks with 0 population and 4 blocks with non-zero population where analysis produced no data; n = 377,587

Income: Excludes 1,572 2020 block groups with $0 reported income; n=24,027

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