People of Color are Systematically Underrepresented in the U.S. Petrochemical Workforce

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Research Report (Direct Submission)

Keywords: *Employment disparities, Social inequality, Industrial jobs, Fossil fuel, Environmental justice*

Abstract

The burden of petrochemical pollution on U.S. communities of Color is well established, but the corresponding distribution of economic benefits is unclear. We evaluated state-level employment equity in chemical manufacturing (NAICS 325) and petroleum/coal products manufacturing (NAICS 324) using U.S. Equal Employment Opportunity Commission data. People of Color were generally *underrepresented* in high-paying jobs in both subsectors and *overrepresented* in low-paying chemical manufacturing jobs, while the pattern of low-paying petroleum jobs was mixed. Louisiana was the only state where people of Color were underrepresented across the board; further analysis found that disparities persisted on a local scale, including in localities providing large tax subsidies for job creation. For both subsectors, the strongest predictor of disparities in high-paying jobs was state demography (i.e. population of Color; $P \leq 0.002$). Education gaps did not explain observed disparities in either subsector ($P \geq 0.16$). Collectively, our findings reveal that people of Color are systematically underrepresented in the best petrochemical jobs in the United States. These disparities appear to be driven by systemic racism, not education gaps. Regulators should consider that current approaches to industrial permitting, which typically ignore the distribution of economic benefits, are likely to perpetuate this pattern of racial injustice.

1. Introduction

Job creation is often cited by U.S. environmental regulators and pro-industry advocates as justification for the construction or expansion of petrochemical manufacturing facilities (e.g., 1, 2); but it is not clear if these jobs are equitably distributed among racial or ethnic groups. Further, there is a lack of knowledge about the potential drivers of petrochemical job disparities, including differences among U.S. states. By contrast, a large body of research indicates that petrochemical manufacturing disproportionately and systemically harms low-income communities and Black, Hispanic, and Indigenous people in the U.S. (reviewed in 3). These communities have been described as "sacrifice zones," where industrial pollution and the associated health impacts are concentrated, often as a product of systemic racism (3–5). Disparities in petrochemical pollution are part of a larger pattern of environmental injustice that has been widely recognized for decades, but which continues to persist (6–12). Pollution disparities are largely attributable to the siting of industrial facilities in communities of Color, as opposed to post-construction demographic shifts (13). Such knowledge has helped inform policies to reduce environmental inequities, including New Jersey's landmark 2020 law requiring the Department of Environmental Protection to deny permits for harmful projects in overburdened communities (N.J. Stat. § 13:1D-160). Similarly, knowledge about the racial distribution of petrochemical jobs, including factors associated with potential disparities, may help inform efforts to promote economic equity in industrialized communities.

States have broad discretion over how to approach cost-benefit analyses when deciding whether to permit new or expanded petrochemical facilities (see 40 C.F.R. 70 and 40 C.F.R. 122), and the racial distribution of benefits is rarely, if ever, considered (see, e.g., 14). Certain states have statutes that require agencies to conduct cost-benefit analyses in environmental permitting; however, these laws vary widely. For example, the Massachusetts Environmental Policy Act (1972) requires a detailed assessment that considers specified Environmental Justice Principles, including "the equitable distribution of energy and environmental benefits and environmental burdens" (301 C.M.R. § 11.02). By contrast, the South Dakota Environmental Policy Act (1974) does not require any consideration of environmental justice, nor any evaluation of how the project's costs or benefits would be distributed (S.D.C.L. §34A-9-7). In states without relevant statutes, court rulings (i.e. case law) may require a cost-benefit analysis in environmental permitting decisions, but these rulings are generally unspecific about methodology (e.g., *Save Ourselves, Inc. v. The Louisiana Environmental Control Commission*, 452 So2d 1152 (La. 1984)).

Extensive research conducted over more than six decades has documented that Black Americans are underrepresented in many job sectors (e.g., 15–20). By contrast, there is limited research specifically focused on racial disparities in industrial manufacturing. A 1975 report commissioned by the U.S. Department of Labor found that industry avoided hiring Black workers for a number of reasons, all of which were related to systemic racism (e.g., "blacks tend to join unions more readily than whites") (21). The only quantitative, nationwide study of industrial employment disparities appears to be an analysis of 2010 Equal Employment Opportunity Commission (EEOC) data, which found that Blacks and Hispanics were underrepresented among the top 1,000 polluting industrial facilities in the U.S. (including both petrochemical and other types of manufacturing facilities), especially in high paying jobs (22). Yet there are more than 4,000 petrochemical manufacutring facilities in the U.S. (NAICS 324 or 325), and employment equity in the industry as a whole remains unexplored. Further, there is a lack of research about the potential drivers of industrial employment disparities, including state policies and regulations. For decades, access to education has been cited as an explanation for industrial employment disparities (21, 23–26), but without empirical support. This explanation warrants further scrutiny, especially considering that education disparities explain less than half of the wage gap between Black and White workers from all sectors (27).

Several early studies of industrial development found that local residents received a small proportion of jobs at newly-constructed facilities (reviewed in 25, see also 26, 28). While there is a lack of modern-day research, residents of industrialized communities have continued to assert that most of these jobs go to workers living in other areas (e.g., 2). Residents have also alleged that local communities are not receiving their fare share of other economic benefits from petrochemical development, for example, by losing local tax revenue to state industrial incentive programs (2). Conversely, industry advocates have asserted that the economic benefits of industrial development are not being fully considered by decision makers, particularly with respect to job creation (29). Yet, without any knowledge of the racial/ethnic distribution of petrochemical jobs, it is impossible to fully evaluate these tradeoffs.

To increase knowledge about petrochemical employment equity, our study examined the racial composition of the chemical manufacturing (NAICS 325) and petroleum and coal products manufacturing (NAICS 324; excludes extraction) workforce among U.S. states by wage group (i.e. high paying versus low paying). We used public data from the U.S. Equal Employment Opportunity Commission (EEOC) to quantify disparities relative to each state's working-age civilian population. We then examined the extent to which racial disparities in petrochemical employment were associated with four state-level factors, including demography, racial education gaps, industry premium (i.e. relative wage), and job prevalence. Finally, we evaluated local patterns of job disparities and tax incentives in Louisiana. We focused on this state because it stood out in our main analysis, but also due to its relatively large number of petrochemical jobs, extreme racial inequities, and internationally-recognized environmental justice issues (30).

2. Materials and methods

2.1 Data Sources

We used the most recent datasets available at the time of our analysis. We obtained employee race data and job numbers for NAICS 325 (chemical manufacturing) and NAICS 324 (petroleum and coal products manufacturing; excludes extraction activities) industries from the 2021 EEO-1 Public Use File (Job Patterns for Minorities and Women in Private Industry) published by the U.S. Equal Employment Opportunity Commission. This dataset represents private employers with 100 or more employees, as well as certain federal contractors with 50 or more employees (50). The NAICS 325 sector encompasses a broad set of industrial processes, including the manufacturing of basic chemicals, plastics, synthetic rubber, paints, adhesives, cleaning products, pharmaceuticals, explosives, pesticides, and fertilizers (51). We refer to these two sectors collectively as "petrochemical," because both sectors rely heavily on oil and gas feedstocks (52). The NAICS 324 sector consists mostly of petroleum refineries and asphalt product manufacturers (53).

We obtained all wage data from the May 2022 National Industry-Specific Occupational Employment and Wage Statistics (OEWS) published by the Bureau of Labor Statistics. We used 5-year estimates of racial demographics (for the civilian aged 16 to 64 population; C23002) and educational attainment (C15002) from the U.S. Census Bureau's 2021 American Community Survey (ACS). We obtained industrial tax exemption and job creation data for 2010 through 2022 from Louisiana Economic Development's Industrial Tax Exemption Projects Report. This report includes all manufacturing facilities in Louisiana with contracts through the state's Industrial Tax Exemption Program (ITEP).

2.2 Classification of High paying versus Low paying Jobs

Wage data are not provided in the EEO-1 dataset. Therefore, we used OEWS median hourly wage data to classify EEO-1 occupations as high paying versus low paying (Table S1). Because EEO-1 and OEWS do not use the same classification scheme, we assigned multiple OEWS occupations to certain EEO-1 job categories. For example, we considered the EEO-1 "Professionals" category to include OEWS occupations related to business, finance, computers, mathematics, architecture, engineering, and science (Table S1). Because of the differences between EEO-1 and OEWS job classifications, and because of wage differences between the petroleum versus chemical industry, there was some overlap in the range of wages represented in high paying versus low paying jobs (Table S1). High paying jobs had median hourly wages between $28 and $78, while low paying jobs had median hourly wages between $15 and $37 (Table S1).

2.3 State-Level Disparities in Petrochemical Manufacturing Jobs (NAICS 325 and 324)

We analyzed employment data for non-Hispanic White workers (hereafter referred to as "White"), because this group had the highest job numbers overall and therefore the fewest suppressed values in the EEO-1 dataset. Thus, we report disparities in terms of people of Color (including Hispanics), as opposed to specific races. We recognize that this approach may obscure important differences among racial and ethnic groups. However, aggregating these groups allowed us to have a far more complete dataset and more fully evaluate the drivers of potential employment disparities.

Within each subsector (NAICS 325 and 324), we calculated racial disparities in high-paying versus low-paying jobs for each state with available EEO-1 data. We calculated disparities as the people of Color (PoC) share of the state's working-age (18 to 64) civilian population minus the PoC share of subsector jobs. (Because the EEO-1 and ACS datasets do not report people of Color, we calculated the relevant values as 100% minus the share of non-Hispanic Whites.) We considered disparity values lower than 5 percentage points to be non-significant. We generated maps of state-level disparities using QGIS 3.6.1. To ensure data quality, we omitted disparity values that were calculated from incomplete EEO-1 data (i.e. race data missing for 15% or more of jobs in the combination of state, subsector, and wage category). In the rare instance that employee numbers were unavailable for Whites, but were available for other races, we inferred the number of White employees based on other races and the corresponding total.

2.4 Drivers of State-Level Disparities

We evaluated four state-specific variables as potential predictors of racial disparities in petrochemical employment: state demography (i.e. percent population of Color), education gaps, industry premium, and job prevalence. We calculated each state's education gap as the proportion of non-Hispanic Whites with the relevant education minus the proportion of people of Color with the relevant education. We defined relevant education as holding at least a high school diploma or at least a bachelor's degree for low-paying versus high-paying jobs, respectively. We calculated industry premium as each state's median wage for the subsector (i.e. NAICS 325 or 324), divided by its overall median wage. To calculate job prevalence, we divided each state's number of jobs in the relevant wage category (i.e. high or low paying) by its number of working-age (16 to 64) civilians, multiplied by 10,000.

We conducted all statistical analyses in R Statistical Software (54). To facilitate comparison of effect sizes, we scaled and centered all predictor variables prior to regression using the scale function. Using separate multivariate linear regression models, we evaluated predictors of racial disparities in all four combinations of subsector (NAICS 325 or 324) and wage category (high-paying or low-paying). We used quantile-quantile plots to evaluate the distribution of model residuals. Because our data points are defined geographically and spatial relationships in the model residuals could confound our analysis, we tested for spatial autocorrelation in the final models using Moran's I (55).

2.5 Local Disparities in Manufacturing Jobs (NAICS 32) in Louisiana

We quantified parish-level (i.e. county equivalent) employment disparities for Louisiana using the same approach described above for the state-level analysis, except that we used EEO-1 data for the entire manufacturing sector (NAICS 32) because subsector data (NAICS 325 or 324) were unavailable at this geographic scale. The majority (59%) of manufacturing in Louisiana consists of chemical (325) and petroleum and coal products (324), but the sector also includes wood products (321), paper (322), printing (323), plastics and rubber (326), and nonmetallic minerals (327) (56). We excluded occupational categories without any race data from county job totals. If data were missing for Whites but were available for at least one other race, we inferred the number of White employees by subtracting other races from the total for that occupational category (see Results for percentages of excluded or inferred jobs in each county).

3. Results

3.1 Summary Statistics and Quality Assurance

Summary statistics for predictor variables are provided in Tables S2 & S3. Missing data (i.e. non-zero job numbers with no racial breakdown) represented a small proportion (<5%) of jobs in most states (Tables S4 & S5). There were five instances where the proportion of missing data was sufficiently high (>15%) to warrant excluding that state from our analysis: low-paying chemical manufacturing jobs in Montana and high-paying petroleum manufacturing jobs in Mississippi, Kansas, Kentucky, and Utah (Tables S4 & S5). Final sample sizes are provided in tables and figures. Model residuals were approximately normally distributed, with no evidence of spatial autocorrelation ($P \geq 0.39$).

3.2 Geographic Patterns of Chemical Manufacturing (NAICS 325) Employment Disparities by Wage Group

Chemical manufacturers reported EEO-1 data in 44 states (Fig. 1). Most (77%) of the high-paying jobs in this subsector were concentrated in 13 states (in decreasing order: NJ, CA, PA, TX, IL, NC, NY, MA, IN, OH, MI, MN, and LA; Table S4). People of Color were underrepresented in high paying chemical manufacturing jobs in nine of these key states and in 26 states overall, which encompassed most of the subsector (i.e. 73% of high-paying NAICS 325 jobs; Fig. 1A, Table S4). After Nevada and Mississippi (where relatively few of the jobs were located), the most extreme disparities occurred in Texas, Louisiana, and Georgia, where people of Color represented 58.9%, 40.6%, and 48.8% of the population, respectively, but held only 37.6%, 21.2%, and 27.8% of high paying NAICS 325 jobs (Fig. 1A, Table S4). The opposite disparity (i.e. Whites underrepresented) occurred in one only state (Maine), which encompassed less than one percent (0.13%) of high-paying NAICS 325 jobs (Fig. 1A, Table S4).

Most (75%) of the low-paying chemical manufacturing jobs were concentrated in 16 states. In addition to nearly all the states listed above (excluding MA and MN), this list included SC, MO, TN, GA, and FL. People of Color were *overrepresented* in low-paying chemical manufacturing jobs in 13 of these key states and in 29 states overall, which encompassed most of the subsector (i.e. 74% of low-paying NAICS jobs; Table 1B, Table S4). Louisiana and Oklahoma were the only states in which people of Color were *underrepresented* in low-paying NAICS 325 jobs (by 8.9 and 7.0 percentage points, respectively; Fig. 1B, Table S4). These two states combined represented about 4% of the relevant jobs (Table S4).

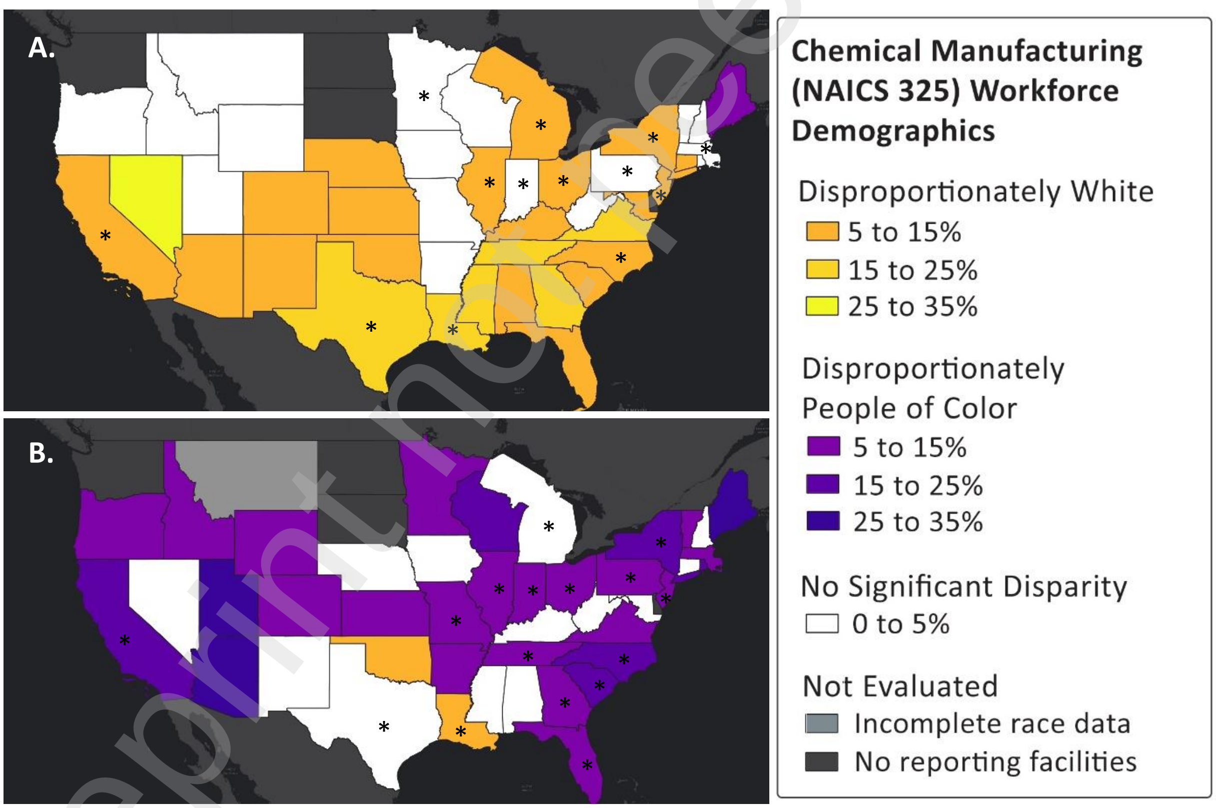

Figure 1. Racial disparities for high-paying (A) and low-paying (B) jobs in chemical manufacturing (NAICS 325). Disparities were calculated as the group's population share minus workforce share and are expressed as percentage points (see Methods). States with the highest numbers of NAICS jobs in the corresponding wage category (collectively representing ≥75% of those jobs) are indicated with an asterisk (*). Numeric values are provided in Table S4.

3.3 Geographic Patterns of Petroleum and Coal Products Manufacturing (NAICS 324) Employment Disparities by Wage Group

Manufacturers of petroleum and coal products reported EEO-1 data in 23 states (excludes extraction operations; Fig. S1). Most (76%) of the high-paying jobs in this subsector were concentrated in six states (TX, CA, LA, OH, PA, IL; Table S4). People of Color were underrepresented in high-paying NAICS 324 jobs in 14 states (including the six key states), which encompassed most of the subsector (i.e. 86% of high-paying NAICS 324 jobs; Fig. S1A, Table S5). The most extreme disparity occurred in Louisiana, where people of Color represented 40.6% of the population, but held only 14.9% of high paying NAICS 324 jobs (Fig. S1A, Table S5). A similarly extreme disparity occurred in Texas (the highest employing state in this category), where people of Color represented 58.9% of the population and held only 34.7% of these jobs (Fig. 1A, Table S5).

Most (77%) of the low-paying petroleum and coal products manufacturing jobs were concentrated in 11 states. In addition to the six states listed above, this list included IN, MN, FL, MO, and UT. People of Color were underrepresented in low-paying NAICS 324 jobs in nine states overall (PA, IL, WA, LA, MO, AL, WI, OH, and TX), which encompassed about half of the subsector (i.e. 54% of low-paying NAICS 324 jobs; Fig. S1B, Table S5). The most extreme disparities occurred in Pennsylvania and Illinois, where people of Color represented 23.6 and 38.8% of the population, respectively, but held only 7.1% and 23.8% of low-paying NAICS 324 jobs (Fig. S1B, Table S5). The opposite disparity (i.e. Whites underrepresented) occurred in six states (NC, GA, CO, TN, FL, and CA), representing less than a quarter of the subsector (i.e. 23% of low-paying NAICS jobs; Fig. S1B, Table S5).

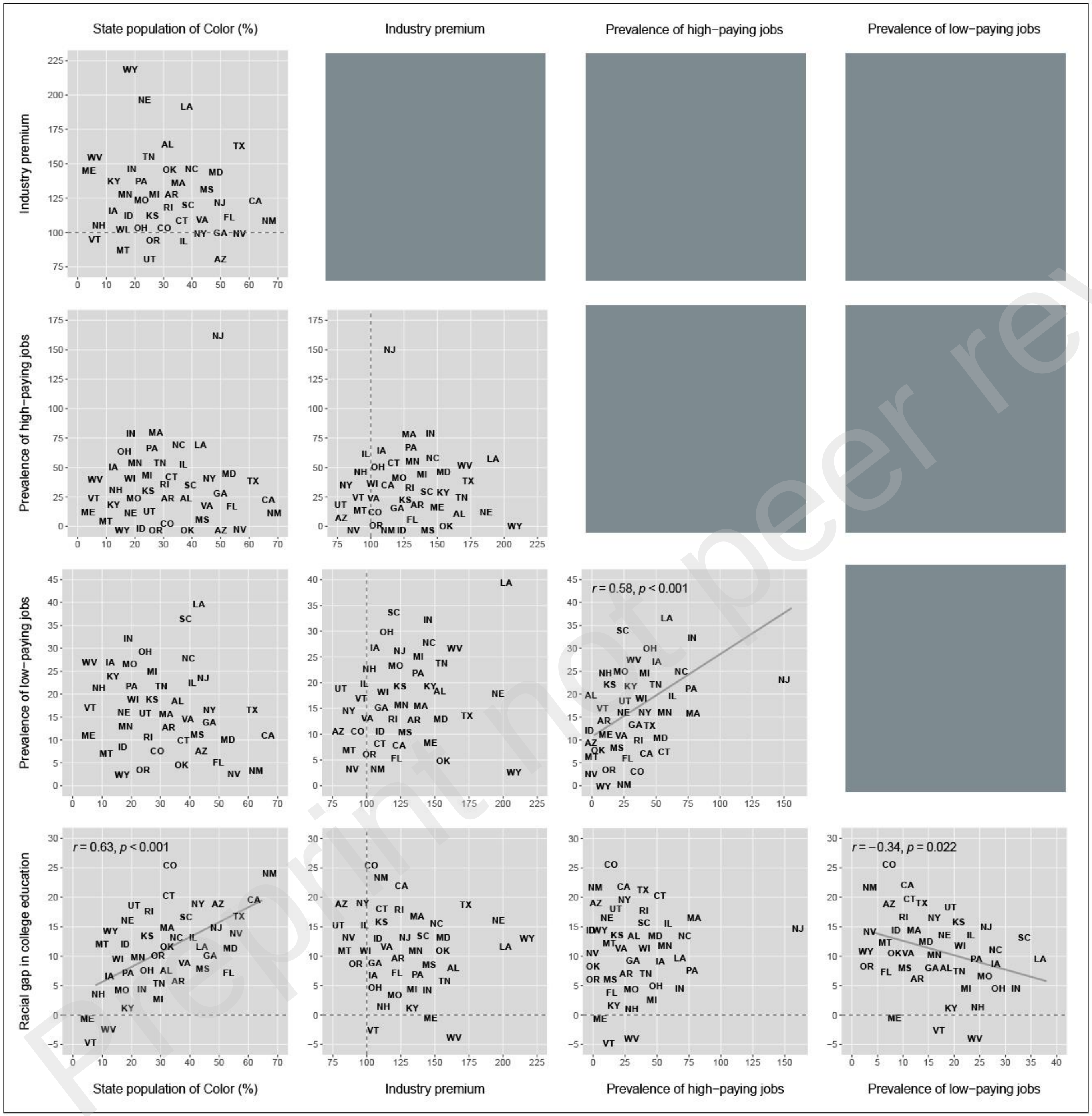

Figure 2. Correlation matrix for predictor variables among states with chemical manufacturing facilities (n = 44 states; NAICS 325). State abbreviations are jittered to avoid overplotting. Trend lines and Pearson's regression coefficients are shown for statistically significant relationships (P < 0.05). Industry premium is median NAICS wage as a percentage of the state's overall median wage. Prevalence of NAICS 325 jobs is reported per 10,000 population. Education gap is the percentage of the White population with at least a Bachelor's degree, minus the corresponding value for people of Color. See Methods for more detail about predictor variables. An analogous plot for petroleum and coal products manufacturing (NAICS 324) is provided (Table S2).

3.4 Drivers of Petrochemical Manufacturing (NAICS 324 or 325) Employment Disparities

Scatterplots revealed several outlying states with respect to potential predictor variables (Fig. 2 and S2). For example, high-paying jobs in chemical manufacturing (NAICS 325) were extremely prevalent in New Jersey, both in absolute terms and relative to low-paying jobs in this subsector (Fig. 2). By contrast, low-paying chemical manufacturing jobs were very prevalent in Louisiana (both in absolute and relative terms), where the industry premium was also very high (Fig. 2). Additionally, Louisiana had the most abundant jobs in petroleum and coal products manufacturing (NAICS 324), by a wide margin (Fig. S2). Relative wages (i.e. industry premium) were generally lower in chemical manufacturing (NAICS 325; Fig. 2) versus petroleum and coal products manufacturing (NAICS 324; Fig. S2).

In the chemical manufacturing subsector (NAICS 325), more extreme disparities in high-paying jobs were associated with a more racially diverse state population ($P < 0.0001$) and tended to track with industry premium ($P = 0.075$; Table 1). By contrast, disparities in low-paying NAICS 325 jobs were associated only with industry premium ($P = 0.002$; Table 1). In the petroleum and coal products manufacturing subsector (NAICS 324), more extreme disparities in high-paying jobs were associated with a more racially diverse state population ($P = 0.002$) and a higher prevalence of jobs ($P = 0.011$; Table 1). Industry premium had the opposite effect, being associated with less extreme disparities ($P = 0.029$; Table 1). There were no significant predictors of disparities in low-paying jobs for the NAICS 324 subsector ($P \geq 0.42$; Table 1). Racial education gaps were not significantly associated with employment disparities in either NAICS 325 or 324 subsector ($P \geq 0.16$; Table 1).

Table 1. Coefficients (SE) from regression models of racial disparities in petrochemical employment among U.S. states

Model Component[1]	Chemical Manufacturing (NAICS 325)		Petroleum & Coal Products Manufacturing (NAICS 324)	
	High-Paying	Low-Paying	High-Paying	Low-Paying
Population of Color (%)	0.879 (0.127)***	0.136 (0.150)	0.709 (0.183)**	-0.194 (0.234)
Racial Education Gap	-0.182 (0.128)	-0.096 (0.154)	0.094 (0.207)	-0.065 (0.263)
Industry Premium	0.183 (0.100)†	0.480 (0.142)**	-0.640 (0.262)*	0.130 (0.353)
Job Prevalence	-0.122 (0.099)	0.089 (0.151)	0.688 (0.236)*	0.234 (0.325)
N (# states)	44	43	19	23
Adjusted R^2	0.58***	0.20*	0.58**	-0.04

[1]Population of Color corresponds to state demography. Racial education gap is the percentage of Whites with the relevant degree (Bachelor's for high-paying, high school diploma for low-paying), minus the corresponding value for people of Color. Industry premium is the median wage as a percentage of the state overall median wage. Job prevalence is number of employees per 10,000 population. See Methods for full descriptions of predictors. *P<0.05, **P<0.01, ***P<0.001.

3.5 Local Disparities in Manufacturing Jobs within Louisiana (NAICS 32)

Race data (EEO-1) for manufacturing employees were available for 18 of 64 Louisiana parishes (Fig. 3, Tables S6 & S7). Notably, data were not available for Calcasieu Parish, which has more than 50 petrochemical facilities and more manufacturing workers than most parishes in Louisiana (31). Livingston Parish was excluded from the analysis of high-paying jobs due to the large proportion (53%) of missing race data. All other parishes had <15% missing race data (Table S7). Most (77%) of the high-paying jobs were concentrated in six parishes (in decreasing order): East Baton Rouge, Iberville, Ascension, St. Charles, Jefferson, and St. John the Baptist (Table S7). Consistent with state-level data, People of Color were underrepresented in high-paying manufacturing jobs in nearly all parishes, representing almost the entire sector (i.e. 97% of high-paying NAICS jobs in the EEO-1 dataset; Fig. 3A, Table S7).

Most (74%) of the low-paying manufacturing jobs were concentrated in seven parishes: the six listed above, plus Caddo. Consistent with state-level data, the pattern of disparities was more complex for low-paying (versus high-paying) NAICS 32 jobs (Fig. 3B, Table S7). People of Color were underrepresented in four parishes, which were high-employing parishes that collectively represented nearly half the sector (i.e. 43% of low-paying jobs; Fig. 3B, Table S7). The opposite disparity (i.e. Whites underrepresented in low-paying jobs) occurred in nine parishes, which represented about one third of the sector (i.e. 35% of low-paying NAICS 32 jobs; Fig. 3B, Table S7). For both wage categories, the most extreme disparities occurred in St. John the Baptist Parish, where people of Color constituted 69% of the population, but held only 19% of high-paying and 29% of low-paying manufacturing jobs (Fig. 3B, Table S7).

Estimated first-year values of *ad valorem* tax credits granted through Louisiana's Industrial Tax Exemption Program (ITEP) from 2010 to 2022 were available for 4,965 individual contracts, representing 60 parishes. After excluding projects that were canceled, denied, withdrawn, missing key information, or listed in duplicate, 4,595 contracts remained. This dataset contained the *estimated number of new jobs* associated with each tax-exempt project but did not include net change in jobs or actual (i.e. confirmed) job numbers. A small proportion of contracts (n = 204) were listed with estimated new jobs as "NA," which we considered to be zero. Overall, chemical manufacturers (NAICS 325) represented one-third (32.8%) of ITEP contracts but received a large majority of tax credits by value (82.6%). Petroleum and coal products manufacturers (NAICS 324) represented 9.1% of contracts and 7.0% of tax credit value. The aggregated totals of tax credits and estimated new jobs varied widely by parish, both overall and for petrochemical subsectors (Table 2). St. John the Baptist Parish had the highest aggregated *credit per-job*, having provided nearly $1 million in first-year tax credits for each estimated new job (Table 2). This tradeoff was even more extreme for petroleum manufacturers in St. John the Baptist Parish, which received over $19 million in aggregated first-year tax credits for creating zero new jobs (Table 2). Cameron Parish had the highest *absolute cost*, with $1.1 billion in aggregated first-year tax credits from 2010 to 2022 (Table 2). Because nearly all ITEP contracts are 10 years in duration, these values can be multiplied by 10 to provide some indication of total cost over the life of the exemption (not accounting for depreciation or millage rate changes). According to the ITEP dataset, the highest numbers of new manufacturing jobs were created in Calcasieu Parish (3,970 estimated jobs), followed by Cameron Parish (1,904 estimated jobs). Notably, the EEO-1 dataset contained no race data for either of these high-employing parishes.

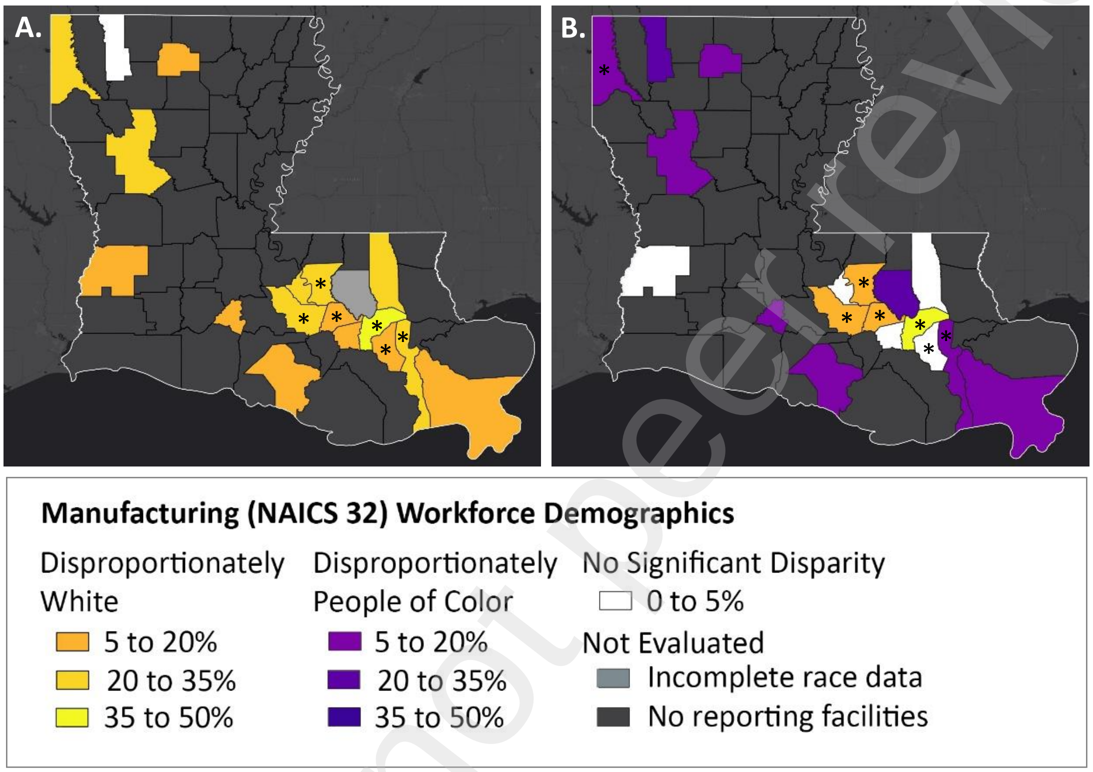

Fig. 3. Racial disparities in high paying (A) and low paying (B) manufacturing jobs (NAICS 32), among Louisiana parishes (n = 18) with EEO-1 data available. Disparities were calculated as the group's population share minus workforce share and are expressed as percentage points (see Methods). Parishes with the highest numbers of manufacturing jobs in the corresponding wage category (collectively representing ≥74% of those jobs) are indicated with an asterisk (*). Numeric values are provided in Table S7.

Table 2. First-year *ad valorem* tax credits and estimated new jobs, aggregated for the 20 Louisiana parishes with the largest petrochemical tax credits (NAICS 325 and 324 combined), relative to racial equity in manufacturing jobs.[1]

Parish	Racial Job Gap[2]	First-Year Tax Credit ($)[3]			Estimated New Jobs			Petrochem Credit Per Job (325 & 324)
		All Mfg	Chemical (325)	Petroleum (324)	All Mfg	Chemical (325)	Petroleum (324)	
Cameron	?	1,122,104,000	1,122,076,000	NA	1,904	1,904	NA	589,000
Calcasieu	?	797,838,000	695,858,000	57,009,000	3,970	1,927	230	349,000
Ascension	All jobs	196,510,000	194,460,000	271,000	1,721	1,535	0	127,000
Iberville	All jobs	123,300,000	120,225,000	NA	1,553	1,438	NA	84,000
St. Charles	Good jobs	140,631,000	25,257,000	76,791,000	273	82	122	500,000
Plaquemines	Good jobs	85,731,000	84,004,000	456,000	527	312	0	271,000
East Baton Rouge	All jobs	69,888,000	44,475,000	11,309,000	645	164	43	269,000
St. James	Good jobs	37,999,000	22,480,000	10,820,000	724	289	86	89,000
West Baton Rouge	Good jobs	33,090,000	25,045,000	6,204,000	356	123	53	178,000
Rapides	?	29,024,000	8,483,000	80,000	782	209	5	40,000
St. John the Baptist	All jobs	22,740,000	2,054,000	19,282,000	23	23	0	928,000
Jefferson	Good jobs	19,598,000	2,187,000	79,000	1,417	29	4	69,000
Caddo	Good jobs	17,744,000	2,275,000	2,270,000	996	256	15	17,000
St. Bernard	?	10,688,000	NA	10,503,000	83	NA	81	130,000
St. Mary	Good jobs	9,679,000	2,718,000	NA	1,476	53	NA	51,000
Lafourche	?	9,538,000	2,732,000	3,555,000	344	57	5	101,000
Red River	?	5,658,000	5,531,000	NA	150	60	NA	92,000
Lincoln	Good jobs	5,147,000	3,303,000	NA	74	10	NA	330,000
Richland	?	3,640,000	1,268,000	NA	383	12	NA	106,000
Bienville	?	1,967,000	1,271,000	NA	31	0	NA	∞

[1]Tax and job values from contracts granted (2010-2022) under Louisiana's Industrial Tax Exemption Program (ITEP) for manufacturing (mfg). NA indicates no ITEP contracts. Infinity symbol (∞) denotes non-zero credit divided by zero jobs.
[2]Denotes parishes where people of Color are underrepresented among all manufacturing jobs or among the high-paying (i.e. good) subset. Question marks (?) indicate that race data are unavailable for manufacturing employees.
[3]Values are rounded to the nearest thousand.

4. Discussion

We found that people of Color in the U.S. are underrepresented in petrochemical manufacturing, with differences linked to industry subsector, geography, and relative wage (Figs. 1 & S1; Table 1). There was no evidence that petrochemical employment disparities were driven by racial education gaps – a longstanding narrative without empirical support (21, 23–26, 32). Rather, disparities were generally more severe in states that were more racially diverse (i.e. non-White). Additionally, people of Color were more consistently underrepresented in occupations that were high paying (versus low paying) or in the better-paying (i.e. petroleum) subsector (Fig. 1 & S1, Table 1). People of Color were generally *overrepresented* in the lowest of the low-paying (i.e. chemical) jobs, especially among states where chemical industry wages were not competitive with the state median wage (Fig. 1B, Table 1). Collectively, our findings reveal a systemic problem that reflects opportunities and incentives for racial discrimination in petrochemical employment, with no connection to educational attainment.

Our findings emphasize the need to consider the *distribution* of economic benefits from petrochemical operations in environmental decision-making. Existing economic impact assessments likely overestimate these benefits for minority communities. For example, the American Petroleum Institute predicted that over 700,000 new petrochemical jobs would become available for minorities from 2015-2035, solely based on the location of the job and the proportion of minorities in that area (33). Our analysis of EEOC data highlights the obvious flaw in this approach and indicates that White workers will receive a significant portion of those "job opportunities for minority workers" (33). Implicit in a cost-benefit analysis is the assumption that costs and benefits affect the same population. Not only are the costs of petrochemical manufacturing disproportionately placed on communities of Color (reviewed in 3), it is now evident that the benefits (i.e. jobs) disproportionately go to White workers. This "double disparity" means that a typical cost-benefit analysis for a proposed petrochemical facility would yield drastically different results depending on the focal population. These considerations are especially important in states with large numbers of petrochemical jobs and extreme employment disparities, particularly Louisiana and Texas.

Louisiana stood out as the only state in our analysis where people of Color were underrepresented in high-paying and low-paying jobs in both petroleum and chemical subsectors. Analysis of Louisiana's local employment disparities yielded results that were consistent with the state-level analysis (Figs. 1, 3, & S1). Louisiana's most extreme disparities in manufacturing employment occurred in St. John the Baptist Parish (Fig. 3, Table S7), a majority-Black area that has received considerable attention for the impact of industrialization on human health and cultural/historic resources (34–38). St. John the Baptist Parish also had the highest cost-per-job of industrial tax credits during the study period, at nearly $1 million per job (Table 2). The costs were even more extreme for the petroleum subsector (NAICS 324), which received $19 million in first-year tax credits for creating *zero* direct jobs (Table 1). Notably, these totals are derived from first-year credits *only* and thus underestimate the full cost of Louisiana's Industrial Tax Exemption Program (ITEP), which typically allows each tax exemption to last 10 years. (The total 10-year costs, which are influenced by depreciation and millage rates, are not available as a public dataset.) Research has found that the value of tax credits granted through Louisiana's Industrial Tax Exemption Program (ITEP) is not significantly correlated to job growth or personal income growth (40), yet represents a substantial portion of local tax revenue in many parishes (39). For example, in 2018 and 2019, the value of taxes exempted through ITEP exceeded the total taxes levied in St. John the Baptist Parish (39). This magnitude of incentives, combined with the extreme pollution burden in Louisiana (41, 42), have led some to argue that Louisiana taxpayers "have indirectly subsidized the destruction of their own environment and health" (40). Our study extends this argument to employment inequality, as these subsidies benefit industries that disproportionately hire Whites, at the expense of workers of Color across Louisiana (Table 2).

Understanding the drivers of petrochemical job disparities is key to improving employment equity in this industry. Given the non-significant effect of racial education gap, our study suggests that investment in education/training is unlikely to be an effective solution. This topic could be further explored by examining enrollment and job placement rates for industrial training programs among different racial groups. Yet, researchers should consider that enrollment is likely influenced by the perceived likelihood of job placement, which in turn may be influenced by systemic racism. In addition to education, geography has been cited to explain the lack of diversity in petroleum jobs, specifically the alleged lack of workers of Color near oil reserves (23). Although our study did not address *extraction*, we found widespread employment disparities in petrochemical *manufacturing* linked to systemic racism. It seems unlikely that extraction jobs are exempt from the discriminatory patterns and practices of the broader petrochemical industry. Addressing systemic racism in the petrochemical workforce will require data-driven interventions by state and federal regulatory authorities. These interventions include consistent enforcement of Title VI under the U.S. Civil Rights Act of 1964, a goal that is complicated by recent attempts of state governments to require proof of discriminatory intent under EPA Title VI regulations (REF).

As with any analysis, our study had limitations. Because we focused solely on employee numbers, we could not detect other forms of racial inequity. For example, previous studies of U.S. workers have documented racial inequities with respect to employment benefits (43, 44), workplace harassment (45), job insecurity (46), and workplace hazards (47, 48). Additionally, we did not consider the racial demographics of construction workers that build new/expanding petrochemical facilities; however, research indicates that people of Color are underrepresented in the U.S. construction industry (reviewed in 49). Finally, we did not evaluate the racial demographics of contract workers, because such data are not available. This topic is an important area for future research, especially given the potential differences in wages, benefits, job security, and workplace hazards between contract workers and full-time employees.

Our study provides unequivocal evidence that people of Color do not receive a fair share of U.S. petrochemical jobs, consistent with allegations made by community members. Environmental justice requires that decision-makers consider how the “pollution versus jobs” tradeoff differs among racial groups; jobs that mostly go to White workers cannot offset industrial toxins that mostly occur in Black, Hispanic, and Indigenous communities. Future research should focus on racial disparities in job placement rates for industrial training programs, as well as local workforce demographics in states with significant petrochemical operations. More importantly, U.S. environmental regulators should use EEOC data to evaluate employment equity for petrochemical companies seeking permits to expand their operations. Without data-driven interventions, racial disparities in industrial employment will persist alongside the intractable disparities in industrial pollution.

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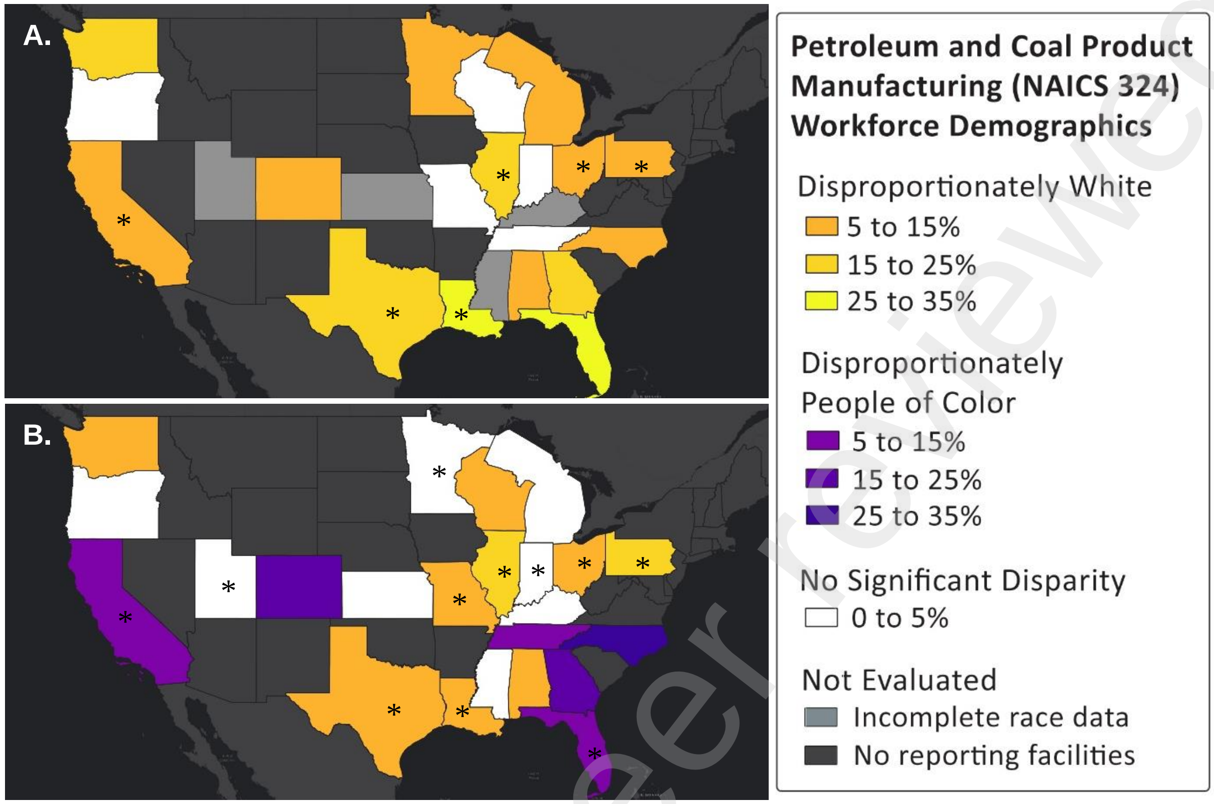

Fig. S1. Racial disparities for high-paying (A) and low-paying (B) jobs in petroleum and coal products manufacturing (NAICS 324). Disparities were calculated as the group's population share minus workforce share and are expressed as percentage points (see Methods). States with the highest numbers of NAICS jobs in the corresponding wage category (collectively representing ≥75% of those jobs) are indicated with an asterisk (*).

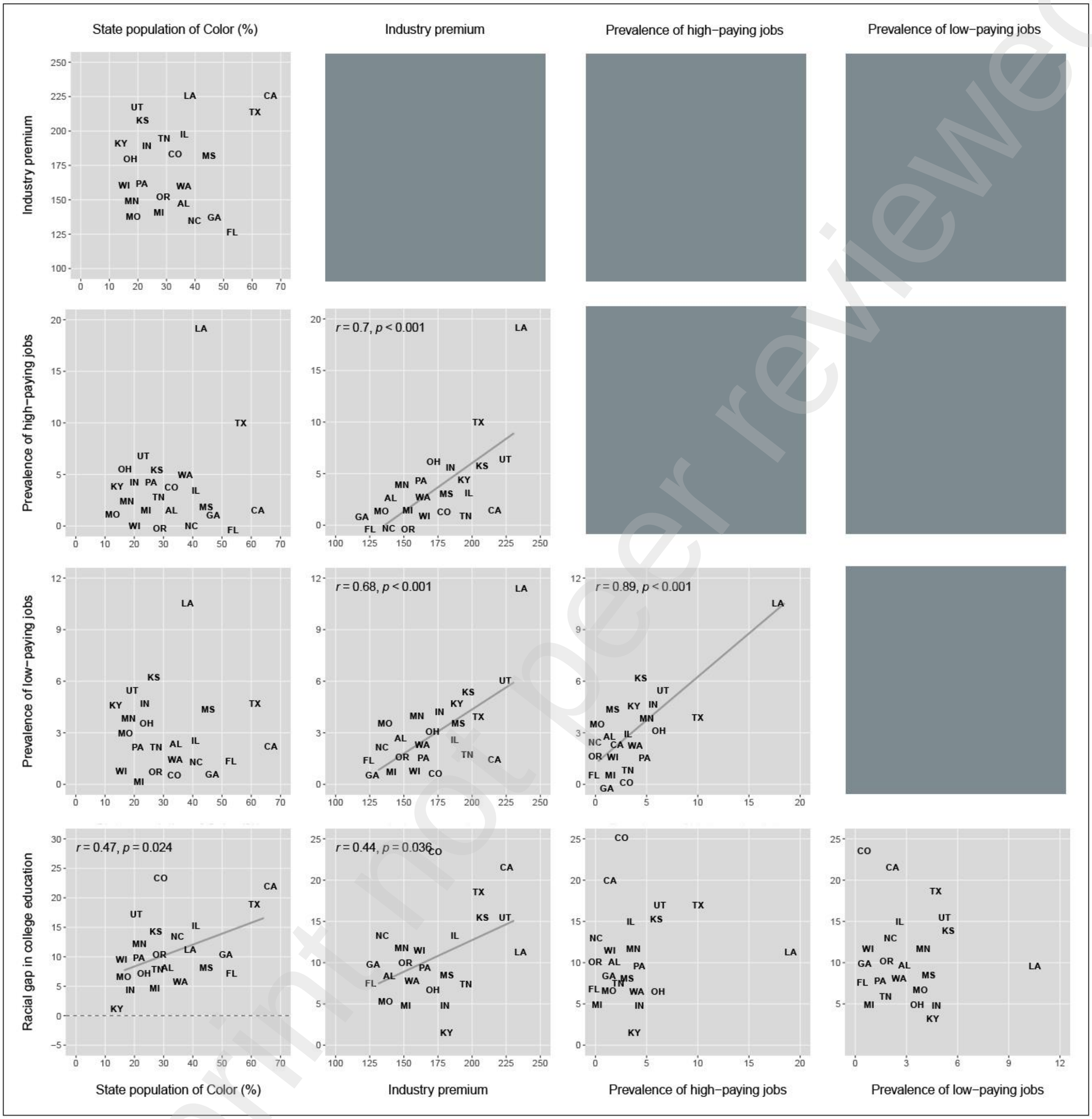

Fig. S2. Correlation matrix for predictor variables among states with petroleum and coal products manufacturing facilities (n = 23 states; NAICS 324). State abbreviations are jittered to avoid overplotting. Trend lines and Pearson's regression coefficients are shown for statistically significant relationships (P < 0.05). Industry premium is median NAICS wage as a percentage of the state's overall median wage. Prevalence of NAICS 324 jobs is reported per 10,000 population. Education gap is the percentage of the White population with at least a Bachelor's degree, minus the corresponding value for people of Color. See Methods for more detail about predictor variables.

Table S1. Typical Wages in the Petroleum and Coal Product Manufacturing (NAICS 324) and Chemical Manufacturing (NAICS 325) Industries, U.S. Overall.

EEOC Job Category[1]	EEOC Tier(s)	OEWS Occupation Code(s)[2]	OEWE Median Hourly Wage ($)		Category for Disparity Analysis
			Petroleum (324)	Chemical (325)	
Officials and Managers	1, 1_2	11-0000	71.98	64.38	High-paying
Professionals	2	13-0000, 15-0000, 17-0000, 19-0000, 23-0000	43.30 to 73.05	35.25 to 78.45	
Technicians	3	29-0000, 31-0000	41.94	18.24 to 29.22	
Sales Workers	4	39-0000, 41-0000	46.00	38.14	
Craft Workers	6	27-0000, 47-0000, 49-0000	28.16 to 46.87	29.75 to 30.97	
Administrative Support Workers	5	43-0000	24.50	22.68	Low-paying
Operatives	7	51-0000, 53-0000	23.55 to 36.88	18.63 to 22.24	
Laborers & Helpers	8	37-0000, 45-0000	21.85	16.83 to 17.96	
Service Workers	9	33-0000, 35-0000	23.52	14.77	

[1] For descriptions of job categories, including required skill levels, see U.S. Equal Employment Opportunity Commission (EEOC). 2021 EEO-1 Component 1 Data Collection Instruction Booklet. Appendix E. Available at https://www.eeocdata.org/pdfs/2021_EEO_1_Component_1_InstructionBooklet.pdf.

[2]All managers are represented in a single OEWS occupational code (11-0000, Management Occupations). For descriptions of occupational codes, see Bureau of Labor Statistics. National Industry-Specific Occupational Employment and Wage Statistics (OEWS). May 2022. Available at https://www.bls.gov/oes/current/naics3_324000.htm and https://www.bls.gov/oes/current/naics3_325000.htm.

Table S2. Summary Statistics for States with Chemical Manufacturing (NAICS 325) Facilities.[1]

Variable	Min	Max	Median	Mean	SD
Working-age civilian population of Color (PoC, %)	7.7	64.8	28.8	31.3	15.2
Racial disparities in college attainment (%)[2]	-3.7	24.4	10.8	11.0	6.1
Racial disparities in high school attainment (%)[2]	-0.5	22.9	12.2	12.7	5.2
Workers of Color in chemical jobs (%)					
Overall	6.3	60.4	27.8	29.9	13.4
High paying	6.0	53.7	22.9	23.7	10.9
Low paying	8.1	82.3	37.0	49.3	17.2
Number of chemical jobs per 10,000 population					
Overall	6.2	180.9	43.4	48.3	33.3
High paying	1.6	156.0	26.9	31.6	27.6
Low paying	4.1	38.0	15.1	16.4	8.6
Chemical industry premium[3]	85.9	213.4	119.0	127.3	28.3

[1]As reported in the Equal Employment Opportunity Commission's 2021 EEO-1 database (n = 44 states).

[2]Proportion of White population with the relevant degree/diploma, minus corresponding proportion of PoC.

[3]State-specific median NAICS 325 wage, as a percentage of overall median wage. See Methods for a full description of variables.

Table S3. Summary Statistics for States with Petroleum and Coal Products Manufacturing (NAICS 324) Facilities.[1]

Variable	**Min**	**Max**	**Median**	**Mean**	**SD**
Working-age civilian population of Color (%)	16.4	64.3	27.1	32.5	13.4
Racial disparities in college attainment (%)[2]	2.4	24.4	9.3	10.7	5.3
Racial disparities in high school attainment (%)[2]	5.8	21.5	11.6	12.6	4.6
Workers of Color in petroleum jobs (%)					
Overall	9.2	59.7	21.4	25.8	15.7
High paying	9.7	64.9	24.3	26.6	15.1
Low paying	7.1	73.3	25.7	32.7	19.8
Number of petroleum jobs per 10,000 population					
Overall	1.7	41.7	4.8	7.7	8.6
High paying	0.3	18.5	2.4	3.5	4.1
Low paying	1.0	11.0	2.0	3.0	2.3
Petroleum industry premium[3]	131.1	230.7	176.5	173.2	30.3

[1]As reported to the Equal Employment Opportunity Commission's EEO-1 database (n = 23 states). Excludes extraction and mining.

[2]Proportion of White population with the relevant degree/diploma, minus corresponding proportion of PoC.

[3]State-specific median NAICS 324 wage, as a percentage of overall median wage. See Methods for a full description of variables.

Table S4. Job Disparity Data for States with Chemical Manufacturing Facilities (NAICS 325)[1]

State	Number of NAICS 325 Jobs	Working-Age Population of Color (%)	NAICS 325 Workers of Color (%)			Jobs with Missing Race Data (%)	
			Overall	High Paid	Low Paid	High Paid	Low Paid
Texas	65,216	58.9	43.0	37.6	54.6	0.0	0.0
Louisiana	20,509	40.6	25.1	21.2	31.7	0.0	0.0
Mississippi	2,745	42.9	29.9	20.9	43.6	1.9	0.0
Connecticut	10,093	34.9	26.1	23.9	36.8	0.0	0.0
Oklahoma	2,460	34.7	27.0	28.2	27.7	2.5	0.7
Maryland	15,851	50.8	43.8	41.6	51.7	0.0	0.0
Virginia	13,099	40.0	33.2	21.8	49.5	0.0	0.0
Tennessee	18,741	27.1	20.4	11.9	34.3	0.0	0.0
New Jersey	82,467	46.7	40.1	36.9	60.3	0.0	0.0
Illinois	49,452	38.8	32.8	27.0	48.5	0.0	0.0
Georgia	16,069	48.8	42.9	27.8	63.7	0.0	0.0
Alabama	7,251	34.3	28.9	23.0	37.2	3.0	0.0
Kentucky	8,747	16.4	11.1	10.4	11.8	0.0	0.0
New Mexico	1,068	64.8	59.6	53.7	69.5	0.0	0.0
Nebraska	3,358	21.0	16.2	10.3	22.6	0.0	0.0
California	72,197	64.3	59.6	52.2	82.3	0.0	0.0
Michigan	28,892	24.8	20.1	16.8	25.4	0.0	0.0
Nevada	903	53.7	49.1	28.1	56.3	0.0	0.0
Montana	701	13.6	9.1	14.8	NA	4.8	39.1
New York	43,890	44.7	41.9	31.2	63.0	0.0	0.0
Iowa	11,044	14.9	12.4	10.5	15.8	0.0	0.0
West Virginia	5,049	8.3	6.3	6.0	8.1	0.5	0.0
Florida	17,391	50.9	49.5	40.7	64.5	0.0	0.0
Rhode Island	2,361	28.5	27.7	24.3	44.8	3.2	0.8
New Hampshire	3,445	10.8	10.3	12.0	11.7	2.8	0.3
Arkansas	3,661	29.1	29.1	24.4	38.7	2.7	1.1
Ohio	38,966	21.0	21.4	14.9	30.5	0.0	0.0
Wyoming	284	16.0	16.5	11.8	26.5	0.0	2.7
Colorado	4,639	31.5	32.3	23.5	46.0	0.0	0.0
North Carolina	43,787	37.5	38.4	30.9	56.4	0.0	0.0
Kansas	6,007	24.2	25.2	17.6	33.6	0.0	0.0
Indiana	33,413	21.0	22.9	21.5	26.2	0.0	0.0
Massachusetts	31,772	29.8	32.0	29.9	42.8	0.0	0.0
Minnesota	18,281	20.2	22.6	20.1	30.9	0.0	0.0
Pennsylvania	59,098	23.6	26.6	23.8	35.6	0.0	0.0
Oregon	2,397	26.4	29.5	26.4	33.7	0.0	0.0
South Carolina	14,665	36.5	40.3	25.5	52.4	0.0	0.0
Missouri	17,117	21.0	25.5	20.2	32.8	0.0	0.0
Vermont	1,119	8.1	14.1	7.4	22.6	0.0	0.0
Wisconsin	14,698	17.8	24.7	17.2	36.1	0.0	0.0
Idaho	1,224	19.6	27.8	18.4	32.4	0.8	0.0
Arizona	5,416	47.5	60.4	37.8	79.6	0.0	0.0
Utah	5,784	22.7	35.8	22.8	50.1	0.0	0.0
Maine	1,440	7.7	22.4	15.5	35.0	2.1	0.0

[1]N = 44 states. NA: Not analyzed due to high proportion of missing race data.

Table S5. Job Disparity Data for States with Petroleum & Coal Products Manufacturing Facilities (NAICS 324; excludes oil and gas extraction).[1]

State	Number of NAICS 324 Jobs	Working-Age Population of Color (%)	NAICS 324 Workers of Color (%)			Jobs with Missing Race Data (%)	
			Overall	High Paid	Low Paid	High Paid	Low Paid
Texas	25,677	58.9	40.4	34.7	53.8	0	0
Louisiana	8,434	40.6	21.5	14.9*	26.8	0.1	0
California	7,382	64.3	59.7	52.3	69.6	1.4	0.3
Ohio	5,084	21.0	11.4	12.2	14.9	2.5	0.9
Illinois	3,989	38.8	18.4	16.7	23.8	2.5	0
Pennsylvania	3,852	23.6	9.4	9.7	7.1	0	0
Indiana	3,168	21.0	19.4	25	23.3	8.6	0
Minnesota	2,262	20.2	15	10.6	22.4	1.6	0
Kentucky	2,136	16.4	9.2	NA	12.7	62.2	0
Utah	1,794	22.7	18.1	NA	24.6	19.4	0.6
Kansas	1,787	24.2	21.4	NA	27.7	36.9	0
Washington	1,754	33.4	13.5	11.1	19.2	0	2.4
Florida	1,598	50.9	50.4	25.8	56.4	0	0
Missouri	1,369	21.0	12.1	21	11.4	13.9	0
N. Carolina	1,094	37.5	56.7	25	68	0	0
Mississippi	1,064	42.9	27.3	NA	41.5	46.5	0
Michigan	994	24.8	22.6	16.8	28.7	2.7	0
Tennessee	984	27.1	29.8	26.1	35.5	0	0
Colorado	894	31.5	28.9	20.8	49.3	2.3	0
Georgia	855	48.8	53.3	24.3	73.3	0	0
Alabama	796	34.3	19.3	20.3	25.6	10.4	0
Wisconsin	586	17.8	9.9	17.3	11.6	9.7	0
Oregon	402	26.4	24.9	30.7	25.7	11.9	0

[1]N = 23 states. NA: Not analyzed due to missing race data for 15% or more of jobs in the wage group.
*White employees for Category 3 (Technicians) inferred from the category total minus other races.

Table S6. Summary Statistics for Louisiana Parishes with Manufacturing (NAICS 32) Facilities[1]

Variable	Min	Max	Median	Mean	SD
Working-age civilian population of Color (%)	13.0	68.7	41.0	41.0	13.4
Workers of Color in manufacturing jobs (%)					
Overall	13.5	50.8	31.9	33.8	11.6
High paying	10.6	40.6	21.1	22.8	7.2
Low paying	18.5	66.4	42.1	44.3	15.4
Number of NAICS 32 jobs per 10,000 population					
Overall	38.7	3,447.9	441.9	632.5	798.2
High paying	7.8	2,131.7	205.2	361.2	500.6
Low paying	20.0	1,307.3	145.2	236.6	308.0

[1]Based on data from the Equal Employment Opportunity Commission's 2021 EEO-1 database (n = 18 Louisiana parishes).

Table S7. Disparities in Manufacturing Jobs (NAICS 32) among Louisiana Parishes (N = 18).

Parish	NAICS 32 Jobs (#)	Working-Age Population of Color (%)	NAICS 32 Workers of Color (%)			Missing race data (%)	
			Overall	High Paid	Low Paid	High Paid	Low Paid
Ascension	3,524	32.1	18.6	17.7	20.1	0.0	0.0
Beauregard	787	21.5	13.5	10.6	18.5	0.0	0.7
Caddo	1,397	56.5	50.8	23.8	66.4	0.0	0.0
E. Baton Rouge	4,096	54.7	28.0	24.9	43.1	0.0	0.0
Iberville	4,262	51.0	27.6	22.4	36.3	0.0	0.0
Jefferson	2,010	49.2	41.6	21.3	64.0	0.0	0.0
Lafayette	496	33.0	37.5	20.9	41.0	12.5	0.0
Lincoln	644	44.9	50.3	30.9	54.8	4.0	0.0
Livingston	246	13.0	39.4	19.6*	43.7	53.2	0.0
Natchitoches	1,358	47.4	48.2	18.2	65.7†	0.0	0.0
Plaquemines	897	30.6	24.9	20.8	36.4	0.0	0.0
St. Charles	3,265	32.9	25.4	22.9	29.8	0.0	0.0
St. James	602	49.9	43.5	40.6†	46.6	0.0	0.0
St. John The Baptist	1,655	68.7	23.0	18.8	28.9	0.3	0.0
St. Mary	348	39.9	33.9	26.0	59.0	0.0	0.0
Tangipahoa	389	36.1	29.8	13.9	38.4	6.2	0.0
W. Baton Rouge	438	42.0	24.0	20.9	38.7	4.4	0.0
Webster	788	35.0	48.4	36.0	65.6	10.7	0.0

*Disparity value omitted from Fig. 3 due to the large proportion of missing race data.

†White jobs for one or more occupations were inferred from total jobs minus jobs for other races.